REVIEW ON DEVELOPMENT OF INTEGRATED PEST MANAGEMENT FOR BASAL STEM ROT AND RHINOCEROS BEETLE IN OIL PALM

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ABSTRACT

Oil palm has been recognized as the most sustainable and high yielding crop as it becomes the main source of world edible oil. Over years, serious incidence of disease and pest attack has been observed which resulted to the high yield loss. Currently, the sustainability of oil palm industries has become the global concern as an indiscriminate chemical application had caused environmental pollution and at the same time eliminates beneficial organism in the plantation. Integrated Pest Management, IPM is a combination of various control methods such as chemical, biological and cultural control to reduce or to manage the level of disease and pest in the field. This article reviews the development of IPM for controlling major disease and pest in oil palm which are basal stem rot and rhinoceros beetle (Oryctes rhinoceros). The disease and pest are selected due to their significant impacts on the oil palm plantations around the world particularly in Malaysia. This article also reviewed the details procedure of each control method that has been or has a potential to be integrate together to reduce the level of disease and pest in the field.

Key words: Disease, Pest, Integrated Pest Management, Oil Palm, Sustainability

INTRODUCTION

The oil palm (*Elaeis guineensis* Jacq.) is economically valuable for its oil and is now one of the largest oil producing crops. In Malaysia, the oil palm serves as an important commodity crop and were cultivated on over 4.49 million hectares of land and has been producing approximately 17.73 million tons of palm oil in 2020. The cultivation of oil palm has been tremendously affected by disease and pest attacks that had caused significant reduction of palm oil production. The pest and disease not only attacks the Fresh Fruit Bunch (FFB) but also prone to cause a damage on other parts such as stems, roots, fronds and inflorescence. Daily and unlawful use of chemical control has caused instability in the environment as farmers begun to rely heavily on the use of pesticides. Farmers have shifted from need-based spraying to time-based spraying, which has contributed to several unwanted issues, such as insect resistance build-up, disrupting ecosystem due to the reduction of biotic control, pest re-emergence, biological control agent extinction, secondary pest outbreaks and more. Due to those reasons, Integrated Pest Management (IPM) was developed to maintain the sustainability of oil palm agrosystem. The major objectives of IPM development is to minimize the chemical application and to maximize the application of cultural control. Each method that has been implemented must be continuously monitored to determine the effectiveness of the program. It is also not necessary to combine all of the control methods together at once but just consider the methods that more effective in terms of cost and effects.

MAJOR DISEASE AND PEST OF OIL PALM

BASAL STEM ROT

Basal Stem Rot (BSR) is a very important oil palm disease that can decrease production by 50-80%. It has evolved in the last two or three decades due to the spread from infection foci at a higher pace following repetitive crop cycles in infected sites (Murphy et al.,2020). Losses also economically affected as soon as the disease reaches over 10% of the stand. The losses occur because of the reduction of number of oil palms in the stand and the decreased in the number and weight of fruit bunches from infected palms and those with undetectable infections (Flood et al., 2000). The yield of the fresh fruit bunch (FFB) decreases by on average 0.16 tons/ha for every palm lost, and when the stand decreases by 50%, the average FFB yield decrease was 35% (Subagio & Foster, 2003). BSR can kill 80% of a stand when the oil palms are halfway through their 25 years economic lifespan (Murphy et al., 2020). This disease also has recorded an annual losses of up to RM 1.5 billion (USD 500 million) in Malaysia (Noor Azmi et al., 2020).Phytopathogenic Fungus known as *Ganoderma boninense* is the causal agent of BSR disease. It is a ligninolytic fungus, common to white rot fungi and known for its ability to degrade the wood's lignin layer while exposing the white cellulose (Paterson, 2007). This fungus is therefore more active than other classes in degrading lignin. *Ganoderma* are identified by their large and woody fruiting bodies or basidiocarps. Their fruiting bodies on the trunks of infected palms are usually fanlike, double-walled, truncate spores, with yellow to brown decorated inner layers (Chong et al., 2017).

