# Criteria of pesticide selection in shallot pest-disease control in Brebes Regency, Central Java

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**Abstract.** Farmers' socio-economics, beliefs, perceptions, and attitudes affect their behavior toward pesticides. This study was aimed at identifying criteria considered by shallot farmers in selecting and using pesticides. A survey of shallot pesticide-use was carried out in Brebes, Central Java. Data were collected by interviewing 75 respondents that was proportiona-tely and randomly selected from three villages in Brebes. By using factor analysis, four components are extracted and they account for 65.15% of the total explained variation. The rank of importance of selection criteria is "financial and accessibility criteria" (FA-1st), "performance, knowledge and information criteria" (PK-2nd), "safety and environmental criteria" (SE-3rd), and "technical and operational criteria" (TO-4th). Farmers with higher education prefer more PK, FA and TO criteria for pesticide-use. Farmers with land size of 1,001 - 2,000 $m^2$ prefer more PK and FA criteria. Farmers who put attention to pesticide active ingredients and pesticide movement in the plants show a tendency to prefer to PK and TO criteria more than farmers who do not. Farmers who have participated in IPM training tend to consider all of the four criteria when selecting and using pesticides. The findings provide useful information for improving extension programs related to safe and appropriate pesticide use.

## 1 Introduction

In tropical countries, such as Indonesia, prevailing high temperature and high humidity are very conducive to pest and disease development that has frequently caused a significant crop loss [1, 2]. Moreover, climate change has impacted pest and disease both directly and indirectly [3, 4], with its negative impacts surpassing the positive ones. Due to climate changes, it is almost certain that farmers will confront more pest problems in the coming years.

In response to reduce shallot yield losses by the pest/disease attacks, farmers in Brebes depend heavily on pesticides as the main pest management strategy. They view pesticide use as the best means to protect their crops against pest/disease as such pesticides can provide

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the only form of crop insurance available [5-10]. Worldwide experiences suggest that pesticides have taken a significant part in viably improving crop yield and quality [11-14]. However, their potentials of generating negative externalities were also high mostly because of their intensive and extensive use [15,16]. These externalities include the threat of pesticide exposure to farmer's health [17-19], the contamination of pesticide residue to food safety [20-22], and the degradation and deterioration of ecosystem and environment [23-27]. The double-edge of pesticide use insists farmers to continuously equip themselves with pesticide related knowledge for being able to wisely select pesticides that have minimum externalities.

Even though some alternative non-pesticide control strategies continue to be developed, farmers are still heavily depending on pesticides [2, 27, 28]. Pesticides have been perceived as the most efficient tool for not only managing pests/diseases, but also for increasing crop yield [29]. These perceptions seem to have motivated shallot farmers in Brebes for continuing to use pesticides, even leading to overuse of them. Nonetheless, there is very little evidence with regards to the pattern of pesticide use either for various pests or crops [30- 32]. Overuse or excessive use of pesticides carried out by Brebes shallot farmers is probably intended to control a wide range of pest organisms and deal with pests' pesticide resistance and the simplifications in the production system (mono-cropping and decrease of natural enemies) that cause imbalances in the agricultural ecosystems [33,34]. In practice, farmers even have different perceptions about the benefits and hazards of pesticides and consequently they choose or select pesticides based on different variables and criteria [35- 37]. Therefore, understanding the behavioral drivers of farmers' pesticide use is indispensable to promote and design the campaign of pesticide safe behavior [38, 39].

The effectiveness or efficacy of pesticides in controlling pest/disease is usually considered by farmers as one of important criteria in selecting and using pesticides [2, 8, 35, 40, 41]. Shallot farmers in Brebes tend to keep using or to apply in higher quantity if the effectiveness of a pesticide satisfies them. Once farmers think that a pesticide is starting to reduce its effectiveness, there are two possible actions most likely taken by them. First possibility is that farmers will try to improve its effectiveness by using it in higher dosage or shortening its spraying interval. Second possibility is that farmers will completely replace this particular pesticide with another one [42]. Reduced effectiveness or ineffectiveness of a pesticide in controlling key pest/disease will most likely change the pattern of pesticide use. Lack of information and knowledge may lead to inappropriate pesticide selection that will result in an unsuccessful pest control and crop failure [43- 45].

Farmers with more knowledge and information are more likely to have higher levels of risk perception regarding the harmful effects of pesticides. Several behavioral studies on farmers' pesticide handling have shown that unsafe use of pesticides is quite common in developing countries [46-51]. Even though, farmers are sufficiently aware of pesticides' harmful effects to human and environment, they still do not show a significant change in their pest control practices, and often tend to adopt risky behavior as yet. This anomaly is mainly linked to the poor knowledge and understanding related to safe practices of pesticide use [44, 52-55]. Therefore, it is important to first improve knowledge on proper pesticide use among farmers as knowledge can influence attitudes and in turn their perceptions.

