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Pesticide application and the residu on *Citrulus vulgaris* (Schard)

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Abstract:

Residues of pesticides can affect the ecological system and human health. The aim of this study identify the behavior of the watermelon`s [*Citrullus vulgaris* (Schard)] farmers in applicating the pesticides. There are five principles in applying pesticides (5R): Right target of pest, the right target of the plant, right dose, right application timing or usage, right method of application (the right form of application and the use of Personal Protective Equipment [PPE]). It was a descriptive observational study in *C. vulgaris*, farmer group to identify the application pesticides, and analysis the residue of pesticides. Data were collected by interviews and observations. The Residues of pesticides in *C. vulgaris*, Schard and in the soil were analyzed by HPLC with Triple Quadrupole Tandem Mass Spectrometry detector (LC–MS/MS) using single point matrix based calibration at RL, in the angler bioChemlaboratory. Descriptive observational study. In this study, the result showed there were 13 pesticides used by farmers including insecticides and fungicides. All respondents did the right target of pest, however, they were not doing on the right target of plant, right dose, right application timing or usage, the right method of application (the right form of application and the use of PPE). Conclusion respondents that did not apply the 5R Principles. Pesticides residues, however, is still not detected on the soil (< 0.025 mg kg^{-1}) and watermelons (< 0.01 mg kg^{-1}). Therefore, it is still safe for agriculture and consumption.

Keywords: Behavior, personal protective equipment, watermelon.

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Introduction

Indonesia is one of the countries producing horticultural crops such as watermelon [*Citrullus vulgaris* (Schard)]. Jember is a regency in East Java, Indonesia which is a regional commodity producer of CVS. It has the most CVS varieties. Cultivation of watermelons reached 1 461 ha, with a total production of 33 711 t in 2011. Watermelon farmings spread across several districts in Jember, Indonesia, where the biggest is in the district of Puger. Watermelon cultivation takes place throughout the year because of the growing season of watermelon were all the year. Meanwhile, the watermelon planting period in the area of Puger district named Mojosari Village lasted four times a year, starts from January to March; April to June, July to September; and last on October to December. Farmers group work together to grow watermelon in the area. Watermelon is often impaired by the pest. Accordingly, farmers use the chemical pesticides to control the pest. The pesticides that commonly used were Antracol, Score, Curacron (Profenofos), Demolish (Abamectin) and Furadan (Carbofuran). The cultivation of watermelon is throughout the year, furthermore, the farmers apply pesticides also continuously throughout the year. Pesticides are considered to have an important role in overcoming problems of pests. Nonetheless distribution and use of pesticides as pest controllers are restricted by the goverment regulations because of pesticides had the risk over human health and the environment [(1)]. Toxins from pesticides are very harmful to humans and the environment. Pesticide residues can enter the human body through the remaining residue which is still attached on the agricultural products consumed. Some agricultural products were found contaminated by pesticide residues such as small chili, brocolli, tomato [(2–6)]. Application of pesticides for agriculture must be precise and thoughtful. The Indonesian Agriculture Minister Regulation Number 6/1995 release that application of pesticides in Indonesia must meet the 5R requirements. The first is right target of pest, second is right target of plant, third is right dose, fourth is right application timing or use (time when spraying, frequency, the first and ended application during plantation), and the last is right method of application (form of pesticides and application, PPE. These five principles must be fulfilled as a security guarantee that pesticide residues do not contaminate food products and other environments. According to the characteristic and the way it works, the pesticides that usually used by watermelon farmer are systemic pesticides. The systemic pesticides can be absorbed by plant organs such as roots,

stems and leaves. Chemical pesticides were used to control pest on CVS continously by the farmer because of the continous plantation. That was the background of this research to analyse the behaviour of watermelon farmer in applicating the pesticides and the residues of pesticides contained in the CVS agricultural farm and in the CVS`s product.