RHINOCEROS BEETLE

Rhinoceros beetle or *Oryctes rhinoceros* is a major pest in oil palm plantation especially in South East Asia. This insect aims immature and young palms by boring into the base of a cluster of unopened fronds (spears) and destroy the folded fronds (Manjeri, 2014). This boring activity causes holes on the petioles and 'V' shaped cuts on the fronds as they unfold. The mandibles of the beetle are used to chisel the inside of the palm while the horn, the clypeus and the tibiae are used to bore holes. Beetle did not swallow the solid plant stuff, but drained the juices (Manjeri, 2014). Damaged on the inflorescence leads to the reduction of photosynthetic area which ultimately affects the fruit development (Bedford, 2014). Ongoing attacks against young oil palms can also be fatal. The rhinoceros beetle have four stages of life cycle (egg, larvae, pupa and imago), with the duration between each stage vary on weather condition, food availability and humidity in the various places where the production cycle has taken place (Darus & Basri, 2000; Manjeri, 2014). Their life cycle typically takes between four to nine months which allow them to produce more than one generation in one year (Manjeri, 2014).

INTEGRATED PEST MANAGEMENT

According to (Matyjaszczyk, 2018) integrated pest management means consideration and integration of all possible control methods to discourage or inhibit the development of harmful organisms with minimal impacts to economic, environment and human health.The basic concept of IPM application in agriculture has been form by Stern et al. in 1959 and the concept is still valid till today (Bottrell et al., 2018; Singh et al., 2020). The basic concept of IPM is to maximize the application of non chemical alternatives such as cultural and biological control and minimize the chemical usage and only applied pesticides after non-chemical components fail to manage the pests effectively. Implementation of IPM is vital and necessary to obtain sustainable agriculture in which the main objective is to ensure the secure, sufficient and balance flows of food productions and ecosystem health (Tilman et al., 2002).

INTEGRATED PEST MANAGEMENT OF BASAL STEM ROT

The IPM concept to control Basal stem rot involves a combination of cultural control (clean clearing, soil mounding, curative surgery, trenches), the use of resistance variety, biological control (bacteria, fungal) and chemical control.

CULTURAL CONTROL

Clean Clearing: The procedure of clean clearing involves surgical removal and removal of all remaining pieces within the area of infected oil palm by digging pits with 1.5 m2 wide and 60 cm deep from both untreated empty points and diseases palm points. In general, all remaining pieces of the infected palm are deposited on the soil to be burned down. However, this practice is expensive and open burning is banned in many oil palms producing countries and in Malaysia it is regulated under 1978 Air Regulation Act. Therefore, all infected palm parts are shredded and can be dispersed over the field, or piled in rows and covered by leguminous cover crop, to promote decay (Chong et al., 2017).

Soil mounding and curative surgery: Nearly all plantations have used soil mounding as their common practices. Soil is gathered from nearby areas for heaping to the affected palm trunk to a height of 75 cm (Hushiarian et al., 2013) However, this approach only helps to lengthen the economic life of BSR-affected palms and has not delayed the spread of *Ganoderma* (Chong et al. (2017). Some plantation carried out surgery by hand-held chisel or mechanically using backhoe blade to remove diseased tissues. A sealing procedure after the surgery is done to control spores from come into contact with the wound through the freshly cut palm tissue (Panchal & Bridge, 2005). However, this method is not really effective to control BSR as certain injury are happen in lower ground which resulted in the collapse of treated palms (Chung et al., 2011).

Trenches: Cultural practices have often introduced digging trenches to prevent contact from palm to palm. It might be a safer choice than clean clearing and windrowing but this practice is not commonly used. The trenching area is 2 m x 2 m, enough to separate the sick palms and it is 0.5 m width and 1 m depth (Lim & Udin, 2010).However, this procedure has usually been inefficient because the trench depths were inadequate to eliminate all infected root debris and that the trench edges are being eroded progressively so control measures must be maintained (Chong et al., 2017).

RESISTANT VARIETIES

The search for stable resistant varieties is become the main concern and aspects in IPM to control basal stem rot disease. The identification of resistant genes in the breeding material of oil palm has been conducted based on field observations and screening test with seed inoculation (Breton et al., 2006). According to Tisne et al., (2017), most resistant variety studies are based on seed inoculation at nursery stage. To date, there is no variety with total resistance to *Ganoderma* has been reported but only partial resistance has been observed. An extensive research on this aspects still ongoing as the development of resistant varieties will become a long term control method towards basal stem rot disease.