Various socio-economic variables may affect farmers' decisions in choosing pest control products. In this case, one factor that needs to be carefully considered is the price of pesticides and the costs to acquire them. As in other crops, shallot smallholder farmers in Brebes will be mostly concerned to the cost of inputs that they have to spend. For two insecticide products that have the same active ingredients, farmers may prefer to purchase the cheaper one with the expectation of no less efficacy than the more expensive one. Hence, product affordability and accessibility should also be considered important in influencing farmers to choose pesticides [27,56]. In Indonesia, despite the government and non-governmental organizations initiatives to promote non-chemical control methods as alternatives to chemical pesticides, their development is yet to take off in a significant way. Farmers are reluctant to adopt these methods because they are too technical and often impractical to apply [57]. Due to these reasons, the option of using pesticides tends to be more interesting to farmers since pesticides are more easily handled and applied. Hence, other criteria that should be taken into account in farmers' pesticide selection are the technical and operational aspects. The objective of the present paper is to explore the importance of pesticide selection criteria and to identify its differences among shallot farmers in Brebes.

## 2 Materials and methods

Brebes Regency, Central Java Province was selected as the study location. This area was the biggest shallot producing region contributing about 30-35% of total shallot production in Indonesia. Brebes is also considered as one of vegetable production center in which pesticides are allegedly overused, or even misused. Eighty (80) shallot farmer respondents were selected from in Wanasari District (26 farmers from Klampok Village, 34 farmers from Sidamulya Village) and Losari District (20 farmers from Prapag Kidul Village). After sorting the questionnaires, five of them were dropped then further analysis involved the remaining 75 shallot-farmer respondents. The sample selection followed a multi-stage sampling method to draw representative survey respondents. First, two districts, Wanasari and Losari were selected as these two districts contribute for more than 40% of shallot production in Brebes Regency. Second, a total of three villages were randomly selected from those two districts to reflect potential differences in pesticide-use in shallot cultivation. Finally, shallot farmers (landholders) from those three villages were randomly selected. A standardized questionnaire was used as a survey instrument. The survey carried out in May-August 2021 was administered by five trained interviewers and closely supervised and checked by the principal investigator.

A questionnaire was structured to cover the topic of (i) respondent socio-economic characteristics, (ii) farm characteristics, (iii) pesticides used in shallots, and (iv) farmers' knowledge and attitude towards pesticides and pesticide-use. Some relevant literatures were referred to initially identify criteria items that farmers may consider in selecting and using a pesticide product [2, 7, 29, 30, 41, 45, 46, 47, 51, 53], which then reviewed in research team discussions. Furthermore, a questionnaire testing was carried out involving 15 farmers out of the sample. All pre-tested farmers were asked to provide feedbacks mainly with regards to their understanding about all items in the questionnaire. Based on their feedbacks, the questionnaire was revised so that it would be more easily responded by farmers during formal survey. The questionnaire was designed to contain open-ended, closed-ended and Likert-scale questions. A five-point Likert-scale (from 1 = never to 5 = always; or from 1 = very disagree to 5 = very agree) was used to quantify the responses of respondents.

Descriptive statistics (frequency distributions, percentages, means, and standard deviations) were calculated. Factor analysis was used to reduce 19 criteria items into a more manageable criteria level. Significant differences and rank of importance among extracted factor were examined by using the Friedman's test. In the case of dichotomous socio-demographic variables, statistically significant differences regarding farmers' criteria were assessed with the t-test. In the case of variables measured in interval scale, statistically significance differences regarding farmers' criteria were tested by using one-way ANOVA. When employing parametric analysis, ordinal data were required to be converted into interval data first. The data were entered and analyzed using the Statistical Package for Social Sciences (SPSS Version 25.0, SPSS Inc., Chicago, IL, USA). A level of significance at $p < 0.05$ and $p < 0.10$ were used for all statistical tests.

# 3 Results and discussions

## 3.1 Results

### *3.1.1 Respondent's characteristics*

Table 1 presents that respondents were mainly between the ages of 41–60 years (61.4%), followed by the ages of 28-40 years (22.7%). Most of the respondents had attended Elementary school (58.7%), followed by High School (16.0%) and Middle school (13.3%). About 8.0% of respondents did not have education background at all. Nearly half of respondents (48%) had 16-30 years of experience in cultivating shallots, while one-third of them had 2-15 years of experience. About 59% of respondents used mostly one person of monthly paid permanent labor. Family labor as many as one person was used by 58.67% of respondents.

One-third of respondents had off-farm income (livestock, construction, trader, transportation, retired government official). The average proportion was on-farm income (69.8%) and off-farm income (30.2%). A majority of respondents (94.6%) were registered member of farmer-group. The average land-holding size was 2,792.5 $m^2$, but most of the respondents (46.7%) held about 1,000 – 2.000 $m^2$. Only 18.7% of respondents cultivated their own land, while 69.3% of them worked on rented land, and the rest of respondents grew shallots on lands that were both owned and rented. More than half (52.0%) of the respondents planted shallots 3 times a year and 40% of them cultivated shallots 2 times a year. There were few of respondents grew shallots just 1 time/year (5.3%) or 4 times a year (2.7%). About 56.0% of respondent received loans for working capital and Bank was the most common source of money lending (76.2%).

