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Farmers' perceptions and knowledge on chrysanthemum pests and its management in West Java, Indonesia

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Abstract. Sustainable pest management on greenhouse crops should be based on farmers' perspectives, obstacles, and technical knowledge. A survey of 41 farmer households that producing chrysanthemum was conducted to identify pest problems that were considered most important by farmers and identify knowledge of insecticides used in pest management. The respondents were chosen purposively based on easiness encountered in the greenhouse from the three districts of chrysanthemum production centers (Bogor, Cianjur, and Sukabumi) in West Java Province. The data were collected through group discussion techniques and individual interviews using a questionnaire and then analyzed by descriptive statistical methods. The results showed that among the pests, mostly farmers (90%) perceived that thrips were the main pest. Regarding to control pests, all farmers used insecticides thrice a week, and the most insecticide groups applied were avermectin, cyromazine, organophosphate, diafenthiuron, neonicotinoid, and pyrethroid. The determination of insecticides was based on farmers' own past experiences, other farmers' experiences, and suggestions from pesticide retailers. Even though the pesticides were implemented intensively, most farmers (78%) were unsatisfied with the effectiveness of control. Understanding farmers' knowledge dealing with pests and their impacts is baseline information to develop sustainable pest management on chrysanthemum under greenhouse conditions.

1. Introduction

The chrysanthemum cultivation in Indonesia is currently multiplying in several production centers, in particular, West Java, Central Java, East Java, North Sumatra, West Sumatra, South Sumatra, Lampung, Bali, and North Sulawesi, with the largest proportion in West Java [1][2]. The rapid growth of chrysanthemums in Indonesia is due to the favorable environment, appropriate natural resources, government support, and easy labor accessibility [3][4]. Nowadays, the production area of chrysanthemum for both cut flowers and potted plants occupies approximately 1,110 hectares of greenhouses [5]. Regardless of hobbies and people's needs, chrysanthemum production is also supported by a marketing system that allows consumers to get the desired variety at the right time. Moreover, herbivorous arthropods are the prime threats to chrysanthemum on greenhouses, as that is always in other monoculture crops [6][7]. Synthetic pesticides have been the primary choice for farmers to control chrysanthemum pests for years with calendar scheduled spraying, either single or mixed. It's performed as a preventive measure to minimize yield losses and keep high product quality. However,

overuse of pesticides has negative impacts for instance, pest population explosion, pest resistance, depletion of beneficial insects, environmental pollution, and residues on flowers [8][7]. Furthermore, it can also reduce farmers' profitability by increasing production costs, including the fee of pesticide, and labor for its utilization. Contrastingly, farmers are also fronted with a limited selection of pesticides with the most recent of active ingredients, environmental, and work safety regulations are stringent, and market demands for producing ornamental plants in a manner that meets for sustainable practices [8][9][10].

The sustainable control strategy in the ecological and economic context is one technique to reduce synthetic pesticides used in ornamental plants pest management [11]. Recently, the Indonesian Ministry of Agriculture has strongly recommended using integrated pest management (IPM) strategy as part of a good agricultural practice system for floriculture to be implemented by farmers [12]. However, farmer adoption of the control strategies is still slightly despite various attempts to stimulate chrysanthemum farmers [8]. Evidence indicates that practically farmers are still using pesticides to control insect pests by single and mixed insecticides with high dosages, scheduled spraying, and short term intervals. Since sustainable practices have become rules imposed by governments and laws; therefore, it's logical to perceived that farmers' knowledge and attitudes towards these methods will shift their pest control strategies. In several countries, besides being proven effective, sustainable pest control has also been able to reduce insecticide used up to 70% [9][12][13]. The success of sustainable pest control requires an understanding of the biology, ecology, and strategy to control target pests. Furthermore, information about the essential socio-economic attributes of farmers, knowledge, and ways to perceive pests, behavior, and pest management practices is needed. This information is a critical component that needs to be explored to strengthen the practical basis for developing IPM-oriented pest control and minimizing the use of synthetic pesticides [14][15].

The present research was conducted to identify the major pests of chrysanthemum considered essential by farmers and to elicit the knowledge of farmers on pest control practices in the West Java Province. The information of research could be the principle for developing integrated pest management strategies in chrysanthemum that are appropriate to farmers' needs and potential to be adopted.

2. Materials and method

The research was undertaken in three districts of highland chrysanthemum production centers in West Java Province, namely; Bogor, Cianjur, and Sukabumi Regencies. The research location units were determined purposively based on farmers easiness encountered in the greenhouse. Furthermore, respondents who planted chrysanthemums year-over-year were randomly selected, particularly regarding nine farmers in Bogor, 25 farmers in Cianjur, and seven farmers in Sukabumi Regency. Data were obtained using a questionnaire containing questions in the form of closed questions (multiple choices), open-ended answers questions, and a combination of open and closed questions through individual interviews and discussion groups.