BIOLOGICAL CONTROL

Bacteria: It is claimed by researchers that endophytic bacteria such as *Burkholderia* spp., *Pseudomonas* spp., *Bacillus* spp. and *Serratia* spp. are able to control *G.boninense* (Sapak et al. 2008) by inducing systemic resistance in plants. Endophytic bacteria are bacteria that colonizing the internal tissue of the plant without negatively affecting the host (Boyle et al., 2006). Those bacteria mentioned earlier are found mostly in the vascular systems, near the xylem and phloem and uniform all over the cortex so they may inhibit *Ganoderma* from penetrating the plant (Bivi et al., 2010). In addition to this report, *Bacillu*s spp. also able to abnormalize *G.boninense* in vitro by degrading its cell wall (Suryanto et al., 2012).

Fungi : *Trichoderm*a has been reported as important Biological Control Agent (BCA) againts basal stem rot disease disease (Musa et al., 2018; Sujarit et al., 2020) Some *Trichoderma* species that are antagonistic against *G.boninense* are *Trichoderma virens, Trichoderma viride* and *Trichoderma harzianum*. In plant house trials, *Trichoderma.harzianum* were found effective in controlling the disease developmentof BSR. The *Trichoderma* has various mechanism to inhibit or control the *Ganoderma* such as production of antifungal metabolites, competing with pathogen for space and nutrients, induce host resistance and production of cell wall-degrading enzyme (Naher et al., 2018). An endophytic fungus known as *Hendersonia* spp. has been found as promising BCA agent as it manage to inhibit the growth of *G. boninense* (Munthe, 2018). Malaysian Palm Oil Board (MPOB) has successfully produce commercial biofertilizers, GanoEF1 that incorporates *Hendersonia* fungus together with inorganic and organic fertilizers which the main function is to control *G. boninense* attacks in oil palm .

CHEMICAL CONTROL

Fungicides able to reduce the progressions of BSR in early diagnosed palms if it were applied with correct amount and technique. The use of systemic fungicides, Hexaconazole in trunk injection is able to minimize the occurrence of BSR to other healthy palm (Maznah et al., 2017). Hexaconazole acts by produce systemic demethylation inhibitors (DMI) that could block the mycelial growth of fungi at vegetative stage. Another types of well known fungicide to control BSR disease is Dazomet which is a soil fumigant that produce methyl isothiocyanate (MITC) that has broad spectrum activities in inhibiting the growth of pathogenic fungi (Maluin et al., 2019) .However, excessive use of fungicides, leads to the accumulation of chemical residues in the root tissues which could negatively affecting useful soil microbes.

INTEGRATED PEST MANAGEMENT OF RHINOCEROS BEETLE

The IPM in controlling rhinoceros beetle involves the application of cultural control (field sanitation, pheromone traps ,leguminous cover crop) biological control (*Metarhizium anisopliae, Oryctes rhinoceros* nudivirus) and chemical control . Chemical control is not a preferable way in controlling rhinoceros beetle as it possess great threat to the environment and the population of natural enemies.

CULTURAL CONTROL

Field sanitation: Logs, stumps and piles of rubbish that serves as the beetle's breeding ground must be cleared to diminish the sources for the beetle to breed(Jackson and Klein, 2006). Currently, field sanitation is conducted using pulverizing techniques which is a zero burning method. Pulverization is a method of crushing or chipping the palm trunks into fine pieces and spreading it over the entire field (Ooi & Heriansyah, 2005). The new pulverizing techniques is useful in reducing the decomposition period of the felled palm hence, limiting the availability of beetles breeding grounds.

Pheromone traps: Pheromone trap has been implement in many IPM program as it has many advantages over other control method. The main purpose of using pheromone traps are for mass control and mating disruption (Ahmad & Kamarudin, 2011). Ethyl 4–methyloctanoate (E4-MO) is the main male produced aggregation pheromone in the *O. rhinoceros* which is now available in slow-release sachet dispenser (Bedford, 2014). The pheromone trap is ideally to be placed at least 3 meter above ground and 1-2 meter above the young oil palm canopy. The recommended density for the trap is at least 1 trap for every 2 hectare (Ahmad & Kamarudin, 2011).