**Table 1.** Characteristics of respondents.

| | | **Frequency** | **Percentages** |
|---|---|---|---|
| Age (year) | 28-40 | 17 | 22.7 |
| | 41-50 | 23 | 30.7 |
| | 51-60 | 23 | 30.7 |
| | 61-70 | 9 | 12.0 |
| | >71 | 3 | 4.0 |
| Education Level | No school | 6 | 8.0 |
| | Elementary | 44 | 58.7 |
| | Middle School | 10 | 13.3 |
| | High School | 12 | 16.0 |
| | College | 3 | 4.0 |
| | No school | 6 | 8.0 |
| Experience in shallot cultivation (year) | 2-15 | 23 | 30.7 |
| | 16-30 | 36 | 48.0 |
| | 31-45 | 11 | 14.7 |
| | 46-60 | 5 | 6.7 |
| Use monthly paid permanent labor | Yes | 44 | 58.67 |
| | No | 31 | 41.33 |
| Use of family labor | Yes | 52 | 69.33 |
| | No | 23 | 30.67 |
| Number of family labor | 1 | 37 | 71.15 |
| | 2 | 15 | 28.85 |
| Off-farm income | Yes | 29 | 38.7 |

| | | | |
|---|---|---|---|
| | No | 46 | 61.3 |
| | | **Frequency** | **Percentages** |
| Join farmer-groups | Yes | 71 | 94.6 |
| | No | 4 | 5.4 |
| Land size ($m^2$) | 812.5-1000 | 12 | 16.0 |
| | 1001-2000 | 35 | 46.7 |
| | 2001-3000 | 7 | 9.3 |
| | 3001-4000 | 9 | 12.0 |
| | 4001-5000 | 5 | 6.7 |
| | >5001 | 7 | 9.3 |
| Land tenure | owned | 14 | 18.7 |
| | rented | 52 | 69.3 |
| | owned & rented | 9 | 12.0 |
| Number of plantings per year | 1 x | 4 | 5.3 |
| | 2 x | 30 | 40.0 |
| | 3 x | 39 | 52.0 |
| | 4 x | 2 | 2.7 |
| Receive loans for working capital | Yes | 42 | 56.0 |
| | No | 33 | 44.0 |
| Source of loans | Lenders | 2 | 4.8 |
| | Bank | 32 | 76.2 |
| | Family | 6 | 14.3 |
| | Cooperatives | 2 | 4.8 |

### *3.1.2 Pests and diseases, and pestiicde use in shallot*

**Table 2.** Ranks of importance of pest/disease infestation during wet and dry season as perceived by farmers

| **Pests and diseases** | | **Wet season** | | **Dry season** | |
|---|---|---|---|---|---|
| ***Scientific name*** | **Local name** | **Value** | **Rank** | **Value** | **Rank** |
| *Agrotis ipsilon* | Ulat tanah | 2.02667 | XI | 2.74667 | IX |
| *Gryllotalpa* sp. | Anjing tanah/orong[2] | 3.12000 | IV | 3.49333 | V |
| *Holotrichia sp.* | Uret | 1.66667 | XIV | 2.44000 | X |
| *Spodoptera exigua* | Ulat grayak eksigua | 2.45333 | V | 4.42667 | I |
| *Spodoptera litura* | Ulat grayak litura | 2.36000 | VI | 4.32000 | II |
| *Spodoptera mauritia* | Ulat grayak mauritia | 2.18667 | IX | 3.97333 | III |
| *Spodoptera exempta* | Ulat grayak eksemta | 2.17333 | X | 4.01333 | IV |
| *Thrips tabaci* | Trips | 1.93333 | XII | 3.42667 | VII |
| *Neotoxoptera sp.* | Kutu daun | 1.81333 | XIII | 3.37333 | VIII |
| *Liriomyza chinensis* | Lalat pengorok daun/grandong/inul | 2.32000 | VII | 3.46667 | VI |
| *Fusarium* sp. | Layu fusarium/moler | 4.56000 | I | 2.34667 | XI |
| *Xanthomonas sp* | Kresek | 4.24000 | III | 2.09333 | XII |
| *Colletotrichum* spp. | Busuk daun antraknos/otomatis | 4.34667 | II | 2.04000 | XIV |
| *Alternaria porrii* | Bercak ungu/trotol | 4.12000 | IV | 2.01333 | XV |

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As shown in Table 2, farmers mentioned *Fusarium* sp., *Colletotrichum* sp., and *Xanthomonas* sp., as the three most important diseases during rainy season, followed by *Peronospora destructor* and *Alternaria porrii*. Meanwhile during dry season, the three pests considered as the most important were *Spodoptera* sp., *Gryllotalpa* sp., and *Liriomyza chinensis*, followed by *Thrips tabaci*, *Neotoxoptera sp*., and *Agrotis ipsilon*.

