FUNGICIDE APPLICATION FOR THE CONTROL OF *Ganoderma* UPPER STEM ROT (USR) DISEASE IN OIL PALM

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Productivity losses caused by the widespread of plant diseases are one of the biggest challenges faced by the agriculture industry. In oil palm, the most serious threat to its production is the basal stem rot (BSR) caused by *Ganoderma* species, which has lead to significant losses to the industry in Malaysia. Although BSR is the most prominent disease affecting the oil palm industry, the upper stem rot (USR) disease in oil palm is also associated and caused by *Ganoderma*. In USR-infected palm, the *Ganoderma* infection was found to occur on the upper portion of the stem or trunk (*Figure 1*) as opposed to the BSR symptoms which appears at the base of an infected palm (Rakib *et al.*, 2014; Hassan *et al.*, 2005). Flood *et al.* (2002) suggested that USR disease dispersal is more associated with airborne-basidiospores. Generally, in the initial stage of USR-infected palm, yellowing leaves are accompanied with the formation of *G. boninense* fruitification on the oil palm trunk. In the final stage of infection, severe desiccation of leaves and the production of more fruiting bodies along the trunk was observed. USR disease is generally accepted to be less common than BSR and its occurrence is very estate specific (Gassner *et al.*, 2005). Nonetheless, USR disease in recent years has gained more attention with a sudden increase of cases with mostly reported in Sabah, Malaysia (Gassner *et al.*, 2005), Sarawak, Malaysia (Rakib *et al.*, 2017) and Indonesia (Hari *et al.*, 2011). There is an immediate need to control the USR disease and the current technology explores the potentials of a commercial hexaconazole (systemic fungicide) as a curative treatment.

Figure 1. Upper stem rot (USR) disease symptoms; formation of the fruiting body and stem rotting appearing at one meter above ground. No Ganoderma *infection at the palm base.*

THE TECHNOLOGY

The increased number of cases of USR disease in existing oil palm stands necessitates immediate short-term control measures. There are several methods to control *Ganoderma* in replanting and existing plantation such as cultural practices, including deboling and sanitation, soil mounding and application of biological control agents (BCA) (Idris *et al.*, 2016). As a short-term measure fungicide application remains crucial for the control in the fields as the curative treatment. Agrochemicals used in modern agriculture are constantly evolving and no doubt that their applications have contributed significant importance towards the crop protection (Smith *et al.*, 2021). Idris *et al.* (2002) assessed the effectiveness of hexaconazole and tetraconazole, both in the triazole group, in prolonging the productive life of *Ganoderma* infected palms. Hexaconazole, a systemic fungicide, reported to control a broad spectrum of diseases, and was more efficacious and cost-effective than other triazole group fungicides. The fungicide is generally active against basidiomycetes and ascomycetes in which it is a potent inhibitor of ergosterol biosynthesis (Huang *et al.*, 2012). The application of fungicide hexaconazole was proven to prolong the life of BSR palms in previous reports (Idris *et al.*, 2016; Maluin *et al.*, 2019). Given the success of the hexaconazole in controlling BSR disease, this study was designed to evaluate the ability of the fungicide (hexaconazole) to control USR-infected palms through trunk injection.

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FIELD APPLICATION OF HEXACONAZOLE

The study was conducted at two sites, Miri and Sessang in Sarawak on approximately 31.93 ha of field plot and was identified of having cases of USR disease incidences. The palms were 15-years old (first generation) planted in the year 2005 on peat soil. The field trial was conducted only on USR-infected palms with early (DSI 1) and moderate (DSI 2) symptoms of *Ganoderma* infection and were still producing fresh fruit bunches (FFB) (*Table 1*). USR-infected palms categorised under DSI 1 is referred as early infection, with presence of white mycelium or fruiting body and without foliar symptoms and stem rotting (<10%) at the base. While USR-infected palm in DSI 2 is categorised as moderately infected palms with the presence of fruting body and the palm, showing foliar symptoms (yellowing and collapsed fronds) and stem rotting (<30%) at the base. The application procedures of fungicide on USR-infected palm are shown in *Figure 2*. Each treated USR-infected palm was applied with 3 litres of the fungicide solutions and was repeated three times at six-monthly intervals (Idris *et al.*, 2010).

TABLE 1. FUNGICIDE TREATMENTS APPLIED IN UPPER STEM ROT (USR) - INFECTED PALMS

Treatments	Description
T1	USR-infected palms treated with hexaconazole – 4.5 g a.i (90 ml) + 3 litres water
T2	Control – Untreated USR-infected palms

Figure 2. Application of fungicide, hexaconazole on the USR-infected palms: (a) Selection of USR-infected palm with disease severity index (DSI) 1 and 2 with fruit bunches; (b) Removal of the old frond and fruiting bodies at the USR-infected stem/trunk tissues using chisel; (c) Drilling of one hole into the stem/trunk at 1 m height from ground level using motorised engine drill attached with a drill bit (45 cm long, 11 mm diameter); (d) Injecting a total of 2 litres of fungicide solution using hand knock injector™ attached to the motorised knapsack sprayers and (e) Spraying of 1 litre fungicide solution onto the USR stem/trunk infected tissues.

FIELD EVALUATION OF HEXACONAZOLE

The response of USR-infected palms due to *Ganoderma* infection after the application of fungicide was evaluated. The effects of the treatments were assessed at six-monthly intervals over a duration of five years by recording the presence or absence of USR symptoms, including external symptoms (*e.g.* foliar symptoms and appearance of *Ganoderma* fructification) and decay of the trunk. The assessment was also carried out based on the quantitative assessment by checking the dead palms. Isolates of *Ganoderma* from oil palm trunk tissues of USR-infected palms were collected and cultured on the *Ganoderma* selective medium (GSM) to confirm the presence of *Ganoderma* in the trunk tissue (*Figure 3*). The result was confirmed by the presence of brown halo on the GSM media and the presence of *Ganoderma* fungus.