Materials and Methods

Methods

This research is a descriptive observational study conducted cross sectional study among CVS. The population were "Subur Jaya" farmer group, Puger, Jember, Indonesia. All population were taken for samples. The samples size were taken from 30 farmers who had planted CVS, varietas quality. The characteristic of the farmer were identified in age, education, and knowledge. The informations about pesticides application (5R) by the farmer were collected throught interview and observational guide.

Material

There were five soil samples location (from 10.6 ha) which still active for plantation. The soil were composite. CVS varieties quality samples were taken randomly from the location of soil samples. CVS samples were taken in the age of 50 d to 55 d. Sample were taken on 1st April 2015 at 8 a.m. The soil and CVS samples were analysed by HPLC with Triple Quadrupole Tandem Mass Spectrometry Detector (LC–MS/MS) using single point matrix based calibration at RL, in the angler bioChamlaboratory.

Results and Discussion

Respondent characteristic

All respondents in this study were male farmers with a length of service more than 5 yr. Based on the interview; data showed that the majority of respondents' age was 18 yr old to 40 yr old (53.3 %). While the education level of respondents was elementary school (90 %). The knowledge of the CVS farmers mostly enough (50 %). (table 1, and table 2)

Table 1. The characteristic of respondent based on ages and education

Ages			Education	
	total	**(%)**	**Total**	**(%)**
Early adult (18 yr old to 40 yr old)	16	53.3	1 (Elementary school)	6.6
Middle adult (40 yr old to 60 yr old)	13	43.3	2 (Senior high school)	3.3
Elder (≥ 60 yr old)	1	3.3	27 (Elementary school)	90
Total	**30**	**100**	**30**	**100**

Table 2. The knowledge of the respondents

Knowledge	Total	(%)
Good	6	20
Enough	15	50
Poor	9	30
Total	**30**	**100**

Age related to the ability to work. Age will affect the physical ability of farmers to work optimally. Data showed that most respondents were young and productive farmers. Education related to personal ability to absorb information. Persons with low education will be difficult to receive the latest information including new knowledge. Therefore knowledge comes from education, teaching and formal education [(7)]. Knowledge contributed to the application of pesticides by farmers. Farmers who have low knowledge had correlation with careless using of pesticides on the farmers [(8)]. Furthermore the farmers in the rural Tanzania showed farmers who have higher education significantly more careful to use pesticides [(9)] and also the farmer knowledge about pesticides contributing risk of pesticide use [(10)]. All respondents were farmers who had already working more than 5 yr, it provide more skilled farmers than the new workers. The new workers were more careless [(11)].

Pesticides application

The right target of pest

Applications of pesticides must be in accordance with the type of pest. Data from the interviews and observations of the respondents, showed that all farmers (100 %) used pesticides in accordance with the type of pests that attack crops of watermelon. Pesticides used are insectiside and fungicides. Respondents were already able to choose pesticide to be applied in accordance with the type of pest. All respondents were able to identify the types of the

pests then choose the most appropriate pesticides to address them. Agriculture Department had sosialized the way to identify the pest and choose the pesticides in a standart operational procedure. Right target of organism is important thing to control the pest. (table 3)

Table 3. Right target organism

Kind of pest	Pestiside		
	Commerce	**Aktif subtance**	**Target organism**
Thrips dan Aphids	Demolish	Abamektin	Insecticide
	Confidor	Imidaklropid	Insecticide
	Marshal	Karbosulfan	Insecticide
	Curacron	Profenofos	Insecticide
	Regent	Fipronil	Insecticide
Antraknosa	Antracol	Propineb	Fungicide
(*Colletotrichum lagenarium*)	Antila	Mankozeb	Fungicide
Downymildew	Agronil	Klorotalonil	Fungicide
	Score	Difenoconazol	Fungicide
	Dithane	Mankozeb	Fungicide
Spodoptera sp.	Prevathon	Klorantiniliprol	Insecticide
	Furadan	Karbofuran	Insecticide
Fusarium oxysporum schlecht	Dithane	Mankozeb	Fungicide
	Acrobat	Dimetomorf	Fungicide
Powdery mildey	Acrobat	Dimetomorf	Fungicide
	Antila	Mankozeb	Fungicide
	Antracol	Propineb	Fungicide
Dacus	Curacron	Profenofos	Insecticide
	Regent	Fipronil	Insecticide