Data were collected from 41 farmers, in particular basic demographic characteristics of farmers; identification of major pests; pest control strategies; pesticide types and formulation concentrations used; pesticide efficacy; pesticide sources of knowledge and information; pesticide measurements, application times and spraying intervals; and estimates of the percentage of crop by farmers. Specifically, for the question of identifying the primary pest of chrysanthemum, pictures of pests and symptoms of an attack are included which are shown to farmers to select the type of pest that is their main problem. The images of these pests are coded by A to F, respectively. Code A for aphids, B: thrips, C: spider mites, D: whitefly, E: leaf miners, and F: caterpillars. If the respondent farmer mentions a pest whose photo is not available, then it is recorded. Furthermore, additional information was gathered through direct observations and informal interviews with field officers. The information obtained from all questions were analyzed in tables using descriptive statistics to to determine the percentage of respondents who answered each question posed.

3. Results and discussion

3.1. Basic demographic characteristics of farmers

The basic demographic characteristics of farmers (Table 1) show the age range, education level, gender, farming experience, and greenhouse structure of those interviewed. The majority of chrysanthemum farmers surveyed were male (95%), and the age characterizes of 30 and 65 years, with an average of 45.95 years. Most of the farmers were in the age group 41-50 (36.59%) and 31- 40 (29.27%), with farming experience over five years (78%). The majority of farmers qualification surveyed were at the high school graduate level (48.78%), 12 % had undergraduate degrees, while 2.44% did not complete primary school, but were practically able to read or write. Most of the farmers (80.48%) cultivated chrysanthemum without greenhouse screens, while a few (19.52%) used it. The total land tenure ranges from 2000 to 15000 m^2 (on average 5593 m^2), and most of the farmers (68.29%) are a tenant. The majority of farmers have received education at various levels. These indicate that the higher a person's education, will faster to accept innovation. Furthermore, the majority of farmers have a fairly long farming experience of more than five years, so their ability to manage the farm is also really high. The education level ensures that connectivity between farmers and technology transfer is easy to accept. The adoption of innovative ideas is essential for developing sustainable pest management in chrysanthemum production [17][18].

3.2. The main pests of chrysanthemum according to farmers' perceptions

Based on a survey conducted on 41 farmers, most respondents (90.24%) determined thrips as the most destructive pest on chrysanthemums (Table 2). According to farmers, spider mites are second ranks after thrips, followed by leaf miners. The three types of pests appeared in every growing season and causing low to moderate damage. Regarding the infestation period, farmers generally explain that pests began to attack when the chrysanthemum was two weeks after planting. During the interview, farmers were asked to estimate the chrysanthemum losses due to pests. The farmers revealed that thrips caused severe damage and crop failure (31%), moderate (65%), or low (2%). Farmers also perceived that the presence of thrips causes a reduction in the quality and quantity of chrysanthemums. Thrips feed on flower petals, pistil, and flower stamens, then the affected portion turns brownish-yellow, blackening, and curling. The affected chrysanthemum turns brown, and the buds do not open completely. Besides, there are many punctures on the surface of the flower petals and cause characteristic features to reduce the selling price dramatically. Meanwhile, the leaf miner only attacks the leaves, so that the chrysanthemums are still be harvested even though the price get off. In line with [19][20], the main obstacle in chrysanthemum production is the presence of three major pests, such as thrips, leafminers, and spider mites. Several researchers [21][22][23] also state that thrips causing severe damage to chrysanthemum, either through feed directly, or indirectly by the virus it transmits, management of thrips is difficult because of its short life cycle, cryptic behavior, and high reproductive rate. In particular, the presence of thrips in chrysanthemum cut flowers could reduce the volume of exports as a result of hampered international trade [19].

3.3. Pest management practices

Based on an interview with the farmer, it has been shown that both the farmer in question used synthetic pesticides in the vegetative and in generative phases to suppress chrysanthemum pests. Farmers use more than 20 types of insecticides to suppress pests, most of which include: avermectin, neonicotinoid, organophosphate, cyromazine, diafenthiuron, and pyrethroid groups (Table 3). Based on farmers' answers, the most widely used insecticide was abamectin (41.85%). However, farmers differed on the efficacy of pesticides. The majority of farmers felt that even though the insecticide was applied intensively, the chrysanthemum pest had not been successfully controlled. It can be seen from the farmers' responses, who mostly (78%) expressed dissatisfaction with the results of the control.

