JOURNAL OF AGROBIOTECHNOLOGY 2019, VOL 10(1S):75-87
e-ISSN: 2180-1983
https://journal.unisza.edu.my/agrobiotechnology/index.php/agrobiotechnology/index

PENERBIT Universiti Sultan Zainal Abidin

JOURNAL OF AGROBIOTECHNOLOGY eISSN : 2189-1983

Survey on Pest and Disease of Corn (*Zea Mays* Linn) grown at BRIS Soil Area

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Received: 05/08/2019, Accepted: 06/10/2019, Available online: 31/10/2019

ABSTRACT

A field survey was conducted to identified insect pest, beneficial insect and plant disease that associated with corn (*Zea mays* Linn) at BRIS soil area. Hybrid sweet corn variety Sugar King 516 was used as a sentinel plant in this study. All insect pest and beneficial insect observed at the experimental plot was collected and identified in the laboratory. Corn plant that shows the symptom of disease infection was collected for the isolation of pathogen and identification. The data on plant growth such as plant height, corn ear height, dry straw weight, ear weight, ear length, grain dry weight and shell weight was recorded. Data obtained shows the performance and adaptability of hybrid sweet corn variety Sweet King 516 in this experiment was comparable to the local hybrid sweet corn grown at other BRIS soil area at Terengganu. There is no strange pattern on the plant growth, thus prove that the insect infestation or disease infection does not disturb the plant development. Thirteen species of insect pest were identified. There are grasshopper (family Acrididae), katydid (family Tettigoniidae), sweet potato bug (*Physomerus grossipes*- family Coreidae), derbid plant hopper (*Proutista moesta*- family Derbidae), cotton stainer (*Dysdercus* sp- family Pyrrhocoridae), largid bug (*Physopelta* sp- family Largidae), corn leaf hopper (*Peregrinus maidis*- family Delphacidae), corn rootworms (*Diabrotica virgifera*- family Chrysomelidae), green chafer beetle (*Anomala albopilosa*- family Scarabaeidae) and tussock moth (*Orgyia* sp- family Erebidae). Three species of predatory insect were identified; Asian lady beetles (*Harmonia axyridis*- family Coccinellidae), transverse lady beetle (*Coccinella transversalis*- family Coccinellidae) and assassin bug (family Reduviidae). Two species of fungal pathogen that attacks corn in this experiment were identified as *Fusarium* sp. and *Puccinia* sp. Data obtained in this study provides info on pests and diseases associateed with corn, thus could be beneficial for the farmers to be prepared with the best pest and management strategies for their corn plantation at BRIS soil area.

Keywords: Sweet corn, insect pest, plant disease, BRIS soil

INTRODUCTION

Zea mays L. (corn) is widely cultivated all over the world in a different agro-climatic zones (FAOSTAT, 2017). It is popularly known as "Queen of cereals" due to its wider adaptability and highest genetic yield potential among cereal crops (Brar et al., 2017). In 2014, 183,319,737 hectare of land worldwide was planted with corn (USDA, 2015). Corn was considered as a main cereal crop of the world in 2018/2019, because of its production is around 1099.61 million metric tons compared to other cereal crop such as wheat (734.74 million metric tons), rice (495.87 million metric tons) and barley (104.6 million metric tons) (Statistica, 2019). Corn is very significant in developing country, where quickly expanding population has officially outstripped the accessible nourishment supplies (Reddy et al., 2013). It is estimated that corn will be the developing world's largest crop; and between now and 2050 the demand for maize in the developing world is expected to double (CIMYYT, 2019). Overall, 35% of the maize production was used for human consumption, 25% for animal food , 25% for poultry feed and another 15% is for the use in industrial products such as starch, alcohol and seed (Harris et al., 2007).

In Southeast Asia, Indonesia was the largest producer of corn 27.95 million tons, while Malaysia only produced 0.7 million tons in 2018/2019 (Statistica, 2019a). Corn is not a main crop in Malaysia as it is not a staple food for the people at that area, and most of corn production was used as animal feed (DOA, 2019). The fertility and suitability of soil; the threat from the plant pest such as insect and disease also influenced the productivity of corn in Malaysia (Faruq Golam, 2011; Nur Ain Izzati et al., 2011; Ishaq et al., 2014). Overall, Malaysia only has approximately 758 hectare of corn plantation area where 293 hectare of that area is located at Terengganu (Mohd Supaat, 2017). Most of the corn plantation at Terengganu area located at the BRIS soil area where the soil fertility is low.

