INTEGRATED WEED MANAGEMENT PROGRAMS AT OIL PALM PLANTATION -A SURVEY

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ABSTRACT

Weed control is always regarded as one of the essential operations in the oil palm plantation management. It is the second most costly operation after fertilising. Hence, it is vital to manage noxious weeds' growth in oil palm plantation areas effectively. Integrated weed management (IWM) refers to a system of sustainable weed management. This system is comprehensive through various control strategies that are undeniably capable of reducing the weeds' impact to reach economically acceptable levels. The most widely practiced IWM method by plantation companies has been mainly spraying herbicide and cultural practices; many companies are solely depending on the chemical approach for weed control. Our survey indicated that IWM methods always produced lower management costs than non-IWM in FGV Lepar Utara. This indicates that the implementation of IWM could save on weed control cost up to RM34.00/ha/year. Besides, the cultural practices like mulching (in immature palm) and EFB applications would reduce weeding cost-efficiently. In addition, the arrangement of fronds, circle raking would reduce weeding cost. Thus, the combination of chemical control and cultural practices was preferred. As a conclusion, it would be appropriate to argue that through IWM implementation, among others, weed populations will be reduced to manageable levels, in addition to the environmental impact that can be reduced significantly instead of adopting an individual weed management practice and reducing the occurrence of herbicide resistance in weed species.

Key words: integrated weed management, oil palm, weeds.

INTRODUCTION

In Malaysia, agriculture is an important industry. Malaysia widens and diversifies its economy through industrialisation; however, the agricultural sector continues to be the backbone of Malaysia's economy. The agriculture sector continued in 2015, expanding and contributing 8.9% to the gross domestic product. (Department of Statistics Malaysia, 2016). Integrated weed management (IWM) refers to the long term weed management through a combination of various management and control techniques (Thill et al., 1991). IWM supports optimisation as it allows company policies to tailor the system based on weed attributes that include ecology, density, and land-use. Physical, mechanical, chemical, biological and cultural or social control practices will be incorporated into integrated weed management techniques (Thill et al., 1991). IWM system does not encourage applying a single control measure, but instead combining all techniques, to support its effectiveness over the long term. Compared to simple weed managements or direct treatments that only reduce weed infestation, IWM, on the other hand, addresses the underlying causes of a weed infestation. In other words, IWM will be focusing on controlling weed at its root course. Through in-depth studies on weeds according to their stages of development, specific measures can be applied in an effort to prevent weed reproduction, besides, to reduce weed emergence, as well as promote seed bank depletion and minimise weed rivalry with desirable vegetation (Davies et al., 1990). These integrated systems will require in-depth research and are more demanding than simple chemical spraying methods, but planters will definitely enjoy fruitful rewards that are worth the effort. In the long-term, the IWM approach ultimately aims to develop a plan supporting effective and economical weed control, which does not provide unfavorable impacts on non-target plants and animals (Thill et al., 1991). Since IWM does not encourage the use of one type of control method over a specific time, herbicide resistance can be significantly reduced, which in turn will optimize plantation management.

INTEGRATED WEED MANAGEMENT

Integrated weed management (IWM) refers to the long term weed management through a combination of various management and control techniques (Thill *et al.*, 1991). An IWM supports optimization when it allows company policy to tailor the system based on weed attributes that include ecology, density and the land-use situation. Physical, mechanical, chemical, biological and cultural or social control practices will be incorporated into integrated weed management techniques (Thill *et al.*, 1991). IWM system does not encourage the application of a single control measure, instead of all techniques as mentioned earlier, to support its effectiveness over the long term. Compared to simple weed management or direct treatments that treat only weed infestation, IWM, on the other hand, addresses the underlying causes of a weed infestation. In other words, IWM will be focusing on controlling weed at its root course. Through in-depth studies on weeds according to their stages of development, specific measures can be applied in an effort

to prevent weed reproduction, in addition, to reduce weed emergence, as well as promote seed bank depletion and minimize weed rivalry with desirable vegetation (Davies *et al.*, 1990). In this strategy, legume species such as *Mucuna bracteata, Calapoginum mucunoides* and *Centrosema pubescens* are the primary choices. Cover crops increase the efficacy of nutrients by minimising soil erosion (less depletion of soil organic matter and soil nutrients in the topsoil). Residual nitrogen (N) scavengers, transforming N into proteins (enzymes, hormones, amino acids), are the cover crops. These integrated systems will surely require in-depth research and are more demanding than simple methods like chemical sparying but planters will definitely enjoy fruitful rewards which are worth the effort. In the long-term, the IWM approach ultimately aims to develop a plan that supports effective and economical weed control, which does not provide unfavourable impacts on non-target plants and animals (Thill *et al.*, 1991).