Table 1. Basic demographic characteristics of the surveyed farmers

Farmers characteristics	No. of farmers	Percentage (%)
Education;		
Not graduated from elementary school	1	2.44
Elementary school graduate	9	21.95
Middle school graduate	6	14.63
High school graduate	20	48.78
University	4	12.20
Experience as chrysanthemum farmer (years)		
< 5	9	21.95
5-10	17	41.46
11-15	8	19.51
16-20	7	17.07
Age category (years)		
30	1	2.44
31– 40	12	29.27
41– 50	15	36.59
51– 60	12	29.27
> 60	1	2.44
Gender		
Males	39	95.12
Females	2	4.88
Greenhouse size (m^2)		
< 3000	9	21.95
3000 - 6000	21	51.22
6001 - 9000	5	12.20
9001 - 12000	3	7.32
>12000	3	7.32
Greenhouse structures		
With screens	8	19.52
Without screens	33	80.48
Land tenure		
Own farmland	8	19.51
Rental arrangement	28	68.29
Sharecropper	5	12.20

Table 2. Farmers' perceptions of the effect of main pest on chrysanthemum

Pests	The most damaging (%)	Perceived impact on chrysanthemum (%)		
		Low	Moderate	High
Aphids	0	87.80	12.20	0
Thrips	90.24	2.44	65.85	31.71
Spider mites	7.32	58.54	36.59	4.88
Whiteflies	0	73.17	26.83	0
Caterpillar	0	90.24	9.76	0
Leaf miner	2.44	58.54	39.02	2.44

Direct observations in the field also showed a high level of chrysanthemum damage when the insecticide was applied three times a week. Based on the interview, it was also revealed that dissatisfaction with insecticide spraying had encouraged most farmers to enhance insecticide concentration, switch insecticide types, increase spraying frequency, and take regular spraying on flowers (Table 4).

Table 3. List of active ingredients of insecticides used by farmers to protect chrysanthemum against arthropods pests

Active ingredients	Percentage (%)	Active ingredients	Percentage (%)
Avermectins		**Pyrethroids, Pyrethrins**	
Abamectin	41.85	Cypermethrin	3.51
Cyromazine		Lambda-cyhalothrin	1.60
Cyromazine	8.63	Fenpropathrin	0.64
Organophosphates		Deltamethrin	0.96
Chlorpyrifos	7.99	Betasiflutrin	0.32
Profenofos	2.24	**Diamides**	
Triazophos; deltamethrin	0.32	Chlorantraniliprol	2.56
Metidation	0.32	**Carbamates**	
Diafenthiuron		Carbosulfan	1.92
Diafenthiuron	7.67	**Pyridazinon**	
Neonicotinoids		Pyridaben	1.92
Imidacloprid	13.42	**Amidin**	
Dinotefuran	0.32	Amitraz	0.32
Pyrroles			
Chlorfenapyr	3.51		

Regarding to control pests on chrysanthemum, all respondents depend on synthetic pesticides. Pesticides application was started when chrysanthemum was a week after planted, before emerging of damage, to avoid the risk of injury and yield losses that arose. Risk-averse behavior is the general characteristic of most smallholder farmers [24]. Another factor that encourages risk aversion was the ongoing advertising and promotion by pesticide companies [25]. There are more than 20 types of pesticides used by farmers to control pests. But, the survey results do not determine with certainty the factors that influence farmers to choose a particular type of pesticide. It was estimated that the elements include price, level of effectiveness, availability, advertising, and promotion by pesticide distributors. From the many types of insecticides, the most use was abamectin, and its efficacy against thrips, spider mite, and leaf miner has been known [6][26]. Abamectin belongs to the avermectin group, which is a microbe metabolite (*Streptomyces avermitilis*), a translaminar trait, capable of regulating immature insects found in petals [8]. However, most farmers were dissatisfied with chemical control because it was not effective in minimizing pest attacks, and despite its higher costs, precisely led to increased use of pesticides. Considering that pest infestation remains high, farmers are more and more to respray it by changing the type of insecticide, mixing, and frequently in higher dosages. These experiences continued until the chrysanthemum harvest period. This is strengthened by some farmers' attitude of who assume that every pest attack shall reduce production quantity, quality, and price of chrysanthemum [8][13].