The disease severity of foliar index (DSFI) of each palm within each treatment was found to be no significant differences between treated (T1) and untreated (T2) of USR-infected palms (*Table 2*). Disease manifestation through DSFI after 60-months was lower in USR-infected palms treated with hexaconazole (T1) at 41.7%-48.1% compared to the percentage recorded in untreated palms (T2) at 100%, for both study sites.

It was also observed that the percentage of dead palms in T2 treatment proportionally increased

TABLE 2. PERCENTAGE DISEASE SEVERITY OF FOLIAR INDEX (DSFI) DUE TO UPPER STEM ROT (USR) DISEASE IN OIL PALMS, AT 1, 12, 36 AND 60-MONTHS AFTER FUNGICIDE TREATMENT

Treatments	DSFI due to infected USR-palms (%)							
	Site 1 (Miri)				Site 2 (Sessang)			
	1 month	12 months	36 months	60 months	1 month	12 months	36 months	60 months
T1	4.21[a]	17.2[a]	31.6[a]	48.1[a]	3.2[a]	10.8[a]	25.6[a]	41.7[a]
T2	10.5[a]	37.7[b]	78.7[b]	100[b]	3.9[a]	18.6[a]	42.8[b]	100[b]

with percentage of DSFI. The percentage of dead palms was found to be the significantly lowest at P<0.05 in USR-infected palms treated with hexaconazole in both study sites, Miri and Sessang at 50.0% and 36.6% of dead palms, 60-months after treatment (*Figure 5*). All the surviving palms were still producing fruit bunches at the end of the 5 years.

Figure 3. Infected tissues from upper stem rot (USR) infected palms cultured on Ganoderma *Selective Medium (GSM). The presence of* Ganoderma *fungus was confirmed.*

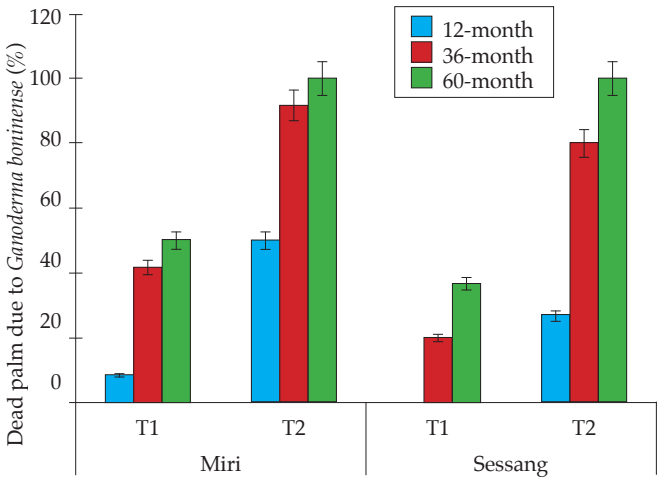

Figure 5. Percentage of dead palms due to upper stem rot (USR) disease.

The use of fungicide is recommended to prolong the economic life-span of the USR-infected palms as it suppresses the spread of the *Ganoderma* infection within the infected tissues. Repeated application of the fungicide is necessary in the event of relapse of infection within the palms. Therefore, with repeated applications of systemic fungicide over a period of time, infection spread to adjacent healthy tissue by the fungus would cease.

ECONOMIC ANALYSIS AND COMMERCIAL BENEFITS

The technology offered is a method of controlling USR-infected palms due to *Ganoderma* in oil palm plantation. The cost of fungicide application, hexaconazole vary between RM8.00 and RM10.00 per palm. *Figure 6* shows the average fresh fruit bunch (FFB) yield treated with fungicide treatment is relatively more compared to untreated infected palms under the assumptions that the expected FFB loss is 30%-40% at the age of 12 years after planting.

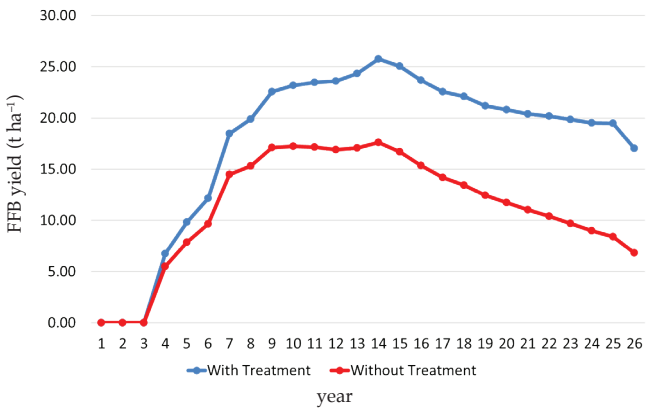

Figure 6. Average yield of fresh fruit bunch (FFB) of upper stem rot (USR)-infected palms with and without hexaconazole (fungicide) treatment.

IMPACT

- An efficient of curative treatment for USR-infected in productive oil palms under field conditions.
- Limit the spread of *Ganoderma* infection in standing infected palms which results in prolonged life span of USR-infected palms.
- Reducing the risk of *Ganoderma* spread in healthy adjacent oil palms.
- Reduce the yield losses in oil palm due to *Ganoderma* infection.

CONCLUSION

The study has demonstrated the efficacy of hexaconazole on the incidence and severity of USR-infected palms. The hexaconazole showed positive curative treatment to control USR-infected palms under field conditions. Fungicide control can affect the amount of *Ganoderma* inoculum available by reducing the rate of disease development and killing a portion of the pathogen involved.

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