Water Management in Oil Palm Plantation for Control of G. Boninense: A Review on the Application of Nano-Porous Pipe

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***Abstract*— Endophytic fungi defined as fungi that colonize internal plant tissues without causing visible damage to their host plant. The fast spread of pathogens such as G. Boninense causal agent of Basal Stem Rot (BSR) disease in oil palm as they are internal colonizers. Water management is very important part in oil palm plantation which has been successfully proven that oil palm can grow under flood condition but the mortality rate of G. Boninense is abruptly dead within 3 months from its growth. Nano-structure porous pipe as an alternative way that can be installed in oil palm irrigation system which supply water optimally and efficiently for controlling the outgrowth of G. Boninense.**

Keywords— ***Basal Stem Rot Disease, Flooding Condition, Anaerobic Condition, Soil Matric Potential, Subsurface Irrigation and Drainage.***

INTRODUCTION

Elaeis guineensis Jacquin, is a species of palm that is principal source of palm oil. Oil palm in Southeast Asia is badly affected by basal stem rot (BSR) and upper stem rot (USR) disease caused by G. Boninense. According to Hama Ali et al. (2015), BSR disease causes serious problems in oil palm production. This disease causes the collapse of the lower leaves. The vertical hanging of the leaves is one of the remarkable symptoms of this disease among the old palms. The leaves hang vertically from the point of attachment to the trunk. This is followed by the curvature of the younger leaves, which turn a yellowish color and the die back of some branches. Infection in younger palms leads to a one-sided yellowing of the lower leaves. When the disease develops and the fronds start to desiccate, the symptoms first appear in the oldest leaves and then in the youngest ones.

It is typically found that at least half of the basement trunk is destroyed by fungal enzymes; thus when the trunk is destroyed, water and other nutritional requirements cannot go up to the leaves and finally this leads to the death of the palm. The disease dramatically reduces the yield of affected trees and gradually destroys the trees in a few years. Hama Ali et al. (2015) state that the average losses reported in several reviewed articles range from 10 to 45 % yield reduction among palm trees aged between 10 and 15 years old. A more recent study found that the losses in fresh fruit bunches were 0.04 and 4.34 tons/ha in 10 and 22 years of planting, respectively. BSR disease is still common and is getting worse among palm trees in Malaysia and Indonesia despite the considerable scientific efforts, including fungicide use, biological control, replanting method, and excision treatment to control the disease.

G. Boninense causes both Basal Stem Rot (BSR) and Upper Stem Rot (USR) and remains South East Asia's most devastating oil palm diseases with direct loss of the stand, reduced yield of diseased palms and the resultant requirement for earlier replanting. When young palms show symptoms of the disease, they usually die within 1 to 2 years later, while for matured palms they are able to survive for only another 3 or more years (Hushiarian et al., 2013). Strategies for early detection of oil palm disease are still immature even though it has been clearly identified as the main disease. According to Nurnadiah et al., (2014), BSR usually could be detected at the critical stage where some of the symptoms are wilting the leaves, production of fruiting bodies, holes on the trunk and even falling tree. Thus, the objectives in this study are to identify the ecosystem of the parasite affected the oil palm conditions, relationships between G. Boninense and soil properties, soil water relations to G. Boninense growth and effect of BSR on water stress.

Ecosystem of the harmful parasite affected oil palm conditions

Fungi are aerobic or anaerobic absorptive chemo heterotrophs. Most fungi are decomposers and a few are parasites of plants and animals. G. Boninense is one of the facultative parasites that attacked oil palm through the BSR disease. This parasite can grow with or without oxygen because they can metabolize energy aerobically or anaerobically. Facultative parasite that can live as a saprophyte on rotting stumps and roots, but when suitable hosts like oil palm becomes available, it will colonize the host and establish a parasitic relationship. It is a characteristic of basidiomycete fungi which cause root diseases and require wounded or dead roots for infection of the host plant. Later on, the disease spreads from plant to plant by roots or by spores (Laila, 2013).

Historically, control of BSR has involved cultural techniques, mechanical and chemical control. The failure to control is due to the characteristics of G. Boninense. The fungus is soil borne and so fungicides may be ineffective due to the degradation in the soil before they can reach their target. In addition, G. Boninense also has many forms of resting stages including resistant mycelium, basidiospores, chlamydospores, and pseudosclerotia. In order to fight these characteristics, the best approach to the control of BSR may be biological control and the utilization of resistant oil palm. Breeding for resistance is a long-term activity, whereas biological control may be developed over a shorter time scale.