BRIS (Beach Ridges Interspersed with Swales) soil is a problematic soil for many types of crop plantation due to the inherently low soil fertility, nutrient imbalance and water deficit which can seriously inhibit plant growth and may influence the yield of the crop (Roslan et al., 2011). Thus, the capability of BRIS soil for maize cultivation needs to be improve (Ishaq et al., 2014). Any crop grown under BRIS soil managed with organic materials perform better in term of plant growth and yield development (Usman, 2013). However, many researches was done to investigate the plant growth and performance at the BRIS soil area (e.g: Wan et al., 2010; Hossain et al. 2011; Yusoff et al. 2011; Akbar Basri et al. 2013, 2016; Abdul-Hamid et al. 2014), with less attention was given on the investigation on the abundance of insect pest and disease at this area.

As BRIS soil may influence the growth and performance of plant, it may give a consequent effect to the interaction of plant with surroundings organisms such as insect and microorganism that associated with the crop. Record has showed that the amount of soil bacteria at BRIS soil area is lower (Mustapha et al., 2017) compared to other type of soil such as sandy loam soil (Shen et al., 2008). It is well known that several beneficial belowground microbes such as mycorrhizal fungi and plant growth-promoting rhizobacteria can help plants to deal with insect herbivores, their natural enemies and pollinators via plant growth promotion and induced resistance (Kumar & Verma, 2018; Pineda et al., 2010). The resistancy and plant vigour towards pathogen infection also rely on the plant health (Mitchell et al., 2003; Chakraborty and Newton, 2011). The differences in soil fertility was influenced the growth and performance of plant, thus altered the interaction between plant and their associate's friends and enemies (Shivayya et al., 2009).

Corn attacked by numbers of insect pests and diseases at different plant growth stages which causes damage to all plant parts including root, stem, leaf, tassels, silk and grain (Singh and Singh, 2018). Insect infestation at the corn crop can severe damage to the kernel of corn thus it will reduce the quality of the crop. Approximately 250 species of insect was reported damaging this crop worldwide, but only half a dozen of those insect was classified as economic importance (Mathur, 1991). Some of the major insect pest that reported attacking corn were corn earworm (*Helicoverpa zea*), corn rootworm (*Diabrotica virgifera*), corn borer (*Ostrinia nubilalis*), corn leaf aphid (*Rhopalosiphum maidis*) and armyworm (*Spodoptera frugiperda*) (Dafoe et al., 2013; Farias et al., 2014; Betsiashvili et al., 2015; Fishilevich et al., 2016; Olmstead et al., 2016). In Malaysia, the major insect pest of corn reported was Asiatic corn borer (*Ostrinia furnacalis*), army worm (*Spodoptera litura*), corn fruit borer (*Helicoverpa armigera*), green stink bug (*Nezara viridula*), and aphid (*Rhophalosiphum maidis*) (DOA, 2019b). On the other hand, corn also suffered cause by the attack of pathogenic microorganism. Some of those invisible culprits are *Sclerophthora rayssiae, Puccinia polysora/ Puccinia sorghi, Drechslera maydis Erwinia carotovora, Curvularia lunata, Rhizoctonia solani* and *Ustilago maydis* (DOA, 2019b). Plant diseases cause by fungi, bacteria and viruses can affect all the different parts of the plant including the roots, stems, leaves and the cobs. The latter can have the largest effect on yield when it comes to harvesting the crop, the corn grade will be affected negatively.

Roughly, direct yield losses caused by pests ranging between 20 % and 40 % of global agricultural productivity (Savary et al., 2012). Insect infestation alone destroy an estimated 18-26 % of annual crop production worldwide, at a value of losses is approximately more than $ 470 billion, where the greater proportion of losses (13-16 %) occurs in the field, before harvesting process (Culliney, 2014). It is reported that maize cultivation itself is limited by diseases which cause grain loss of about 11% of the total production (Tagne et al., 2008) where fungi infection is among the principal causes of deterioration and loss of corn grain (Tsedaley and Adugna, 2016) and ranked as second after insects (Suleiman et al., 2013).

BRIS soil covers a quite large area in Terengganu. However, most of this area is abandoned and farmers have no interest to grow any crop due to the soil fertility problem. Effort was done by the Terengganu state government to encourage local people in increasing their household income by growing some potential cash crop plant such as corn at this abandoned are. Many researches were done to improve the soil fertility at BRIS soil area in Terengganu, but less attention was gives on the pest management scope. Thus, this study was designated to identify the insect pest, beneficial insect and plant pathogen that associated with corn at BRIS soil area. Findings of this study may help farmers by providing the information on integrated pest management (IPM) method. Farmer's knowledge on pest and disease of corn crop would contribute in understanding the damage caused by the insect pests and pathogen, thus will educate farmers to apply the right pest management methods when needed. Objectives of this study are (i) to examine the effect of BRIS soil on the growth of corn crop, (ii) to identify insect pests and beneficial insects that associated with corn at BRIS soil area and (iii) to identify the fungal pathogens associated with corn at BRIS soil area.