Farmers were also asked what pesticides did they use to control the above listed pests and diseases. It is a common practice that farmers used a pesticide product to control several pests/diseases. For example, a contact and stomach poison insecticide X (Abamectin) recommended for controlling *Spodoptera exigua*, was used to control 11 other pests/diseases. Insecticide Y recommended for controlling *Helicoverpa armigera* in tomatoes was used for all listed shallot pests and diseases. This might suggest that (a) farmers did not consider the principle of “appropriate target” and “appropriate type of pesticides” as important, and (b) pesticides were most likely used in mixtures. Survey had recorded a quite varied use of pesticides: 20 fungicide products (15 Active Ingredients, and 10 Mode of Action), 43 insecticide products (24 Active Ingredients, and 11 Mode of Action), and 2 herbicide products.

Pesticides are defined as any substance or mixture of substances intended for destroying, preventing or controlling crop pests and diseases. Excessive and misuse of pesticides will cause damage to public health and ecosystem. Giving the importance to public health, World Health Organization (WHO) classifies pesticides according to their toxicity or hazardous effects. Table 3 showed that farmers applied 70% of class U fungicides imposing very low health risk. Farmers applied higher percentage of moderately hazardous insecticides (60.5%) than in fungicides (25.0%). More than 20% of highly hazardous insecticides (Ib class) were used by farmers. This implied that the use of insecticides might impose higher health risk than fungicides.

**Table 3.** Pesticide used by shallot farmers in Brebes based on WHO toxicity classifications

| | | **Fungicide** | | **Insecticide** | |
|---|---|---|---|---|---|
| | | ∑ | **%** | ∑ | **%** |
| Ia | Extremely hazardous | - | - | - | - |
| Ib | Highly hazardous | - | - | 9 | 20.9 |
| II | Moderately hazardous | 5 | 25.0 | 26 | 60.5 |
| III | Slightly hazardous | 1 | 5.0 | 2 | 4.7 |
| U | Unlikely to present acute hazard | 14 | 70.0 | 6 | 14.0 |
| | | 20 | 100.0 | 43 | 100.0 |

More than half of respondents purchased pesticides with cash. Almost four-fifth of respondents (78.7%) stated that they never purchased pesticides by installments. Two-third of respondents (66.7%) never paid for pesticides after harvest. Most of respondents carried out pesticide spraying in the morning. Half of them suggested that they also had experience to spray pesticides in the afternoon. In average, first spraying was applied 9.4 days after planting while the last spraying was carried out 52.8 days after planting (assuming shallots were harvested in 60 days). Spraying pesticides 3 times a week was the most often frequency carried out by respondents, followed by 2 times a week. Nearly two-third of respondents 58.7 % always used manual knapsack sprayer and 29.3% of them used battery knapsack sprayer. Farmers mostly used brass nozzle for their sprayer. It was recommended that this type of nozzle should be replaced every three months of usage. Only 9.3% of respondents followed this recommendation. Majority of respondents (81.3%) just replaced the nozzle after it was broken.

Knowing what is in the pesticide products (Active Ingredients = AI) and how do they work (Mode of Action = MoA), not only makes you a better user/consumer, it also makes you better able to plan your pesticide spraying schedule. When farmers carried out pesticide-use rotation, especially based on MoA, farmers stood a much better chance in reducing development of resistant pests in the fields. Survey indicated that when using pesticides, more than two-third of respondents paid attention to pesticide AI (70.7%) and how pesticide moved in plants – systemic, contact, translaminar (70.7%). More than half of respondents (58.7%) paid attention to how the insecticides/fungicides worked on the target – MoA (disturbing breathing, damaging the stomach, damaging the nervous system, etc.). Respondents alternated the use of pesticides based on AI (56%) and based on MoA (46.7%).