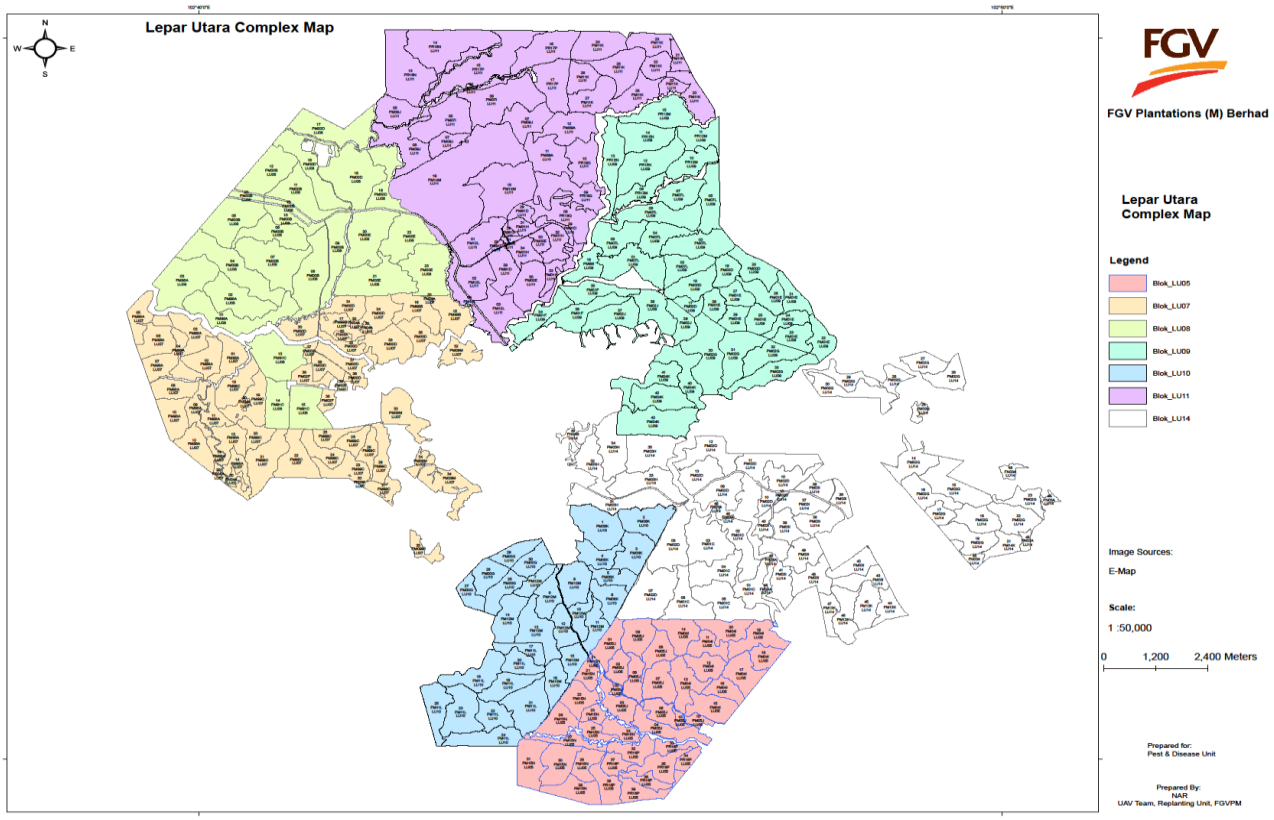
METHODOLOGY

The purpose of this survey was to measure current weed control practices, the implementation of Integrated Weed Management and the cost-efficiency and problems associated with IWM in selected FGV estates in Lepar Utara, Pahang. Prior to the survey, a set of questionnaire was thoroughly designed and subsequently reviewed by the General Manager of FGV and UPM. This was to ensure that the information requested was appropriate and accessible to the respondents and increase the likelihood that respondents will provide feedback as requested without having questions or concerns about how or why the information was requested, how it would be used, and how it would benefit them. The questionnaire was also designed to ensure seamless and quick execution, data transmission and interpretation by including multiple-choice answers, numeric response coding and drop-down numeric data transfer lists. The questionnaires, instructions for completion and details on the IWM project's objectives were written in Bahasa Melayu and English. The questionnaire was divided into four sections, comprising the plantation background, general knowledge on plantation issues and weeds, weed control methods and integrated weed management.

