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Rural farmers' learning of weed management methods in Malaysia

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Malim Nawar in Kampar District, Malaysia, is a potential major production site for modern high-technology farms by 2030. To achieve this, a significant increase in intensive agricultural activities and weed management practices is required. To develop strategies and achieve the goals of sustainable agriculture, the present study used a semi-structured questionnaire survey to assess farmers' knowledge and perception of weeds, their sources of information, and their reasons for willingness or unwillingness to adopt non-chemical weed control methods. The survey was conducted from June to October 2018 and included 62 members of the Malim Nawar Vegetable Farmers Association. Descriptive and chi-square statistics were used for the statistical analyses. Of the 62 participants, 50 (80.6%) were over 50 years of age, and 47 (75.7%) spoke the Hakka dialect. Pest infestation and crop diseases were the most important constraints in crop production, followed by weed infestation. Knowledge of weed species led to the anticipation of yield loss and exploration of potential control methods. Social networking and agriculture chemical companies were the main sources of information on weed control methods. Despite knowing the harmful effects of chemical herbicides, farmers' willingness/resistance to adopt non-chemical weed control methods depended on many different factors. The survey results showed that the proactiveness of farmers' associations and relevant government agencies is a prerequisite for achieving agricultural development through education. Moreover, structure and systematic learning using innovative methods adjusted to local socioeconomic conditions could facilitate a paradigm shift from chemical control to environment-friendly weed control methods.

1. Introduction

Agriculture is the backbone of the industrial sector in many countries. In 2019, the contribution of agriculture to the GDP of Malaysia was 7.1%. Despite its small contribution to the economy, it is recognised as one of the most important sectors that provide food and employment to the rural inhabitants of Malaysia. In general, rural farming is a prominent feature of developing countries. For farmers, weeds can hinder crop yield as they compete with the crop for light, water, and nutrients, resulting in varying extents of yield loss depending on crop type (Gharde, Singh, Dubey, & Gupta, 2018). Therefore, weed management is critical for ensuring food security and environmental sustainability (Yaduraju & Rao, 2013).

Farmers have been learning weed control methods on a trial-and-error basis in Malaysia; however, their limited knowledge of weed control hinders the improve-

ment of methods, including traditional practices commonly used in agriculture (Obidike, 2011; Agahiu, Baiyeri, Ogbuji, & Udensi, 2012). Moreover, farmers' motivation to accept and incorporate new methods into their practices is greatly influenced by practical (i.e., costs and time), personal (i.e., needs and interests), and local factors (i.e., crops and climatic factors) (Franz, Piercy, Donaldson, & Richard, 2010; Šūmane et al., 2018).

Local socioeconomic factors play a role in information sharing and knowledge acquisition among rural farmers (Pratiwi & Suzuki, 2017; Zossou, Arouna, Diagne, & Agboh-Noameshie, 2019). When an increased number of farmers follow certain practices, it could inspire others within the area to do the same; on the contrary, low participation could discourage other farmers from implementing novel practices. Improving farmers' knowledge of agricultural practices is critical for achieving sustainable agriculture (Šūmane et al., 2018). Information accessibility is important for farmers' continuous learning to improve their practices (Franz et al., 2010; Abdullah, Samah, & Othman, 2012; Azman, D'Silva, Samah, Man, & Mohamed, 2013; Adnan, Md, Rahman, & Noor, 2017; Aku, Mshenga, Afari-Sefa, & Ochieng, 2018; Serebrennikov, Thorne, Kallas, & McCarthy, 2020).