### *3.1.3 Criteria for pesticide selection of shallot farmers in Brebes*

**Table 4.** Pesticide selection criteria grouping used by shallot farmers in Brebes

| **Performance, knowledge, and information criteria *(Eigenvalue:* 7.359*; % of variance:* 38.730*)*** | **Factor Loading** | **Mean** | **Rank** |
|---|---|---|---|
| Choose pesticides that have proven to have a good efficacy | 0.777 | 4.6000 | 1 |
| Choose pesticides that can kill all pests or diseases | 0.772 | 3.8000 | 14 |
| Choose pesticides that only kill the targeted pests or diseases | 0.724 | 3.6933 | 15 |
| Choose pesticides that can kill pests or diseases in several different crops | 0.708 | 3.9467 | 11 |
| Choose pesticides that can quickly kill pests and diseases | 0.667 | 4.1467 | 8 |
| Choose pesticides based on knowledge, experience and popularity | 0.639 | 4.3600 | 5 |
| Choose pesticides based on other farmers' recommendations | 0.603 | 3.6400 | 16 |
| Choose pesticides whose last spray are closer to harvesting time | 0.602 | 3.6933 | 15 |
| **Safety and environmental criteria *(Eigenvalue:* 2.076*; % of variance:* 10.927*)*** | | | |
| Choose pesticides that decompose quickly | 0.870 | 3.9733 | 10 |
| Choose pesticides that have a low impact on environmental pollution | 0.869 | 3.8933 | 13 |
| Choose pesticides that do not cause pests & diseases to become resistant | 0.865 | 3.9333 | 12 |
| Choose low-risk pesticides when handling them | 0.572 | 3.9867 | 9 |
| **Financial and accessibility criteria *(Eigenvalue:* 1.530*; % of variance:* 8.051*)*** | | | |
| Choose pesticides that are legally registered | 0.708 | 4.4667 | 3 |
| Choose pesticides that are easily acquired | 0.659 | 4.5067 | 2 |
| Choose pesticides that are affordable | 0.617 | 4.4400 | 4 |
| Choose pesticides that have trustworthy branded | 0.607 | 4.4667 | 3 |
| **Technical and operational criteria *(Eigenvalue:* 1.414*; % of variance:* 7.442*)*** | | | |
| Choose pesticides that can be mixed with other pesticides | 0.589 | 4.3333 | 6 |
| Choose pesticides that are suitable for the sprayer used | 0.569 | 4.2667 | 7 |
| Choose pesticides whose solution preparation process is easy | 0.492 | 4.4000 | 4 |

The population correlation matrix was not an identity matrix as confirmed by the value of Bartlett's test of sphericity (859.810; $p < 0.01$). The Kaiser-Meyer-Olkin (KMO) of 0.795 suggested that the data were adequate for factor analysis (a value of 0.5 is generally acceptable). Factor loadings, means and rank of each criteria item was shown in Table 4. The 10 most important criteria were: pesticides that have proven to have a good efficacy (4.6000), pesticides that are easily acquired (4.5067), pesticides that are legally registered (4.4667), pesticides that have trustworthy branded (4.4667), pesticides that are affordable (4.4000), pesticides whose solution preparation process is easy (4.4000), pesticides based on knowledge, experience and popularity (4.3600), pesticides that can be mixed with other pesticides (4.3333), pesticides that are suitable for the sprayer used (4.2667), pesticides that can quickly kill pests and diseases (4.1467), low-risk pesticides when handling them (3.9867), and pesticides that decompose quickly (3.9733). Factor analysis extracted four components with eigenvalues greater than 1, which accounted for 65.15% of the total explained variation. Factor 1 termed as 'performance, knowledge and information criteria' consisted of eight items and explained 38.33% of the total variance, with an eigenvalue of 7.359. Factor 2 termed as 'safety and environmental criteria' consisted of four items that accounted for 10.93% of the total variance, with an eigenvalue of 2.08. Factor 3 labeled as 'financial and accessibility criteria' accounted for 8.05% of the total variance, with an eigenvalue of 1.53. Factor 4 termed as 'technical and operational criteria' accounted for 7.44% of the total variance, with an eigenvalue of 1.41.

Results of Friedman's test in Table 5 showed that factors being studied varied significantly ($p < 0.05$) and indicated that the ranks of those four extracted factors were not equal. Criteria perceived as the first important by shallot farmers in selecting pesticides were 'financial and accessibility criteria' (mean 4.50), then successively followed by 'performance, knowledge and information criteria' (mean 4.20), 'safety and environmental criteria' (mean 3.95), and 'technical and operational criteria' (mean 3.97).

**Table 5**. Rank of importance of pesticide selection criteria as perceived by shallot farmers.

| Criteria | Friedman Mean R. | Mean | Std. Dev. | Rank |
|---|---|---|---|---|
| Performance, knowledge and information criteria | 2.37 | 4.2017 | .43150 | 2 |
| Safety and environmental criteria | 2.25 | 3.9467 | .83655 | 3 |
| Financial and accessibility criteria | 3.39 | 4.5033 | .44739 | 1 |
| Technical and operational criteria | 1.99 | 3.9689 | .55662 | 4 |
| *n = 75, Chi-Square: 55.924, df – 3, Asymp. Sig: 0.000* | | | | |