Location of Survey

The survey was commenced in FGV Plantations focusing on oil palm estates. (Figure 1).

Figure 1. Location of study



Respondents

The survey was performed by the visiting target respondents according to the techniques used by (Pitt and Miller, 1988). Respondents were contacted for approval and consent prior to the meeting. Respondents were interviewed during the visit, and the questionnaire was distributed to them. The interview was performed separately for the FGV plantation, including with the manager, the field supervisor and the mandore. A total of ten respondents from 6 estates were interviewed, as shown in Table 1.

Table 1. List of surveyed plantations in FGV plantation Jengka, Pahang

No	Estate	No of Respondents
1	Felda Lepar Utara 05	10
2	Felda Lepar Utara 07	10
3	Felda Lepar Utara 08	10
4	Felda Lepar Utara 09	10
5	Felda Lepar Utara 11	10
6	Felda Lepar Utara 14	10
TOTAL		**60**

Statistical Analysis

Interview forms were encoded using Microsoft Excel and analyzed using SPPS software version 11.5. To maintain homogeneity and minimize bias in condition and to interpret questionnaires and interviews, open-questions were regarding soil type, specific weeds and weed control strategies, coded according to the number of answers and interpreted as a percentage. Close-questions such as age, education and experience, on the other hand, were described as frequency.

Secondary Data Review

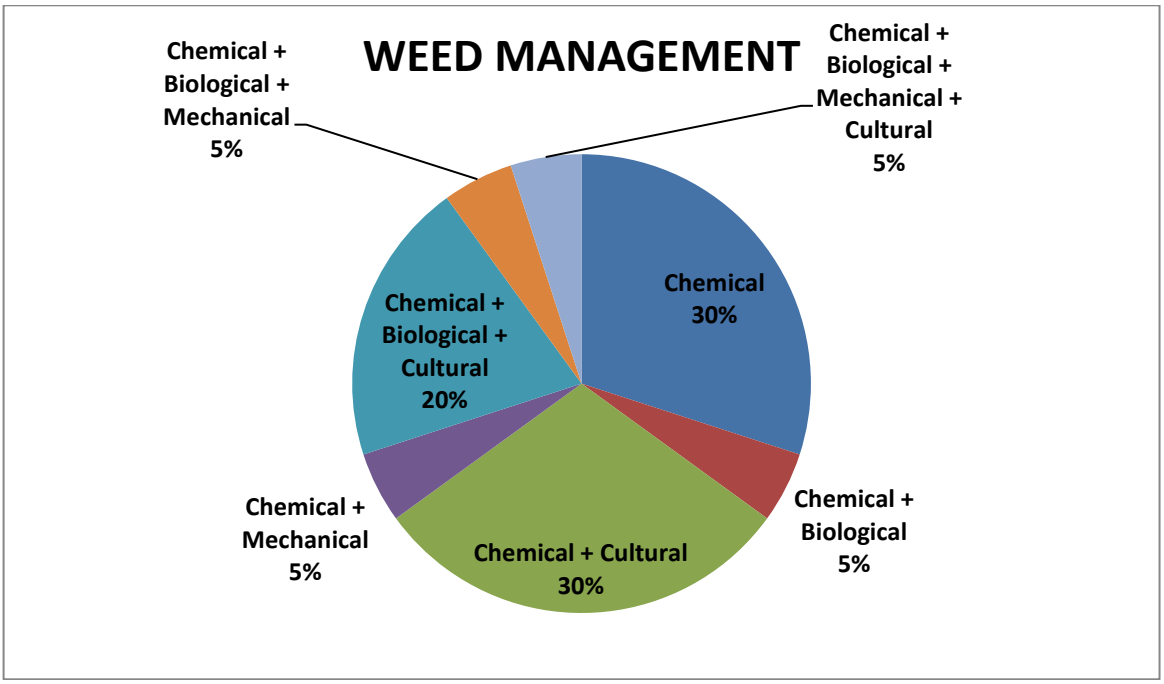
In order to further review the weed management programs for each chosen plantation, a quantification of secondary data have been carried out. Since 2005 onwards, all records on the weed management program from Felda Global Ventures Publication on weed control were compiled. Weed management programs were classified into two (2) types: a program consisting of integration elements and a herbicide-based program only. The data were quantified on the basis of:
a) Time and types of application (nursery/immature/mature oil palm) and types of weed control
b) Frequency, a period of use and sustainability (still being used or not)
c) Efficacy and cost-efficiency