Chemical control is the main weed management control method in Malaysia. Of the total 47,805 tonnes of pesticides used in 2019, 39,692 tonnes (83.0%) were herbicides (FAO, 2021). However, an increasing number of sustainability studies have explained the negative consequences of environmental hazards, food safety issues, and toxicity exposure. The development of herbicide-resistant weed species is one such consequence; there is a total of 263 herbicide-resistant weeds as of June 2021 (Heap, 2021). Herbicides can also affect non-target organisms, usually crops (Herrick, 2017). Studies have shown that herbicide residues in certain foods, such as fruits and vegetables, are major concerns among importing countries and consumers (Amjad, Ahmad, Iqbal, Nawaz, & Jahangir, 2013; Matt, Pehme, Peetsmann, Luik, & Meremäe, 2013). Additionally, the effects of toxicity resulting from herbicide exposure are continuously observed in terrestrial and aquatic organisms (Salvat, Roche, & Ramade, 2016; Diepens et al., 2017; Herrick, 2017) with increasing ecological risks. Therefore, improved weed control methods using non-chemical herbicides are required; however, their acceptability and applicability are highly dependent on the mindset of farmers regarding the adoption of new technologies. Providing this knowledge to policy makers and practitioners on the factors that hinder sustainable use of environment-friendly strategies could help overcome this obstacle.

The Kampar District in Perak, Malaysia, has approximately 67,980 ha, of which 33% is used for agricultural activities (Perak State Government, 2016). These areas were formerly tin mining areas, but gradually, they have been repurposed for agriculture and diverse uses, such as crop cultivation, aquaculture, and livestock practices (Table 1). Agriculture provides 44.5% of the local income (Kampar District Local Plan 2030, proposed by joint efforts of Kampar District Council, Perak Department of Town and Country Planning, and Peninsular Malaysia Department of Town and Country Planning in 2015). To maintain the economic importance of agriculture in the district, Malim Nawar is included in the agricultural planning to be the main agricultural site for vegetable crop cultivation and the development of modern high-technology farms by 2030. This agricultural planning is expected to result in the development of intensive agricultural activities and weed management practices. Providing information and knowledge to rural farmers is, therefore, essential for rural agricultural development as well as for maintaining productivity and achieving sustainability. However, farmer surveys have rarely been conducted in Malaysia. Few surveys have been carried out in a limited number of areas, and they only involved paddy farmers. They surveyed farmers' attitudes toward precision agriculture (Abdullah, et al., 2012), green fertilisers (Adnan, et al., 2017), sustainable agriculture (Abu Samah, D'Silva, Mohamed, Man, & Azman, 2012), and weedy rice (Dilipkumar, Ahmad-Hamdani, Rahim, Chuah, & Burgos, 2021).

Therefore, the present study attempted to fill the knowledge gap among vegetable farmers by assessing their perceptions and knowledge of weeds, sources of information, and reasons for willingness or unwillingness to adopt non-chemical control methods. The questionnaire used here can help policy makers and practitioners develop strategies to achieve the goals of sustainable agriculture.

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Table 1. Land use in Kampar District in 2014

Land use	Area (ha)	Percentage (%)
Forest area	36,484	54.5
Agriculture use	22,128	33.0
Urban development	4,577	6.8
Unused land	2,716	4.1
Water areas (e.g., rivers)	962	1.4
Recreation and park	130	0.2
Total	**66,997**	**100**

(Courtesy: Kampar District Local Plan 2030)

2. Materials and Methods

2.1. Study site and participants

The study was conducted in Malim Nawar, situated in Kampar District. Some members of a local farmers' organisation, called Malim Nawar Vegetable Farmers Association (official name in Malay: *Persatuan Pekebun Sayur Malim Nawar*), were recruited for this study. A total of 97 participants were randomly selected from the list. Farmers working on the same farm were excluded. The survey period was scheduled from June to October 2018 because of the non-responsiveness of some respondents and continued persuasion of some participants.

2.2. Sampling procedures

A three-section questionnaire was designed: Section (A) assessed participants' demographic information, Section (B) assessed their perceptions of weeds and constraints affecting crop production, and Section (C) assessed how they learned weed management practices. The semi-structured questionnaire surveys were conducted by face-to-face interviews so that the questionnaire could be explained to the farmers, and they could answer the questions reliably. The interviews were conducted in a familiar environment (e.g., coffee shops, farms), as suggested by the farmers. The answers provided by the participants were written on the sheets by the researcher because the respondents were not very confident in filling out the questionnaire themselves.