G. Boninense spreads in the soil through roots and through the air. Fungi collected from the same field or area may have different origins so mycelial growth is probably not the only method of transmission of disease among the trees. Wind, rain and insects all assist to carry spores to wounds on trees, most commonly those which have been cut. In particular, the Oryctes beetle and larvae of the Sufetula spp caterpillar plat at least a small role in the spreading the Ganoderma spores. Enormous numbers of Ganoderma spores were released in a field but did not infect most trees which have indicated that infected tissues in the soil are more likely to spread the disease to healthy roots than airborne spores (Hushiarian et al., 2013).

G. Boninense and soil properties

According to Laila (2013), the most soils tested in the coastal areas of the western part of the Peninsular Malaysia are prone to BSR disease. High incidence of BSR on oil palm in inland areas, including soils of Holyrood, Sungai Buloh, Rasau and Bungor series, Batu Anam Burian series and Munchong series, peat soils and lateritic soil especially Malacca series. Oil palm grows on a range of soil types, including soil where few other crops grow successfully. The costs of palm oil production is low because oil palm require relatively low fertilizer inputs per Mega gram of oil produced but still may require large absolute amounts of fertilizer (Weigand, 2016).

Soil water relation to G. Boninense growth

The availability of water also affects the survival, movement and activity in part of from the aquatic nature of many soil organisms and the impact of water on their capacity to move. There is a relationship between matrix potential and the diameter at which soil pores empty, and so the size and volume of water-filled pores available for the movement of soil organism is strongly influenced by soil moisture. The largest pores drain first, and by the time matric potential has decreased to -0.05 MPa, all pores greater than about 6µm in diameter will have emptied. This means that the movement of organisms that live in water films is progressively limited as the water-filled pores or pore necks become too small to permit their passage (Stirling, 2014).

Changes in soil water content have profound effects on their activity by influencing the dispersion of soil organisms. Adequate moisture is essential for optimum growth, and the contribution of some microorganisms to total microbial respiration begins to decline at water potentials of between -0.3 and -0.6 MPa. Soil organisms differ in their capacity to survive in situations of even greater moisture stress, but most can tolerate moisture potentials to -10 MPa. In dry soils, soil air is always maintained at or very near a relative humidity of 100 % and this is perhaps the main reason that organisms can survive relatively low soil moisture potentials (Beddis et al., 1992).

Some soil organism tends to remain active at low moisture potentials. Fungi can continue to separate in relatively dry soils. They are not confined to water-filled pores because their hyphae can bridge air spaces and can spread along the walls of drained pores. The growth of most fungi is not restricted until the water potential drops to between -3 and -6 MPa and some fungi can germinate and grow at potentials as low as -20 to -40 MPa.

Selection of mycelia of G. Boninense in colonized wood was measured in soils with different soil matrix potentials. Survival of mycelia of G. Boninense which do not produce chlamydospores, buried in plots subjected to different soil moisture treatments, declined rapidly, and the fungi could not be recovered after 9 to 12 weeks. When the soil matric potential applied is smaller, the rates of change of mycelia survival over time of G. Boninense was not recovered from pieces of infested wood subjected to 1 and 3 months of flooding. In treatments with lower soil moisture, the survival of this fungus ranged from 80 % to 90 % over 2 years. Flooding infested fields may help to control those wood-inhabiting fungi such as G. Boninense because it cannot survive in flooded soil (Chang, 2003).

Wood-inhabiting fungi that produced arthroconidia from G. Boninense did not survive in flooded soil. Submersion of wood in water has been used to prevent postharvest colonization by wood-decay fungi. The benefit might be due to the activities of anaerobic microorganisms. This is because; wood sections that did not produce chlamydospores were submerged in water, the fungi died within 3 months. Thus, for disease management of root and butt rot caused by wood-inhabiting fungi that do not produce chlamydospores, flooding infested fields might eliminate the inoculum source in infested wood (Chang et al., 1996).

Effect of BSR on water stress

Decay of the oil palm tree lead to the restriction of water and nutrient supply to the aerial parts, causing symptoms resembling those of water stress and malnutrition. Basal stem rot leading to water stress such as drought, high soil water salinity and also affect the foliage. In young palm, the foliage became yellowing or mottling while young unfolded leaves became chlorotic and may be reduced in length, sometimes with necrotic tips. Oil palm may take pale appearance with retarded growth and spear leaves and a generally pale leaf canopy. Affected palm may die the necrosis beginning with the oldest fronds and extending to younger regions of the crown. Palm may normally die within 6 to 12 months after the appearance of unexpected spear leaves (Plantwise, n.d). The side effects of the infection produce a dry rotting of internal tissues at the stem base or root bole and so at any stage in the disease process, the stem or root bole of the infected palm may fracture and the palm will collapse (Steidl, 1999).