RESULT AND DISCUSSION

Production of oil palm and rubber can be accomplished through various approaches to chemical, cultural, mechanical, and biological, excellent planting density, including herbicides, hand weeding, mulch, pasture, planting of cover crops, and mechanical grazing of livestock depending on the growth stage of the crops. (Malaysian Rubber Board, 2009; Chee and Chung 2016; Chung 2013).

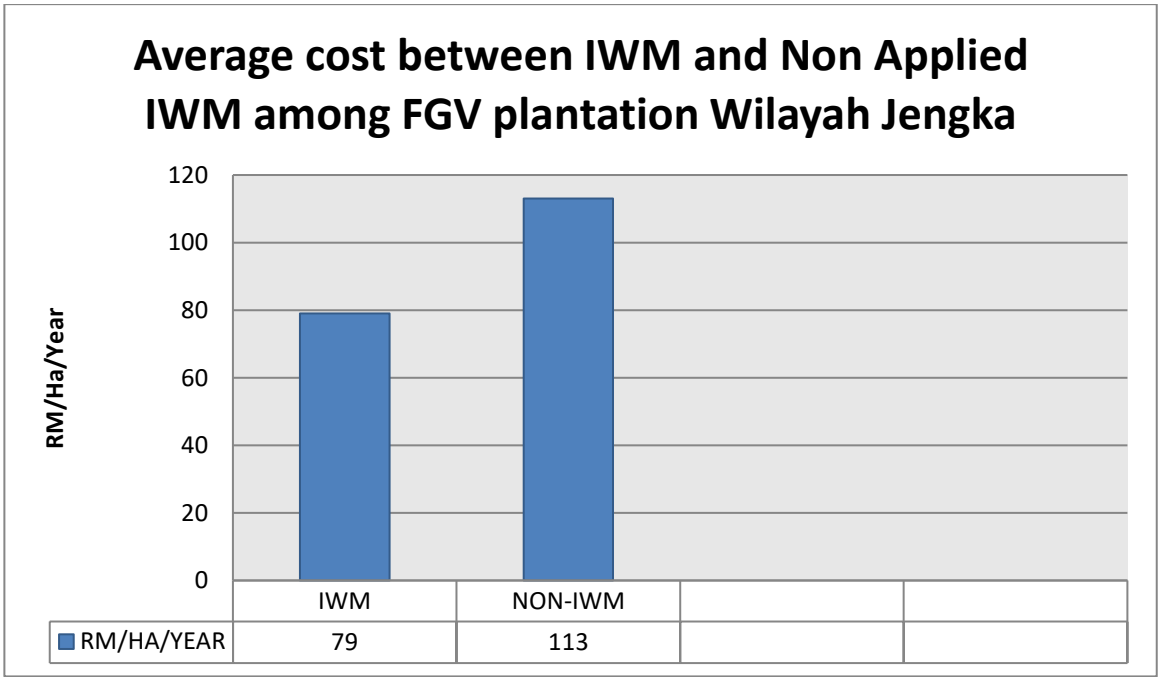
Figure 2 illustrates the methods of weed management employed by FGV Lepar Utara. Of all IWM methods, the combination of herbicide and cultural practices has been generally accepted and adopted, with 30% of the estates following this method. This involved covering crops to combat weeds; particularly in young oil palm plantation areas (less than three years old). This combination has been reported to be very successful in controlling several weed types. In this strategy, legume species such as *Mucuna bracteata*, *Calapogonium mucunoides* and *Centrosema pubescens* are the primary choices. Cover crops increase the efficacy of nutrients by minimising soil erosion (less depletion of soil organic matter and soil nutrients in the topsoil). Residual nitrogen (N) scavengers, transforming N into proteins (enzymes, hormones, amino acids), are the cover crops. In the spring, legumes accumulate nitrogen longer, but legume N fixation decreases with elevated soil N (Luna et al., 1996).