2.3. Statistical analysis

Statistical analyses included descriptive statistics and comparative chi-square tests (χ^2) using SPSS 20.0 to study the association between two variables. A *P*-value of < 0.05 was considered significant.

3. Results

3.1. Participants' demographic information

By the end of the survey period, data were collected from 62 of the 97 participants selected initially using convenience sampling. Among the remaining 35 selected participants, 30 refused to participate (most of them did not share their reason for refusal, while a few expressed that the survey questionnaire would not benefit them). The remaining five participants whose data were not collected were family members of the participants who were interviewed (i.e., father-son) or relatives who were also members of the association; they were randomly selected and subsequently excluded as they worked on the same farm as their family members who were already chosen to participate.

Of the 62 participants who were surveyed, 60 (96.8%) were male, and 2 (3.2%) were female (Table 2). There was a significant association between farmers and their backgrounds (grandparents and parents being farmers) ($\chi^2(1) = 13.18$, $P = 0.000$). The ages of the participants ranged from 20 to 70 years, and 27 (more than 40%) were above 70 years of age. Hakka was the most spoken dialect, followed by Cantonese. Only 3 (4.8%) participants had no formal education, while 37 (59.7%) had secondary school education, and only 2

(3.2%) had tertiary education. One-third of the surveyed farmers had more than 25 years of farming experience. Early dropping out of school was associated with many years of farming experience ($\chi^2(4) = 18.51$, $P = 0.001$).

3.2. Perceptions of weeds and constraints affecting crop production

More than 60% of the farmers considered pests and diseases as major constraints in crop production, followed by weeds (Fig. 1). Herbicides were the main control method used by the farmers. Half of the surveyed farmers agreed that soil fertility was a limiting factor in crop production; while others did not agree. Prolonged seasonal droughts or excessive rain was the main environmental constraint in crop production. Labour shortage due to the declining involvement of locals and foreigners was a cause of concern, whereas farm inputs such as agrochemicals were not a limiting factor if their prices were affordable.

3.3. Participants' perceptions of weeds

Two weed species—*Eleusine indica* and *Cyperus* spp.—were frequently mentioned as the most harmful weeds. The survey showed an association between farmers' knowledge of weed species and perceived economic losses by weeds ($\chi^2(4) = 16.40$, $P = 0.037$) (Table 3). The farmers opined that knowledge of weed species on farms was important, as it helped them select suitable herbicides (e.g., selective or broad-spectrum) for weed control. Moreover, identifying the weeds at an early stage helps remove seedlings before they mature into adult plants. On the contrary, some farmers argued that it was not necessary to learn about weed species to apply herbicides.

Furthermore, an association was found between knowledge of weed species and exploration of the potential uses of weeds ($\chi^2(4) = 20.15$, $P = 0.010$) (Table 4). Less than 10% of the queried farmers agreed that weeds could benefit crop production. Some farmers suggested certain benefits, such as nutrient release, soil improvement, and their function as cover crops. However, none of the farmers had strongly agreed to the potential benefits of weeds. Weed-crop competition, pest harbouring, and increased labour requirement for weeding owing to their root systems were the major disadvantages of weeds reported by the farmers. The farmers wanted to learn about certain weed species (i.e., *E. indica* and *Cyperus* spp.) to estimate yield losses and explore their potential benefits.

3.4. Perception of weed management learning

The relationship between knowledge of other farmers' weed management practices and knowledge of the said practices, particularly in Malim Nawar, was significant ($\chi^2(3) = 9.01$, $P = 0.029$) (Table 5). None of the participating farmers strongly disagreed with the benefits of learning other farmers' weed management practices. Farmers generally agreed that sharing information on weed management and learning new strategies from the experiences of other farmers are useful strategies for their own farming practices. However, the participating farmers claimed that the practices of farmers in their vicinity would not be different from their own practices. This was the reason most of them did not know about the practices of other farmers in Malim Nawar, although they admitted the importance of such knowledge. They had knowledge of the practices of some farmers outside of Malim Nawar.