Nano-Structure Porous Pipe in Water Management

Nanoporous materials supporting a regular, porous structure with the size of the pores is generally 100 nanometers or smaller. Nanoporous materials usually can be classified as bulk materials or membranes. Examples of bulk nanoporous materials are activated carbon and zeolites, while cell membranes can be thought of as nanoporous membranes (Nanoporous, 2016). The nano-structure porous was designed to spread water along a continuous horizontal band in the soil, rather than at discrete locations. Figure 1-2 shows the porous pipe is suitable for closely spaced row crops for allowing water entry, the pipe is bent at one end, and the orifice is made to protrude above ground (FAO, 1997).

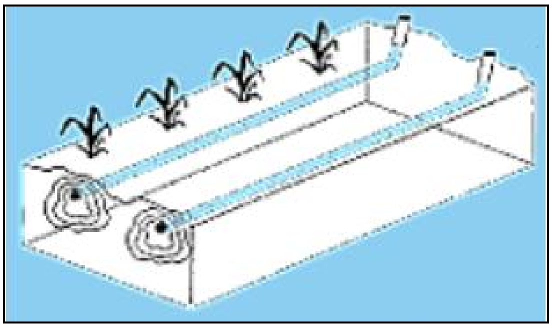

Figure 1: The pattern of soil wetting under irrigation with the subsurface porous pipe applications (FAO, 1997)

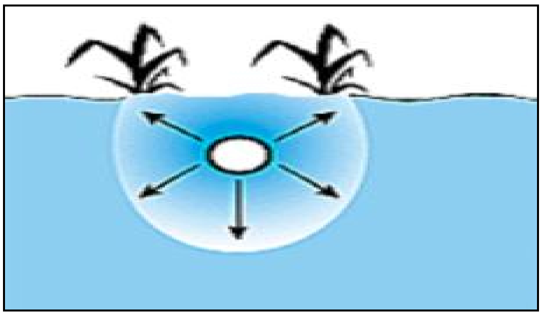

Figure 2: The pattern of soil wetting by a horizontal porous pipe embedded between parallel crop rows (FAO, 1997)

According to Porous Pipe Irrigation Article (2008), watering with porous pipe irrigation provides precise watering and promotes downwards root growth. Water is sent where it is needed and therefore does not end up helping the spread of weeds across the whole plot. There is also a reduction in the risk of moulds and mildews which occur when hand watering splashes leaves. Porous pipe irrigation system is very similar to drip irrigation because it is able to discharge water with low quantity. This system could be installed at soil surface or subsurface. Therefore, it is categorized not only as a micro scale irrigation (like drip system) but as a subsurface irrigation system. The discharge from porous pipe is very low level of water allowing slow infiltration. There are two systems than can be installed as subsurface irrigation system which are vertical and horizontal porous pipe installation.

Vertical system might have two advantages over horizontal installation of porous pipe. First, it might be able to lead root system down enough following length of porous pipe and downward emitted water to preserve tree failure against wind. The second advantage is involved in pipe obstruction by root system. In terms of horizontal installation of porous pipe, obstruction will interrupt all the line. However, obstruction in vertical installation will change the pattern of soil moisture only for the obstructed part, which is an off-line branch from lateral line and works locally like a dripper (Akhoond-Ail et al., 2008).

CONCLUSIONS

BSR is the most important disease in oil palm that caused by harmful parasite, G. Boninense. The ecological environment is an importance factor to control the disease advancement. Soil water relation is the considerable method since the technique is quite easy by measuring the matric potential of soil moisture requirements by oil palm tree.

Application of nanoporous pipe in irrigation system, water is applied directly to the root zone while protecting the structure of the soil. The water is applied via porous or perforated receptacles that are embedded in the soil to some depth with their openings protruding above the soil surface. These receptacles, which are filled with water periodically or kept, filled continuously, exude the water through their permeable walls into the surrounding soil. The moisture applied in this manner feeds the roots of the crop. When arranged in a grid, these embedded applicators produce a pattern of wetting that can be optimized with respect to the spacing and rooting habit of the crop thus irrigated. Soluble nutrients (fertilizers) can be injected into the water supply, to enhance the efficiency of fertilizer use as well as of water use by a row crop. In principle, this type of irrigation can provide water steadily, as long as the receptacles contain water. The frequency with which they must be refilled depends on their water holding capacity as well as on the rate of water flow into the soil.

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