Figure 2. [Types of weed control method practiced by FGV Wilayah Jengka]



Besides, implementing IWM methods has also resulted in lower maintenance costs relative to non-IWM costs in FGV Plantations Wilayah Jengka (Figure 3).

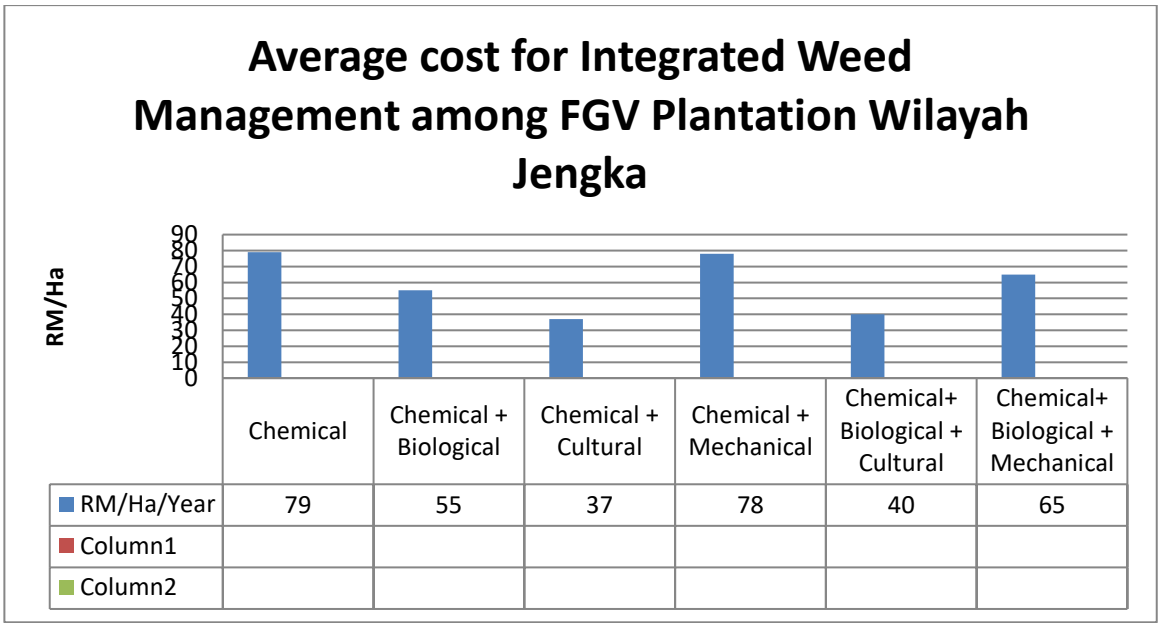
Figure 3. [The average cost between IWM and Non- IWM in FGVWilayah Jengka]



In total, irrespective of the combination implemented, the use of IWM by the FGV plantation in Lepar Utara yielded only RM79.00/ha/year in terms of weed control costs relative to RM113.00/ha/year when the herbicide was used alone (non-IWM). This suggests that the implementation of IWM will save up to 30% weeding cost @ RM34.00/ha/years. A thorough analysis of all weed control methods showed that combining chemical and cultural inputs yielded the lowest cost of RM37/Ha. It was followed by a combination of chemical, biological and control (RM40/ha). Next was a combination of chemical and biological (RM55/ha) and a combination of chemical, biological and mechanical RM65/ha. (Figure 4). The cost of herbicide was only RM79.00/ha/year.

Nevertheless, a combination of chemical and mechanical inputs often generated a substantial cost of RM78.00/ha/year, which led to a high labour cost in terms of wage.