Furthermore, the survey demonstrated correlations between farmers' resistance to learning about non-chemical control methods and the reasons behind this attitude (Table 6). A total of 47.8% of the participants stated that "chemical herbicides are harmful to the environment" and that they did not want to learn about non-chemical weed control measures; 39.1% stated that "chemical herbicides are harmful to consumers", that "some weeds became herbicide-resistant", and that they did not want to learn about non-chemical weed control measures; 34.8% of the participants who stated that chemical herbicides are harmful to farmers and workers also stated that they did not want to learn about non-chemical weed control measures. These results showed that despite being aware of the harmful effects of herbicides, the farmers were sceptical of using non-chemical control methods. The reasons behind this resistance and scepticism included possible high costs, the time needed to learn and practice using non-chemical control methods, and the perceived high efficiency of herbicides.

Information on weed management practices was obtained from formal and informal sources. The formal

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sources included the association, government agencies, workshops, civil society, and agrochemical companies, whereas the informal sources were friends of the participating farmers. Both agrochemical companies (64.5%) and informal sources (64.5%) were equally important sources of information on weed control practices (Table 7). Workshops and seminars were not popular options for obtaining this information. Moreover, all farmers had access to at least one of these sources of information.

Table 2. Characteristics of the participants recruited in our survey

Characters	**N (%)**
Gender	
Female	2 (3.2)
Male	60 (96.8)
Age (years)	
20–30	1 (1.6)
31–40	4 (6.5)
41–50	7 (11.3)
51–60	7 (11.3)
61–70	16 (25.8)
>70 years	27 (43.5)
Speaking dialect	
Hakka	47 (75.7)
Cantonese	7 (11.3)
Others (Teochew, Hokkien)	8 (13)
Level of education	
No formal education	3 (4.8)
Primary education	20 (32.3)
Secondary school (SRP/PMR)*	13 (21.0)
Secondary school (SPM/SPMV)**	24 (38.7)
College degree	2 (3.2)
Years of farming experience	
1–5	8 (12.9)
6–10	11 (17.7)
11–15	9 (14.5)
16–20	12 (19.4)
21–25	1 (1.6)
>25 years	21 (33.9)

*SRP/PMR – Sijil Rendah Pelajaran (SRP) and Penilaian Menengah Rendah (PMR) are public examinations for Form Three students in Malaysia. PMR was formerly known as SRP.

**SPM/SPMV – Sijil Pelajaran Malaysia (SPM) and Sijil Pelajaran Malaysia Vokasional (SPMV) for Form Five students in Malaysia.