Leguminous cover crops (LCC): Cover crop acts as a physical barrier to the beetle breeding ground. According to Kamarudin et al. (2005), beetles are not present when the cover crops are 70 cm in height. Some cover crops species that are most widely cultivated in Malaysia include *Pueraria javanica* and *Centrosema pubescens*.

BIOLOGICAL CONTROL

Metarhizium anisopliae: *Metarhizium anisopliae* is an entomopathogenic fungus which means this fungus has parasitism activities on insects. This species is suitable to be employed as BCA because of their short life cycle, production of high conidial and resistant to environment changes (Indriyanti et al., 2018). The fungus effective to kills the immature stage of the beetle with high mortality rate of the beetle larvae in laboratory trials conducted by (Indriyanti et al., 2017). After infection, the body of dead larvae will become hardened. Formation of white to green hyphae also could be observed on the larvae body.A study by Moslim & Kamarudin (2014) showed that Palm Kernal Cake (PKC) has a great potential as a medium for large scale formulation of *M. anisopliae*. The conidia produced in combination media of PKC and maize is higher compared with conidia that produce in maize alone. The study also recorded 100% mortality rate of beetle larvae that has been inoculated with the fungus.

***Oryctes rhinoceros* nudivirus** (OrNV): OrNV is a Baculovirus that belongs to the Family: Nudiviridae and Genus: Alphanudivirus. The virus infects larvae and adult beetles in midgut epithelial cells and the fat body (Huger, 2005; Jehle et al., 2013) and have shown an excellent reduction in pest population within one to two years after the introduction of the virus to plantations (Bedford, 2014). The Nudivirus have vertical and horizontal modes of modes of infection (Williams et al., 2017) whereas vertical infection is known as persistent infection (Wang & Jehle, 2009) which makes the virus become asymptomatic and can become active under several circumstances. Once activated, it can trigger deadly infections followed by horizontal transmission. The virus was successful in controlling beetles in South Pacific countries (that include neighboring countries, Indonesia and Philippines) (Bedford, 2014). In Malaysia, the OrNV was identified as type A, B, C and D 46 (Ramle et al., 2005). Type B and type A was the most effective in reducing the beetle population. Based on the study by Rahayuwati et al. (2020), the infected larvae were identified by having swollen, transparent abdominal and the belly sometimes appears to be white and shiny. Heavily infected larvae have a symptom of prolapsed rectum while the digestive tract of infected adults was characterized by a whitish swollen gut (Huger, 2005). Some advantages of using OrNV is that it is environmentally friendly, economical and suitable for long term control (Rahayuwati et al., 2020).

CHEMICAL CONTROL

Insecticides like carbofuran and cypermethrin are the most successful in controlling rhinoceros beetle and were effective in reducing the number of holes on the spears and fronds (Manjeri, 2014). However, pesticides are costly and toxic to the workers and non-target species as well as polluting the environment. Widespread application of insecticides will also destroy the pest's natural enemies, causing the pest to spread freely. A field study at oil palm plantation located in Johor, Malaysia showed that rhinoceros beetle has become resistant to carbofuron and cypermethrin due to repetitive application of similar pecticides (Abd Karim et al., 2019).

CONCLUSION

The review indicate that there are many control options are available to manage the major disease and pest in oil palm. The basis component of IPM is the integration of management tactics such as cultural control, biological control, chemical control and development of plant resistance. Farmers especially smallholders can use the finding from this study to make a decision on appropriate control methods that can be implemented in their farm or plantation. From this study, it is obvious that chemical application is still vital however the application can be reduced or minimize with other cultural control such as the using of pheromone traps and LCC for rhinoceros beetle. Future research on the development of suitable and stable formulation of biological control agent is needed to ensure the successful implementation of natural enemies as biopesticides against disease and pest of oil palm. To maintain the sustainability of oil palm plantation, IPM implementation become a priority to minimize the impacts of excessive chemical application on the environment and human health.

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