The right target of plant means the suitability between pesticides used in crop types and kinds of plants. Pesticide application must comply with the plant and intruder pest. From the respondents' interviews and observations we found 13 pesticides that usually used for CVS, where the farmers used pesticides in three to six kinds of pesticides during one period of growing season. There were 93.3 % respondents used pesticides which is not appropriate for CVS. There were six pesticides applied which is not suitable for CVS. Those were for chillis, string beans, oil palm, potatoes, *chrysanthemum*, cabbage, paddy, tomatoes, apples, clove, rubber, cacao, cotton, sugar, crop, tobaccoo. The only two respondents (7.14 %) used the pesticides on the right target of plant. (See table 4).The right type of plant are the important thing. If pesticides used not suit the type of plant, it can be useless to control pest, not effective and efficient and also leave the residues on the product and environment.

Table 4. The right target of plant

Pestiside	Respondents	
	Total	**%**
Not Suitable for watermelon (Demolish 18EC, Agronil 75WP, Dithane–M45 80WP, Furadan 3G, Antila 80WP, Prevathon 50SC)	28	93.3
Suitable for watermelon (Marshal 200EC, Confidor 5WP Antracol 70WP, Acrobat 50WP, Curacron 500EC, Regent 50SC, Score 250EC)	2	7.14
Total	**30**	**100**

The right dose

Pesticide s must be applied on the precise dosage for the plant. Dose is the amount of pesticides applied on each unit area of the target field. Pesticides often used on the dillution to get appropriate concentration. Direction for pestiside concentration applied normally exist in the product label. Insecticides and fungicides are pesticides which applied by mixing or dilluting in a specific concentration then sprayed on pests afterward. The data from the interviews and observations showed that all respondent (100 %) did not use pesticides on the right dosage as on the direction label of the product. Respondents estimated the dose by themselves without looking at the instructions on

the label. The label were not read by the respondents. Respondents only estimate the amount of pesticide then applied using a spoon and a bottle cap of pesticides to be applied to CVS. The number of pest attacks were used to set the dosage of pestisides to use for CVS. The label is an important part that should be read by farmers before applying pesticides on crops. The right dose of pesticide application may help to reduce the environmental risk and health risk. However, they also found 73 % of the farmers in the area of Punjab, Pakistan usually do not read the label information of pesticides [12, 13]. Farmers in Greece (72 %) said that most information on pesticides labels is hard to read and understand ("Damalas attitudes towards pesticide labelling among Greek tobacco farmers," n.d.). That was probably the reason why farmers did not read the pestiside labels. The label provides information regarding the use of pesticides, mixing doses, the disposal of pestisides packaging. If farmers do not read the labels on the pesticides container, probably they also throw away the pesticide containers after use. The farmers from Ghana, who left the container of pesticides on their farm or threw them into the bushes around[14]. The right dose that refer to the instruction label will have an impact on pests, leaving residues on agricultural product and leaves environmental residues. An incorrect dose of pesticides application will lead to an unoptimal control of pest. The dose usage data on each type of pesticide in full can be seen in table 5.

Table 5. The right dose

Pestiside	Measure	Instrument
Demolish 18EC, Curacron 500EC, Regent 50SC,	Roughly	Bottle caps
Marshal 200EC, Confidor 5WP, Antracol 70WP, Acrobat 50WP, Score 250EC, Agronil 75WP, Dithane–M45 80WP, Furadan 3G, Antila 80WP	Roughly	Spoon
Prevathon 50SC	Roughly	Roughly