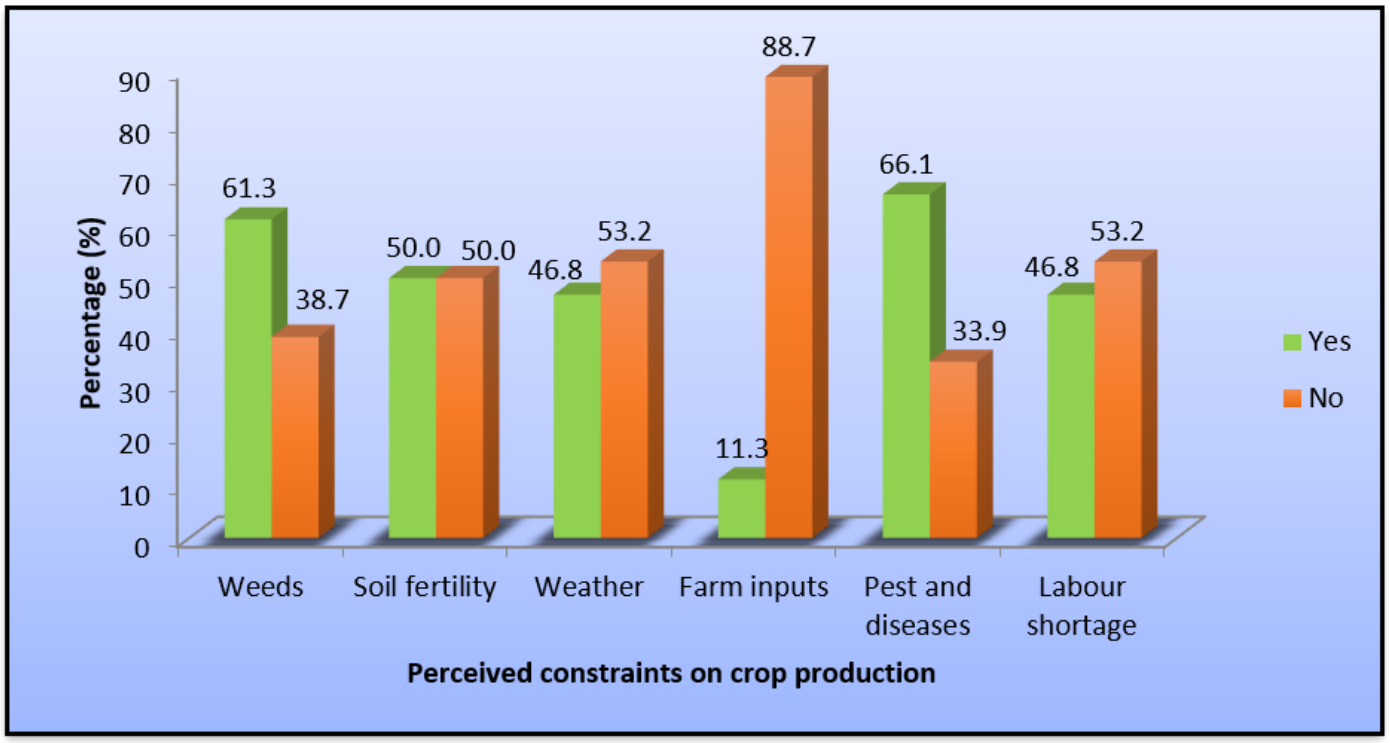

Figure 1. Perceptions of constraints affecting crop production.

Table 3. Association between perceived economic loss by weeds and the importance of knowledge of weed species

Perceived economic loss	Is knowledge of weed species important?				Chi-square (χ^2) value, *P*-value
	Yes	No	NA	Total	
Very high	11	2	2	15	$\chi^2(4) = 16.40$, $P = 0.037$
High	17	5	5	27	
Medium	7	2	2	11	
Low	1	5	1	7	
Very low	-	2	-	2	

Note: NA - No answers

Table 4. Association between the importance of knowledge of weed species and potential benefits of weeds

Weed could be beneficial	Is knowledge of weed species important?				Chi-square (χ^2) value, *P*-value
	Yes	No	NA	Total	
Agree	5	1	-	6	$\chi^2(4) = 20.15$, $P = 0.010$
Neutral	4	7	-	11	
Disagree	16	5	9	30	
Strongly disagree	10	3	-	13	
NA	1	-	1	2	

Note: NA - No answers

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Table 5. Benefits of sharing information on weed management practices

Is knowledge of how other farmers control weeds important?	Knowledge of other farmers' weed management practices in Malim Nawar			Chi-square (χ^2) value, *P*-value
	Yes	No	Total	
Strongly agree	4	4	8	
Agree	14	12	26	$\chi^2(3) = 9.01$, $P = 0.029$
Neutral	4	22	26	
Disagree	-	2	2	

Note: NA - No answers

Table 6. Attitudes toward chemical herbicides and learning non-chemical control methods

No.	Reason		Do you want to learn non-chemical weed control?				Chi-square (χ^2) value, *P*-value
			Yes	No	NA	Total	
1	Chemical herbicides are harmful to the environment	Yes	11	-	-	11	$\chi^2(2) = 22.66$, $P = 0.000$
		No	12	25	14	51	
2	Chemical herbicides are harmful to consumers	Yes	9	-	-	9	$\chi^2(2) = 17.85$, $P = 0.000$
		No	14	25	14	53	
3	Chemical herbicides are harmful to farmers and workers	Yes		18		8	$\chi^2(2) = 15.58$, $P = 0.000$
		No	15	25	14	54	
4	Some weeds can become herbicide-resistant	Yes	9			9	$\chi^2(2) = 17.85$, $P = 0.000$
		No	14	25	14	53	
5	Chemical herbicides are convenient	Yes		18		19	$\chi^2(2) = 33.92$, $P = 0.000$
		No	23	7	13	43	
6	Chemical herbicides are cost-effective	Yes		17	1	18	$\chi^2(2) = 31.09$, $P = 0.000$
		No	23	8	13	44	
7	Other methods are less effective than chemical herbicides	Yes		6		6	$\chi^2(2) = 9.83$, $P = 0.007$
		No	23	19	14	56	