Figure 4. [The average cost for integrated weed management among FGV plantation Wilayah Jengka]



Tough weeds in oil palm plantations like *Tetracera indica, Lantana camara, Solanum torvum, Dieffenbachia sp, Typhonium flagelliforme* and *Stenoclaena sp* are challenging to control merely by using chemical. Weeds infested oil palm and rubber plantations in Malaysia are usually coming from the same species (Asna and Ho, 2005). The widespread woody c*hromolaena odorata (L.) R.M.King & H.Rob., Oldenlandia verticillata L., and Melastoma malabathricum L.,* which the majority of tropical countries are found in (Husnatulyusra, 2012). Broadleaf weeds that crawl, such as *Mikania micrantha Kunth* and *A.gangetica* can decrease the production of palms (Asna and Ho, 2005; Husnatulyusra; 2012). Thus, a combination of cultural, physical, chemical and biological control is needed to eradicate it effectively. Example of cultural control is the use of empty fruit bunch for mulching and Felda Mulch. Felda Mulch is made of biodegradable material suggested for mulching during the early stage of replanting. The primary function of mulching is to conserve moisture and control weed growth in the palm circle area. Examples of chemical control are herbicide (glyphosate isopropylamine for grasses, metsulfuron methyl and triclopyr for broadleaf weed). In contrast, examples of biological controls are grazing animals (goat, sheep, and cow) and ground cover crops (*Mucuna bracteata*). Herbicides are also a relatively straightforward way to ensure quick and cost-effective weed control in the oil palm and industries. The use of chemical for a more extended period, will result in resistant weed populations and increase weeding costs. Thus, a combination of weed control methods is preferred. Besides, differential levels of tolerance between species have led to changes in weed succession. There is a need to develop integrated weed management systems in which herbicide still plays a key role.

For some instances, FGV Wilayah Jengka had to employ workers to slash woodies manually. The lowest expense was a combination of chemical and cultural control of RM37/ha. This was because chemical spray commonly used in oil palm plantations was cheaper, quicker and more effective. In addition, cultural practices such as mulching (in immature palms areas) and EFB and POME applications will minimise weeding cost-effectively. Loong et al., (1988) reported that 1 tonne of empty fruit bunches (EFB) contained nutrients equivalent to 15.3 kg of ammonium sulphate, 2.5 kg of CIRP, 18.8 kg of MOP and 4.7 Kieserite. Consumption of 40 tons of EFB per hectare as mulch is sufficient to supply nutrients throughout the year with a slight increase of nitrogen (N) and phosphorus (P) to balance nutrient needs. Loong et al. (1988) reported that EFB mulching has increased palm oil production. Besides, circle raking arrangements would reduce the cost of weeding. The combination of chemical and cultural inputs was, therefore, preferred. Nevertheless, this report concentrated solely on the annual cost of weed management and thus did not provide the initial cost of other strategies employed (e.g. livestock purchases, crop seed cover, sprayers and equipment, etc.) as this information was confidential. Integrated Weed Management (IWM) will help planters determine if weeds should be sprayed, helping them save money on herbicides. Almost all companies in Malaysia use herbicide as the primary weapon to control weeds. Besides, cover crops are used as a weapon to combat resistant weeds. Cultivation of legume cover crops in the early stages of development of oil palm plantations is aimed at enriching the organic matter in the soil and improving the status of nutrients, especially N. The return of N to the soil is estimated at up to 200-300 kg N/hectare (Tayeb, 1994). Besides, legume cover crops are also used to inhibit weed growth, control soil erosion and improve soil physical and chemical properties. A significant proportion of agricultural chemicals during 2014 (83 percent) of herbicide use was reported (FAOSTAT, 2017). Such data showed that Malaysian farmers depended excessively on this information without considering their effects on human health, herbicides climate.Nevertheless, the government has strengthened the public and customer awareness of the use of herbicides. Reducing herbicide reliance on weed control alone will also minimise the likelihood of developing weed tolerance to herbicides. Skipping spray operation often allows more herbicide versatilities with various modes of action, essential for herbicide rotations. Reduced selection of a single herbicide and improved herbicides rotation ensure the weeds are less likely to establish a resistance to the herbicides used (Wibawa et al., 2007). Considering the growing number of biotypes of resistant weeds, securing diversity in the

management of weeds is a crucial factor in delaying weed management, or reversing the herbicide resistance trajectory (Diggle and Neve, 2001; Goh and Mohd Nasaruddin, 2016; Gressel and Segel, 1990; Maxwell et al., 1990; Neve et al., 2003). In parallel with this, in order to include a comprehensive survey of herbicide resistance, comprehensive details on the allocation and frequency of weeds in oil palm and rubber plantations are herbicide-resistant. This, however, efforts may be wasted due to insufficient funding from the private agencies and government. Building a herbicide resistance database for agrochemical companies is critical when researching new agrochemicals' production to preserve their sustainability as a key agricultural technology instrument in cropping systems.