Farmers' dissatisfaction with insecticides application to control pest attacks has encouraged some farmers to quest and implement non-chemical control methods. The farmers revealed that non-chemical control methods, such as cultural, mechanical, and botanical insecticide methods could be implemented primarily throughout the vegetative phase (Table 5). Several farmers (7.32%) implemented cultural control with trap crops such as celery, basil, tomatoes, chinese mustard on the side of the bedding. Regarding mechanical control, farmers applied yellow sticky traps, handpicking, and removal of infected plants (17.07%). The yellow sticky traps had installed in the form of plastic sheet, and pesticide

bottles that were painted yellow. Besides, only a few farmers implemented botanical insecticides, such as mixing of garlic, neem, and intoxicating yam. Meanwhile, in the generative phase, only a few farmers used mechanical control (17.07 %) by installing yellow sticky traps. Most farmers showed that non-chemical control was difficult to implement during the generative phase, in order to reduce the risk of flower damage. In particular for botanical insecticide, besides being effective, it was also considered difficult to access and cause filthy flowers. The complexity of controlling chrysanthemum pests with pesticides, the finite availability of pesticides with new active ingredients, and the diminished purchasing capacity of farmers as the high price of pesticides were impassioned some farmers to perform non-chemical control. Implementation of non-chemical control not only reduce pest attacks but also minimize synthetic pesticides. Depend on the interviews, it was revealed that the installing of yellow sticky traps and the spraying of botanical pesticides was proved to reduce pest infestations in both the vegetative and generative phases. The combination of trap crops with yellow traps in greenhouses can prevent and reduce pests in main crops by 40% [8][13][16].

Table 4. Farmers' perceptions of pesticide efficacy

Questions	Variables	n	%
Pesticide efficacy	Satisfied	9	21.95
	Unsatisfied	32	78.05
Reason for unsatisfied	Type of insecticide inappropriate	3	7.32
	Low toxicant concentrations	2	4.88
	Inadequate spraying frequency	23	56.10
	Insects resistance	11	26.83
	Others	2	4.88
What are your actions if spraying results were not satisfactory	Change the class of insecticides	3	7.32
	Increase in concentration of insecticides	5	12.20
	Increase in the frequency of spraying	20	48.78
	Distinctive spraying/petals spraying	11	26.83
	Does not make changes	2	4.88

Table 5. Recorded types of pest control among the surveyed farmers

Methods in pest control	Vegetative phase		Generative phase	
	n	%	n	%
Cultural (bedding plants trap: celery, basil, tomatoes, chinese mustard)	3	7.32	0	0
Mechanical (yellow sticky traps, handpicking, removal of infected plants)	7	17.07	7	17.07
Botanical insecticide (mixing of garlic, neem, and intoxicating yam)	1	2.44	0	0
Chemical	30	73.17	34	82.93

3.4. Farmers' knowledge and behavior on pesticides

Related to control pests, farmers tend to depend on previous experience (41.46%) to determine the types of pesticides. Also, the information from other farmers (31.71%) and pesticide retailers (17.07%) are also used as a basis for selecting pesticides. Regarding controlling chrysanthemum pests, most farmers sprayed in the afternoon (63.41%) with a frequency thrice in a week (70.73%), even at 12% applied it five times in a week (Table 6). Depend on the interview, it was revealed that pesticide application is mostly initiated at 7-14 days (Figure 1) and continues till one day before harvest. Based on the average

of applications thrice in a week, the number of pesticide applications during a season of chrysanthemum growing was estimated to be close to 42 times. The majority of farmers mixed insecticides with fungicides (53.66%), and only a few (7.32%) single sprayed. Besides, most farmers used pesticide container caps to measure pesticides (58.54%), and 41.46% used measuring devices (glass or plastic cylinders measuring cup).

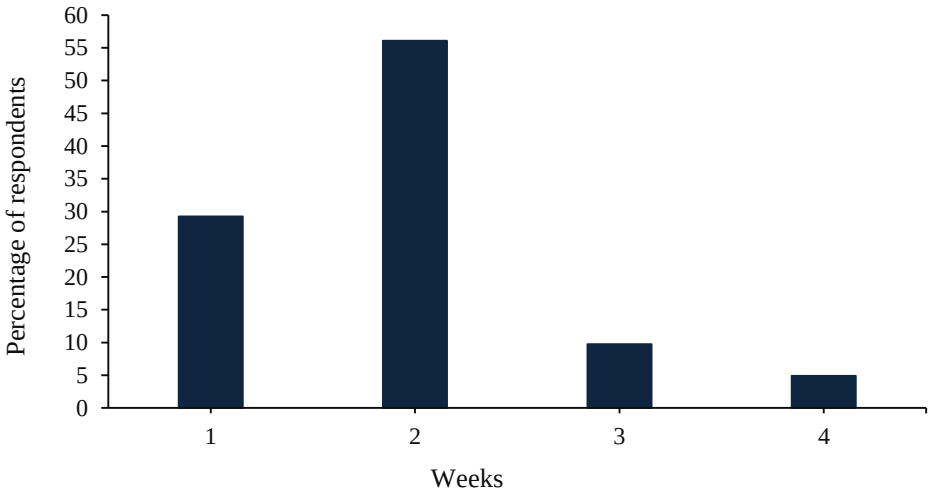

Figure 1. Farmer perception of the infestation period of chrysanthemum by arthropods pests