Note: NA – no answers

Table 7. Sources of information and knowledge on weed management practices

Sources of information	Number of farmers (%)
Malim Nawar Vegetable Farmer Association	24 (38.7)
Workshops and seminars	0 (0)
Government agencies	15 (24.2)
Civil society	3 (0.05)
Friends	40 (64.5)
Agrochemical companies	40 (64.5)
No access	0 (0)

4. Discussion

Agriculture is the main economic activity in Malim Nawar. Farmers in this area are registered with the Malim Nawar Vegetable Farmers Association (official name in Malay: *Persatuan Pekebun Sayur Malim Nawar*), established on November 23, 1992. The mandates of the association are as follows:

- To strengthen networking among farmers,
- To share information and exchange experiences on agricultural practices,
- To contribute to Malaysia's agricultural development, and
- To safeguard the association's members' benefits.

Though the number of registered members has increased over the years, the membership list has not been updated (i.e., deceased members and members who have left farming are still on the list), which is the first challenge for an updated member list. Moreover, there are no specific guidelines to obtain membership in this association—entrepreneurs in aquaculture and oil palm growers were both accepted. This led to the continued addition of new members, resulting in a total of 218 members. Additionally, 123 out of 218 members (56.4%) had registered their names with the association but with no contact details. The actual number of members is unknown, which may have caused a bias in sample selection. In addition, in the present study, there were some limitations related to respondents' literacy levels. Some farmers did not understand the questions even after receiving an explanation or did not know the answer (e.g., scientific names of weed species).

Among the challenges in continuing agricultural activities is the ageing farmer community in Malim Nawar, where 50 (80.6%) farmers in our cohort were over 50 years old, with an average life span of 74.5 years (Department of Statistics, 2019). A similar trend has been reported in the paddy sector, where the average farmers' age was above 50 years old (Alam, Siwar, Murad, Molla, & Toriman, 2010; Abdullah, et al., 2012; Omar, Shaharudin, & Tumin, 2019). This low involvement of the younger generations represents a continuous issue in Malaysia's agriculture. Young people are not interested to work in the agriculture sector even though they have positive perceptions of agriculture (Abdullah, Ahmad, & Ismail, 2012).

Male farmers are the dominant workforce in Malim Nawar. Their wives are housewives and are only occasional assistants on farms, mostly during harvesting. This is different from paddy planting, where both women and men are involved in farming, from planting to harvesting. For paddy farmers in Malaysia, their farming experience correlates to their age; the elder the age of the farmers, the more is their experience (i.e., number of years) in farming (Dilipkumar et al., 2021).

The findings of the present study are similar to those of Serebrennikov et al. (2020) and Dilipkumar et al. (2021), who showed that the adoption of new practices depends on farmers' age and education level. It was observed that old farmers with low education levels were more resistant than their younger and more educated counterparts. Elsewhere in Malaysia, aged smallholder farmers of paddy, rubber, and oil palm plantations also lack of technical knowledge and support in improving weed management practices (Dilipkumar, Chua, Goh, & Sahid, 2020; Dilipkumar et al., 2021). The key reasons for their resistance were the possible risks of implementing new practices, including uncertainty in yield and increased cost. This scepticism was in contrast to their trust in herbicide efficiency.