Table 2 reflects the respondents' response to the advantages of IWM implementation. According to the findings, 82% of respondents agreed that better weed control was achieved via IWM, while 13% of respondents stated that IWM was a practical technique to implement. This indicates that IWM has increased weed control spectrum in FGV Lepar Utara, making it practical and realistic to implement.

Table 2. [Respondent's response to the advantages gained by IWM implementation]

Advantages	Frequency	Percentage
Practical	8	13
Good control of weeds	49	82
Others	3	5
Total	60	100

Table 3 illustrates the savings in estate maintenance costs through IWM implementation. The majority of respondents (92%) could save maintenance costs up to RM50/ha, while 8% of them could save up to RM50 - RM100/ha.

Table 3. [Savings in estate maintenance costs through IWM]

Savings	Frequency	Percentage
<RM 50/ha	55	92
RM 50-RM 100/ha	5	8
Total	60	100

FGV Lepar Utara has implemented integrated weed management (IWM) practices in their plantations. The most recent IWM approach practiced by FGV Lepar Utara is a combination of chemical, biological and cultural control. Based on this study, the combination of chemical + cultural, as well as a combination of chemical + biological + cultural, were the most widely practiced. For example, chemical control like using herbicide (glyphosate isopropylamine for grasses, metsulfuron methyl and triclopyr for broadleaf weed) whereas biological control by using grazing animals (goat, sheep, cow) and ground cover crops (*Mucuna bracteata*). Example of cultural control is by using empty fruit bunch for mulching, and Felda Mulch. Felda Mulch is made of biodegradable material suggested for tree mulching during the early stage of replanting. The main function of mulching is to conserve moisture and control weed growth at palm circle area. However, mechanical control (for example slashing/hoeing, mowing, and tillage) is seldom to practices due to high cost. Several variables were established for the low productivity of crops, for example, soil and seed quality, erratic weather, limitations in the use of emerging technology, shortages of labor, and inadequate and poorly managed facilities for agriculture (Baki, 2004; Kang et al., 2009).IWM approaches fulfill all the criteria of high productivity, low-cost, high adaptability and high effectiveness weed control management. IMW estates deliver the most economical weed management in terms of cost efficiency, better weed control, higher productivity and more sustainable management, compared to non-IWM estates. Other steps of weed control which have been combined with chemical weed control in oil palm plantations (Chung, 2013) include mechanical and manual weeding, cultural tactics (e.g. mulching, planting legume cover crops), and biological regulation (e.g. grazing by ruminants, such as sheep and cattle). Thus, it is recommended that all plantations should consider implementing IWM for sustainable weed control. Weed management presents a considerable challenge to developing integrated weed management for sustainable cropping systems and situations in which cost-effective and environment-friendly weed control is required.

CONCLUSION

These IWM approaches fulfill all the criteria of high productivity, low-cost, high adaptability and high effectiveness weed control management. IMW estates deliver the most economical weed management in terms of cost efficiency, better weed control, higher productivity and more sustainable management, compared to non-IWM estates. Thus, it is recommended that all plantation implement IWM for sustainable weed control. Weed management presents a considerable challenge to the development of integrated weed management for sustainable cropping systems and situations in which cost-effective and environment friendly weed control is required. Through IWM, a framework for effective and sustainable weed management will be developed, which

will allow for the ultimate prevention of weeds from propagating (setting seed or vegetative reproducing) through a combination of chemical, cultural, biological and mechanical control. Over time, planters hope to reduce the weed population in plantations, to reduce weed-crop competition and to increase crop productivity will come true. Application of herbicide in cultivation such as IWMM is significant. Implementation should not be neglected. There is also no single solution in the fight against weed control problems in oil palms. Involvement, collaboration, assistance from all parties (policymakers, stakeholders, researchers and producers of herbicides) is essential when designing an effective weed control method for improved crop management education, manufacturing, and efficiency.Through IWM, a framework for effective and sustainable weed management will be developed, which will allow for the ultimate prevention of weeds from propagating (setting seed or vegetative reproducing) through a combination of chemical, cultural, biological and mechanical control. Over time, planter's hopes to reduce weed population in plantations, to reduce crop competition and to increase crop productivity will come true.

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