The results of this study indicated that most farmers know about pesticides based on previous experience. Meanwhile, to control arthropod pests, chrysanthemum farmers applied pesticides intensively, and most of them were sprayed in the afternoon to break pesticide evaporation [16][19]. For reasons of practicality, most farmers utilize a pesticide container cap to measure pesticides. This measuring instrument contributes to the inaccuracy of pesticide dosages so that its effectiveness was decreased. Also, chrysanthemum farmers also mix pesticides to control various arthropod pests that were found in greenhouses. By combining several pesticides, farmers could save the time of application, efficient and low cost compared to not mix. Pesticides incorporated also increase the effectiveness of pest control; however, there is no quantitative assessment to determine which combinations of two, three, or four pesticide mixtures were more effective [7][25].

All respondent farmers use personal protective equipment when applying pesticides, which shows a right attitude during pesticide handling. The protective gear often used is boots, headgear, trousers, long-sleeved clothing, and masks. However, none of the farmers wore gloves when spraying pesticides because they felt it was difficult at the application time. The reason for using personal protective equipment is to protect themselves from exposure to pesticides, although some farmers claim that they felt dizzy and nauseous after applying insecticides. The farmer then drinks milk and takes a break to treat the effects of pesticide exposure. Also, pesticide storage is also placed in safe places, such as warehouses (31%), greenhouses (39%), behind houses (14%), and particular storage areas (14%). The handling of empty pesticide containers is often done inside or next to greenhouses. Farmers generally throw empty containers with trash into landfills (75%), burn (14%), and some bury near vacant land (9%). All respondent farmers realized the need for personal protective equipment as a measure to avoid exposure to pesticides. However, the use of suitable personal protective equipment varies among people due to their attitude to the risk of poisoning and the lack of availability of funds or appropriate personal protective equipment. Farmers' practices, attitudes, and behavior towards the use, storage, and disposal of empty pesticide containers are essential factors for increasing safety during pesticide use [24][28].

Table 6. Farmers' knowledge and behavior of pesticides.

Questions	Variables	n	Percentage (%)
Sources of pesticides knowledge and information	Previous experience	17	41.46
	Other farmers	13	31.71
	Pesticide retailers	7	17.07
	Agricultural extension official	4	9.76
Time application of pesticides	In the morning	15	36.59
	In the afternoon	26	63.41
How to measure pesticides	Measuring device (glass or plastic cylinders)	17	41.46
	Pesticides container cap	24	58.54
	Approximate/pour directly	0	0.00
Frequency of insecticides application per week?	Twice	4	9.76
	Thrice	29	70.73
	Four times	3	7.32
	Five times	5	12.20
How do you apply insecticides?	Single application	3	7.32
	Mixing two or more insecticides	4	9.76
	Mixing insecticides and fungicides	22	53.66
	Mixing insecticides, fungicides, and fertilizer	12	29.27
Where do you store pesticides?	Warehouse	13	31.71
	Particular storage	6	14.63
	Greenhouse	16	39.02
	Behind the house	6	14.63
How do you handle empty pesticide containers?	Burning	6	14.63
	Throw to the garbage	31	75.61
	Burying	4	9.76
	Clean and reuse	0	0.00
	Disposal facility	0	0.00
What kind of personal protective equipment do you use?	Gloves	0	0.00
	Long-sleeved, trousers, hat	5	12.20
	Long-sleeved, trousers, hat, boots	15	36.59
	Long-sleeved, trousers, hat, boots, masks	21	51.22

4. Conclusion and recommendations

The main pests that were an obstacle for farmers in chrysanthemum production centers on West Java were thrips, spider mites, and leaf miners. As regards the control of these pests, the most widely used type of insecticide was abamectin from the avermectin group. Even though pesticides were applied intensively, most farmers (78%) were not satisfied with the control efficacy. Chemical pest management used by farmers was not a sustainable control strategy, both in an ecological and economic context. Understanding farmers' knowledge dealing with pests and their impacts is baseline information to develop sustainable pest management on chrysanthemum under greenhouse conditions. Consequently, it is essential to develop an integrated pest management approach as part of the good agricultural practices system for floriculture.

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