Table 6 showed that there were no significant differences ($p < 0.05$) among age and experience groups with regards to all pesticide selection criteria. Farmers with college education (mean 3.7121) preferred 'performance, knowledge and information criteria' more than farmers with other education levels. Meanwhile, farmers who had high school education favored 'financial and accessibility criteria' (mean 3.3408) and 'technical and operational criteria' (mean 3.4182) more than those who had college, middle school, elementary and no-school educational background. Farmers who are sometimes and often involved in pesticide spraying tended to be less prefer to 'performance, knowledge and information criteria', 'financial and accessibility criteria' and 'technical and operational criteria' compared to farmers who were always carrying out the spraying (mean 3.2463; 3.1077; 3.0480). Except for 'technical and operational criteria', significant differences among different land size groups for the three other criteria were detected ($p < 0.01$). Farmers with land size of 812.5 - 1,000 $m^2$ (mean 3.6920) showed a tendency to prefer 'safety and environmental criteria' more than farmers with other land sizes. However, farmers with land size 1,001 - 2,000 $m^2$ (mean 3.1348; 3.1803) showed a tendency to prefer more to 'performance, knowledge and information criteria' and 'financial and accessibility criteria. Farmers with pesticide spending of IDR 17-25 million/ ha (mean 3.5100) favored 'performance, knowledge and information criteria', while those who spent IDR 5-8 million/ha (mean 3.3521) favored more on 'financial and accessibility criteria'. A significant difference among the planting frequency per year was detected ($p < 0.01$) only for 'financial and accessibility criteria'. Farmers who planted shallot once a year (mean 3.1428) tended to prefer ‘financial and accessibility criteria’ more than those who cultivated shallot two or three times a year.

**Table 6.** Effects of socio-demographics on pesticide selection criteria used by shallot farmers in Brebes.

| **Variable** | **Criteria (group)** | | | |
|---|---|---|---|---|
| | **Performance, knowledge, and information criteria** | **Safety and environmental criteria** | **Financial and accessibility criteria** | **Technical and operational criteria** |
| | **mean** | **mean** | **mean** | **mean** |
| Age (year) | | | | |
| 28-40 | 3.0222 | 3.1779 | 2.9864 | 2.9480 |
| 41-50 | 2.9155 | 3.4047 | 2.9152 | 2.9190 |
| 51-60 | 2.7887 | 3.4029 | 2.7731 | 2.6642 |
| 61-70 | 2.9197 | 3.5495 | 2.9122 | 3.0206 |
| >71 | 3.3364 | 4.1558 | 3.2513 | 3.3223 |
| F test | $0.704^{ns}$ | $1.14^{ns}$ | $0.52^{ns}$ | $1.18^{ns}$ |
| Education | | | | |
| No school | 3.3771 | 3.8895 | 3.3282 | 2.8014 |
| Elementary | 2.7641 | 3.3272 | 2.9271 | 2.7674 |
| Middle School | 2.4480 | 3.1354 | 2.2371 | 2.6219 |
| High School | 3.4466 | 3.6780 | 3.3408 | 3.4182 |
| College | 3.7121 | 3.2630 | 2.1142 | 3.2903 |
| F test | 9.20* | $1.41^{ns}$ | 8.21* | 3.59* |
| Experience (year) | | | | |
| 2-15 | 2.9591 | 3.1383 | 2.7330 | 2.7752 |
| 16-30 | 2.8819 | 3.4900 | 3.0300 | 2.9152 |
| 31-45 | 2.9822 | 3.5728 | 2.7703 | 2.8925 |
| 46-60 | 2.8494 | 3.5783 | 3.0297 | 3.0175 |
| F test | $0.13^{ns}$ | $1.31^{ns}$ | $1.24^{ns}$ | $0.31^{ns}$ |
| Involvement in spraying | | | | |
| sometimes | 2.3945 | 3.5010 | 2.4428 | 2.7471 |
| often | 2.4692 | 3.1574 | 2.6552 | 2.5976 |
| always | 3.2463 | 3.5165 | 3.1077 | 3.0480 |
| F test | 24.59* | $1.75^{ns}$ | 6.75 * | 4.29 * |
| Land size ($m^2$) | | | | |
| 812.5-1,000 | 3.0528 | 3.6290 | 2.8738 | 3.1660 |
| 1,001-2,000 | 3.1348 | 3.6064 | 3.1803 | 2.9239 |
| 2,001-3,000 | 2.4061 | 2.6274 | 2.0126 | 2.2887 |
| 3,001-4,000 | 2.9027 | 3.4948 | 2.7908 | 2.8285 |
| 4,001-5,000 | 2.8112 | 3.0870 | 2.7192 | 2.7526 |
| >5,001 | 2.2121 | 2.8519 | 2.7094 | 2.8732 |
| F test | 4.74* | 3.44* | 5.61 * | $1.83^{ns}$ |
| Pesticide costs (IDR) | | | | |
| 5-8 mill | 3.1919 | 3.9388 | 3.3521 | 3.0516 |
| 9-16 mill | 2.8256 | 3.3222 | 2.8223 | 2.8232 |
| 17-25 mill | 3.5100 | 3.7448 | 3.2936 | 3.2015 |
| F test | 5.31* | $2.11^{ns}$ | 3.14* | $1.39^{ns}$ |
| Frequency of planting/year | | | | |
| 1 time | 3.2079 | 3.5305 | 3.1428 | 2.9247 |
| 2 times | 2.9174 | 3.3253 | 3.0650 | 2.9337 |
| 3 times | 2.8741 | 3.4377 | 2.7373 | 2.8236 |
| F test | $0.752^{ns}$ | $0.26^{ns}$ | 2.81 * | $0.26^{ns}$ |