The right application timing or usage

The right application timing or usage consist of the right time of spraying, the frequency, and when the start and end of application during plantation. The time of spraying can be done by preventive approach or curative approach. The data showed that all respondents (100 %) using pesticide by preventive approach. The respondents used pesticides regularly although no pest attack. Farmers used the calendar to schedule the time to spray pesticides. This preventive approach gives the risk to the product and environment because using pesticides continuously without measured dose will leave reissues. The accuracy of spraying hours. From the interviews and observations of the respondents, data showed that all respondents (100 %) sprayed pesticides in the morning at 07.00 a.m. to 10.00 a.m. and in the afternoon at 03.00 p.m. to 04.00 p.m. It was a good time to spray the pesticides. Respondents also considered the weather conditions and wind direction when spraying pesticides. Weather and wind direction should be considered, or else, the sprayed pesticides would be wasted in vain. When the weather is rainy, too hot or windy the pesticides would be spread on the environment. The frequency of spraying. CVS is susceptible to pests and diseases. The farmers sprayed regularly every 3 d to 4 d. However, the frequency of spraying is becoming more when there is attack. The farmers would spray every 1 d to 2 d, or twice in a day. The start and end of pesticides spraying during plantation related to residue on the products and environments, especially on waiting period before harvesting. The minimum waiting periods are 7 d before harvesting [2]. Data showed that 76.3 % respondents started to apply the pesticides on CVS at the age of 7 d. Pesticides not recommended for plants less than 7 d age. There were only 23.3 % respondents who sprayed on CVS at the age younger than 7 d. (see table 6). The application of pesticides must be ended at 7 d before harvest. Yet only two respondents (6.6 %) stopped their pesticides spraying. There were 28 respondents (93.3 %) which is spraying the pesticides in an uncertain time, they still sprayed pesticide on the CVS at the harvest time. Sprayed pesticides should be discontinued shortly few days before harvest which is called waiting period. The waiting period is expected to reduce residues in the product and environment, so the risk of pesticides toxic can be derived. (table 7)

Table 6. The first application

Timing	Total	%
7 d after plantation	23	76.6
3 d to 5 d after plantation	7	23.3
Total	**30**	**100**

Table 7. Ended pesticides application cefore harvest

Timing	Total	%
7 d before harvest	2	6.6
Uncertain (depend on the attack) While harvest sprayed the pesticides	28	93.3
Total	**30**	**100**

The right method of application

The right method of application consists of the right method application of the form and PPE. There are many form of pesticide such as emulsible concreate, wettable powder, soluble concentrate, granule etc. The form of pesticides has diffferent application. Emulsible concreate, wettable powder, soluble concentrate must be applied by spraying, but granule applied by sowing. There were two respondents (6.6 %) who applied methods incorrectly by applying granule furadan 3G by spraying instead of sowing. All respondents always sprayed in the same direction with the wind, not during the rain, not in hot and strong wind condition. Right method makes the use of pestiside effective and efficient. (see table 8)

Table 8. Right form application

Pestiside	Form	Right form application
Demolish 18EC	Emulsible Concentrate	Sprays
Marshal 200EC	Emulsible Concentrate	Sprays
Confidor 5WP	Wettable Powder	Sprays
Antracol 70WP	Wettable Powder	Sprays
Agronil 75WP	Wettable Powder	Sprays
Acrobat 50WP	Wettable Powder	Sprays
Curacron 500EC	Emulsible Concentrate	Sprays
Regent 50SC	Soluble Concentrate	Sprays
Dithane–M45 80WP	Wettable Powder	Sprays
Furadan 3G	**Granul**	Sprays **(not appropriate)**
Score 250EC	Emulsible Concentrate	Sprays
Antila 80WP	Wettable Powder	Sprays
Prevathon 50SC	Soluble Concentrate	Sprays

PPE must be worn by farmers in applying pesticides. PPE required to reduce contact between farmers and chemical pesticides so the risk of poisoning can be reduced. Most of respondents did not use personal protective equipment when spraying pesticides (66.6 %). (table 9)

Table 9. Use of PPE

Using PPE	Total	%
Yes (mask, personal protective clothing)	2	6.6
Never	20	66.6
Rarely	8	26.6
Total	**30**	**100**

Point of entry of pesticides exposure are from the absorption of skin, inhalation and ingestioan. Using PPE can limit the toxic of pesticede. PPE must be use on the first contact to pesticide. Personal protective clothing, mask used by only two respondents (6.6 %), there were 20 (66.6 %) respondents never used PPE. PPE is expected to reduce the risk of poisoning among farmers either acute or chronic poisoning. Farmers are often reluctant to use PPE. The research on the farmers from Ghana showed that only 25.7 % respondents wore dresses that covered their whole body without goggles [(14)]. PPE indicate not comfortable for hot and humid climate [(15)] so farmers didnt wear the PPE.