Pests and diseases were perceived as more severe constraints than weeds in crop production. Similar findings were reported in a farmer survey in Africa (Laizer, Chacha, & Ndakidemi, 2019). According to the farmers interviewed in the present study, insect populations can increase dramatically depending on the weather. On dry and hot days, *Thrips palmi, Tetranychus urticae, Polyphagotarsonemus latus, and Empoasca fabae* were prevalent, whereas *Helicoverpa armigera, Maruca vitrata, Maruca testulalis,* and *Plutella xylostella* were prevalent in the rainy season. Herbicides were considered more effective in controlling weeds than pesticides in controlling insects and diseases, which is why pests and diseases were more harmful. Farmers used pre-emergence (before planting) and post-emergence herbicides (after planting); however, they did not have relevant knowledge of weed control methods, including active ingredients and their modes of action. They showed exten-

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sive interest in 'effective' herbicides without necessarily knowing the components. Furthermore, negative psychological perceptions were the major obstacles to learning and accepting environment-friendly control methods.

Agricultural education plays a pivotal role in addressing the sustainability goals of rural farmers (Anderson, 1984; Chittoor & Mishra, 2012). Information sources play an important role in knowledge dissemination, as information accessibility and quality determine the adoption of sustainable agricultural practices (Rodriguez, Molnar, Fazio, Sydnor, & Lowe, 2008; Serebrennikov et al., 2020). Although various knowledge sources could complement each other, government agricultural programmes could be the most influential change agent (Rodriguez, et al., 2008), for example, courses and seminars could be used to enhance farmers' knowledge (Ismail, 1995; Samah, D'Silva, Mohamed, Man, & Azman, 2012). If information sources are scarce, this could limit the exposure to new methods and hinder learning. Although television programmes related to agriculture do not provide sufficient information, they were the only information source in some states, such as Kedah and Selangor (Ramli et al., 2013). The present study showed that television programmes were not a source of information in Malim Nawar. Instead, informal sources such as phone calls, farm visits, and social relations served as major information sources.

In addition to informal sources, the farmers also relied on information from agrochemical companies (i.e., a formal source). Farm visits by the representatives of agrochemical companies or organized talks for farmers were the main information dissemination strategies adopted by agrochemical companies. Farmers mainly attended presentations organized by agrochemical companies to learn about new products and application methods; other reasons included the meals provided by the companies and the opportunity to socialise. Although agrochemical companies are considered a formal source of knowledge, according to Šūmane et al. (2018), their role in information dissemination should be reviewed carefully, as they are profit-driven entities whose main goal is to meet their sale requirements and sell their products. Smallholders who sought advice from agrochemical retailers have used more pesticides in Cambodia, Laos, and Vietnam (Schreinemachers, et al., 2017).

5. Conclusion

The survey revealed that weed infestation is one of the most important agricultural constraints after pests and diseases in Malim Nawar. It demonstrated that knowledge of weed species assisted the anticipation of yield loss and exploration of potential control methods. Weed management is a continuous process in agricultural production, and accessibility to knowledge sources can strengthen farmers' expertise and experience. Social networking and agriculture chemical companies were the main sources of information on weed control methods. However, despite knowing the harmful effects of chemical herbicides, farmers' willingness to adopt non-chemical weed control methods is influenced by several factors. Information sources and quality are critical for encouraging farmers to adopt new weed control methods that could replace herbicides, which are currently used predominantly. New management programmes could build on current activities, such as farm visits and social relations, to disseminate information on eco-friendly weed management practices; local farmer organisations could be a good starting point. Farmer organisations are intermediaries between farmers and government agencies and are responsible for transferring quality information. Functions of the Malim Nawar Vegetable Farmer Association include promoting agricultural development and securing the well-being of the members. This farmer organisation and relevant government agencies could play a role in advancing weed management practices through knowledge transfer as their broad objectives are to spur sustainable agricultural growth and development. In collaboration with the Association, relevant government agencies should be proactive in farmer education through small discussion groups, demonstration plots, hands-on workshops, and on-farm demonstrations, as the government agricultural programmes could be the most influential change agent. Together, the study suggests that sequential capacity-building and educational programmes are catalysts of rural agricultural development. Innovative and localised methods that consider environmental sustainability and socioeconomic factors are needed to ensure progressive learning for farmers with mixed literacy and overcome resistance.

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Conflicts of Interest

The authors declare there are no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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