Table 7 shows that farmers who did not have off-farm income (mean 3.0920; 3.5706; 3.0409; 3.0467) tended to prefer all of the four criteria more as compared to those who did have. Participation in IPM training (mean 2.9911; 3.5112; 2.9277; 2.9834) turned out to be the determining factor that made farmers to consider all of the four criteria more than those who did not participate. Farmers who put attention to the pesticide active ingredients preferred to "performance, knowledge and information criteria" (means 2.9988) and 'technical and operational criteria' (means 2.9670) more than farmers who did not. Farmers who gave attention to the movement of pesticides in the plant tended to consider 'performance, knowledge and information criteria' (means 3.0485) and 'technical and operational criteria' (means 2.9965) more than farmers who did not give any attention.

**Table 7.** Effects of income, pesticide use and IPM training on pesticide selection criteria considered by shallot farmers in Brebes.

| **Variable** | **Criteria (group)** | | | |
|---|---|---|---|---|
| | **Performance, knowledge, and information criteria** | **Safety and environmental criteria** | **Financial and accessibility criteria** | **Technical and operational criteria** |
| | **mean** | **mean** | **mean** | **mean** |
| Off-farm income | | | | |
| Yes | 2.6423 | 3.1298 | 2.6787 | 2.6046 |
| No | 3.0920 | 3.5706 | 3.0409 | 3.0467 |
| t test | -3.258* | -2.464* | -2.463* | -3.047* |
| Participate in IPM training | | | | |
| Yes | 2.9911 | 3.5112 | 2.9277 | 2.9834 |
| No | 2.7630 | 3.3479 | 2.8438 | 2.8251 |
| t test | -2.502* | 2.844* | 2.526* | -2.991 * |
| Attention to Active Ingredient | | | | |
| Yes | 2.9988 | 3.4533 | 2.9327 | 2.9670 |
| No | 2.7238 | 3.2721 | 2.8242 | 2.6558 |
| t test | 1.778* | $0.915^{ns}$ | $0.665^{ns}$ | $1.936^{*}$ |
| Attention to pesticide movement in the plants | | | | |
| Yes | 3.0485 | 3.4835 | 2.9329 | 2.9965 |
| No | 2.6041 | 3.1995 | 2.8236 | 2.5849 |
| t test | 2.979* | $1.446^{ns}$ | $.670^{ns}$ | 2.612* |

## 3.2 Discussions

This study had identified four criteria i.e. performance, knowledge and information, safety and environmental, financial and accessibility and technical and operational as important choice indicators in selecting and using pesticides. Pesticide effectiveness or efficacy had been used by farmers as critical justification for pesticide selection and use as suggested by previous studies [35, 40, 41]. A pesticide would be intensively used (in high dose or in a longer period) if it was proven still effective in controlling pest/disease. It would be easily unselected or replaced when its effectiveness started to fade or disappear as perceived by farmers [42]. Farmers' knowledge and information would enhance their perceived pesticide effectiveness and keep them to use pesticide appropriately [43, 44]. Safety and environmental criteria may actually reflect farmers' concern on the harmful effects of pesticides to human health and environment. However, this awareness was rarely manifested in their actual field practice [46, 48, 50] mainly because of lack knowledge and understanding about safe and appropriate pesticide use [52, 54, 55]. This implied very urgent needs to improve farmers' knowledge which was expected to be able to change their attitudes and behavior in using pesticides. Land size of most shallot farmers in Brebes was between 1,000 $m^2$ and 2,000 $m^2$.

For such smallholder farmers, the cost of pesticides that may account for 10-20% of total production cost always be a concern for them. Motivated by financial gain, farmers regularly considered the price of pesticide very carefully when allocating their budget. This may also include the cost to access the available pesticides. These findings were in line with those of other studies suggesting that product affordability and accessibility were important criteria used by farmers to select and use pesticides [27, 56]. Technical and operational aspects of pesticide use usually became a problem for smallholder farmers to handle. In terms of pesticide use, smallholder farmers tended to prefer practicality instead of complexity even though they may be quite aware of the risks. The important of technical and operational criteria in choosing and using pesticides identified in this study were also suggested by another previous study [57].