Pesticides accumulated in the body and cause health problems. Acute exposure can cause death, whereas chronic exposure can cause reproductive problems, increase risk of cancer, damage the nervous system and immune function [(16)], diverse alterations of the digestive, neurological, respiratory, circulatory, dermatological, renal, and

reproductive system [17]. Some pesticides Organo Phosphat (OP) broke the children effect like effecrs on children's speed of attention, sequencing, mental flexibility, visual search, concept formation, and conceptual [18, 19].

Pesticides soil residues and CVS residues

Improper use of pesticides can leave chemical residues in the environment. Agricultural land often contains residues of pesticides because of continuous spraying pesticides on crops. Since the growing season lasts throughout the year, it is very possible that pesticide residues contaminate the soil. If the pesticide chemical residue contaminated the soil, it will degrade the quality of the soil and make pollution. Soil contamination by pesticides chemicals can be harmful to other environment. Run off can brought the pesticides into the soil so that it can contaminate ground water and surface water. Further accumulation of pesticides can poison for other environment. The soil samples were analysed to find the level of pesticides contents; abamectin, carbofuran, carbosulfan, chorantaniliprole, difenoconazol, dimetamorf, fipronil, imidacloprid, profenofos which cannot be detected (< 0.025 mg kg^{-1}). Like wise, the CVS samples also showed that the level of abamectin, carbofuran, carbosulfan, chorantaniliprole, difenoconazol, dimetamorf, fipronil, Imidacloprid, profenofos cannot be detected (< 0.01 mg kg^{-1}). Their residues were less than Indonesia`s minimum residues Levels (MRLs). Although residues in the soil and CVS were not detected but it did not mean there is no residue left on thesoil and CVS. Data showed that the respondents in the research applied pesticides on the right terget of plantation, but not in the right dose, right timing or usage or right method of application. The behaviour of pesticides application probably leave the residues on the soil and CVS. Pesticides residues often detected on soil samples, water, vegetables etc [20, 21]. The movement of pesticides residues in soil depends on many factors such as the characteristic of chemicals, weather, type of soil, ground water flow, leaching etc. Pesticide can degrade the environment by temperature, volatilization photodecompotion [22] and microbe activities. It can be dangerous if the pesticide residues flow through with leachate and run off and go to the non target places like river, surface water, lake etc. All respondents applicated the pesticides with sprayers. The spraying method may potentially spread the pesticides through the air and finished on the non terget places. So when there were no residues in the soil and the CVS, it could be an attention that residues can be left on other non target organism. Applied pesticides can reach the non target population. When pesticides applied in agricultural land not in the right way, it can affected the structure and function of non terget population at lower doses for longer time spans [23]. There were genetic changes because of intensive application of insecticides [24]. CVS is the family of cucurbitaceae. The cucurbitaceae is a vine which cover the soil surface from pesticides. It probably blocks the residues of pesticides to get into the soil. The CVS rind is thick, it is probably the cause of pestiside residues become undetected. Samples were taken in the high rainfall intensity which enabled the residues come out from the environment.

Conclusions

There were 13 pesticides that applied to CVS. The behaviour of the farmers, associated with 5R principles, showed that all the respondents did the first "R" (right target of pest), but not the other 4 "R" (right target of plant, right dose, right application timing and usage, right method of application). Pesticides residues in the soil and CVS were not detected (< 0.025 mg kg^{-1}), (< 0.01 mg kg^{-1}). It is possible that pesticide residues had moved to other environment.

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