As indicated by this study, financial and accessibility factor was considered by farmers as the first ranks pesticide selection criteria, followed by the criteria of performance, knowledge and information, safety and environmental, and technical and operational. Higher ranks of financial and accessibility criteria compared to performance, knowledge and information criteria seemed to indicate the actual reflection of Brebes shallot farmers' attitude towards pesticide selection and use. Even if a particular pesticide was known as very effective in controlling a certain pest or disease, when it was considered unaffordable farmers would not force themselves to purchase it. The significance of this issue was justified, especially for Brebes smallholder tenant farmers who had limited resources. The safety and environmental criteria that was ranked the third seemed to require further study because the fact that smallholder farmers' knowledge and understanding of pesticide harmful effects on the ecosystem, and the health of both farm families and consumers were generally quite low. Other studies suggested that even when farmers were aware of these harmful effects; their practices and attitudes towards pesticide use were not significantly change yet [41, 51]. The lowest ranks of technical and operational criteria suggested its lower importance in farmers' decision for choosing and using pesticides. Smallholder farmers with lack of knowledge in safe and appropriate use of pesticides often experienced difficulties to deal with the complex technology of pesticides. Consequently, they mostly relied on their own experience, tended to prefer practicality and common sense, and often ignored relevant criteria or recommendation of safer pesticide use.

Farmers with college education background tended to prefer more on the performance, knowledge and information criteria. This confirmed that higher education allowed them to be more selective in choosing the best performance pesticides and more open to accept new knowledge and information. Meanwhile, farmers who had high school education favored more on financial and accessibility criteria and technical and operational criteria also confirmed the role of education for farmers to better financially managed and had higher compliance to pesticide technical requirements and recommendations. Farmers who always carried out the spraying by themselves tended to prefer to performance, knowledge and information criteria, financial and accessibility criteria and technical and operational criteria more as compared to farmers who were not always carrying out the spraying. This suggested that direct and more experience of doing the job encouraged farmers to consider wider criteria so that they may decide to use pesticide products that were adequately effective, affordable, and easy to apply. Farmers with smaller landholding tended to favor all criteria more than those that cultivated a larger size of land. This finding was somewhat difficult to explain because it may contradict the general assumptions inherent for small-scale farmers, such as lack of knowledge and limited resources. A rather plausible argument was that because these small-scale farmers were confronted with a higher risk of meeting their family income, they had a stronger motivation to choose pesticides more carefully that could reduce their farm financial uncertainties. Farmers with bigger pesticide spending were more concerned to select more expensive pesticides expecting the best performance, while farmers with limited resources would consider more on pesticide affordability. Farmers' resources capability determined how many times they could grow shallot in a year. Therefore, it was easily understood that farmers who planted shallot once a year seemed to prefer more on financial and accessibility criteria than those who cultivated shallot two or three times a year. Farmers without off-farm income tended to prefer all of the four criteria more as compared to those with off-farm income. This may indicate that farmers with limited source of income decided to choose less costly, sufficiently effective and less toxic-hazardous and easily handled pesticides. The use of pesticides in IPM was based on the six "right" i.e. (1) right on pest/disease target, (2) right on quality, (3) right type of pesticide, (4) right time of application, (5) right dose or concentration, and (6) right method to apply. This may explain why the participation in IPM training had encouraged farmers to consider all of the four criteria more than those who did not participate. Identifying chemicals in a pesticide product that acted to control the pests and understanding how a pesticide moved, or did not move, in a plant were critical to pesticide selection and proper application. Farmers who put attention to these two important matters prefer to consider performance, knowledge and information criteria, and technical and operational criteria more than those who did not, in deciding which pesticide to choose and use.

Financial and accessibility and performance, knowledge and information were the two higher ranks criteria considered by farmers in selecting and using pesticides. At the farmers' level, pesticide prices were always considered as an important factor that drove farmers' decision in choosing purchased pesticides. Farmers who cultivated shallot in small size of land and confronted to ever-increasing production costs had made them more vulnerable to pesticide prices. Furthermore, farmers' pesticide selection was also directly affected by pesticide availability and marketing. The more pesticides were readily available and accessible, the more likely farmers will choose to use them. In the meantime, since farmers' objectives for using pesticides were not only to have a solution for pest/disease control, but also to increase farm yield, performance and effectiveness also became one of important factors that critically influenced their pest management strategy. Safety and environmental, and technical and operational were considered as the other two criteria that had lower ranks of importance. These implied the urgent needs to strengthen farmers' knowledge, skills and understanding concerning proper, safer and environmentally sound pesticide use.

## 4 Conclusions

Financial and accessibility criteria were considered as the most important factor by Brebes shallot farmers in selecting and using pesticides. This was followed by performance, knowledge and information criteria, safety and environmental criteria, and technical and operational criteria. Significant relationships between each of the four criteria and several farmers' socio-economic characteristic (education, land size, off-farm income, frequency of planting/year, involvement in spraying activity, pesticide spending, participation in IPM training, attention to pesticide active ingredient and movement in the plants) were also indicated. The study was expected to bring forth informative materials that would be useful for improving the comprehension of factors influencing farmers' pesticide decisions, strengthening extension program, and bringing relevant technical and operational supports of safer and appropriate use of pesticides.

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