MATERIALS AND METHODS

Study system

The experiment was done in the experimental plot at the Universiti Sultan Zainal Abidin, Besut Campus (5°45'49.9"N 102°37'33.6"E), which the soil characteristic at this area was identified as BRIS (Mustapha et al., 2017). Half acre of land that originally grown with wild acacia was chosen for this experiment. The land was surrounded with wild acacia plant, pumpkin, and sweet potato farm. According to the local people, corn plant was never grown at the experimental plot or surrounding area before the experiment started (Zakaria, pers. comm., April 19th, 2018).

Hybrid sweet corn variety Sugar King 516 (Leckat, Malaysia) was used as a model plant. Experimental plants were grown from seeds sown in individual cells of plug trays with soilless compost (Agromedia™, Malaysia) under the shade at the experimental plot (Temperature: 25-32°C, relative humidity 87 ± 5 % and L12:D12 photoperiod). Ten days after emergence, seedlings were transplanted to the planting bed at the experimental field. Twenty-five planting beds were prepared with 100 plants per planting bed. Plants were then allowed to grow until the fruit harvested. Plants were watered manually with underground water as needed and any weeds occurring were removed. No pesticide was applied on the plants during experiment.

Land preparation and planting materials

Before transplanted the corn seedling into the planting bed, the land was cleared and ploughed to break the hardpan of the BRIS soil and were planked before levelling. The land was ploughed at the recommended depth about 15 cm for better root penetration of corn crop and for equal distribution of irrigation and fertilizer (Ozpinar, 2009). The seedbed was prepared by using cultivator (cross-wise) followed by rotavator. The size of bed is 2 m × 50 m each. Twenty kilograms of organic fertilize (Aviafic™, Malaysia) and 3kg of "green nitrophoska" (EuroChem Antwerpen NV™, Belgium) were applied per bed. The beds then were covered with silver shine. Distance between plant is approximately 30 cm apart. Nitrogen fertilizer (180 kg ha-1), phosphorus (60 kg ha-1) and potassium (60 kg ha-1) were applied in split twice, first half at the time of sowing and second half at the time of silking stage of corn.

Plant traits measurement

Plant traits were measured to investigate the growth of corn crop at BRIS soil area. Two corn plants per bed were randomly selected for plant traits measurement. The plant traits measured were plant height, corn ear height, dry straw weight, ear weight, ear length, grain dry weight and shell weight. The height of plant and corn ear were measured using measuring tape (Skylon, China). The height of the plants was measured once per week starting from the first day of transplanting until the age of plant reach 49 days (plant started to produce male flower). The corn ear height was measured once it is matured and ready to harvest. The length and weight of the corn ear was measured after harvested. The weight of corn ear, straw, grain and corn shell was measured by using balance (Sartarius, LC 6200S, Germany). In order to measure the dry weight, samples were harvested and dried in an oven at 75°C until reaching constant mass (~48 h).

Insect sampling and identification

Data of insects were taken at two days interval starting from days of transplanting until the crop harvested. The observation was done in cool hours of the day i.e. 07:00-10:00 hours or 16:00-18:00 hours. All insect pest observed at the field were collected and brought to the laboratory for identification based on their morphological characteristic as explained by Alejandro Ortega (1987). Two plants per bed was randomly selected to observe the symptom of damage caused by Asian corn borer (*Ostrinia furnacalis*). The infestation of *O. furnacalis* was surveyed by counting the holes bored by the larvae of this insect pest on the plant stalk.

Plant disease and the isolation of fungus

The symptom of disease on plant was visually observed every two days and the plant part that suspected infected with disease were collected. Samples were labelled, kept in cold box and brought to the laboratory for further investigation. As the symptom of disease on plant shows the sign of fungus infection, the Potato Dextrose Agar (PDA) powder was used to isolate the fungus. Potato Dextrose Agar powder (Himedia, India) were weighed accordingly to the manufacturer's instruction. A total of 39 gram of PDA were weighed for 1 litre of distilled water. The powder was put into a conical flask. Then, the desired distilled water was measured by using a measuring cylinder and it were poured into a conical flask containing PDA. The solutions were shake well to dilute the powder completely. The prepared solution was sterilized in an autoclave at 15 psi, 121 °C for 15-20 min. After sterilization, the media were cooled down and were poured into the Petri dishes in the laminar airflow aseptically.

Method to isolate fungus was adopted from Hailmi et al. (2011). The infected leaves and stems tissue with some adjacent healthy tissues were cut around 0.5 cm × 0.5.cm in diameter. Samples were sterilized in 70% ethanol about 1-3 min, washed with distilled water for 1-2 min and air dried on sterile filter paper. Three pieces of samples were placed on each petri plate containing PDA and sealed with Parafilm®, followed by incubation in the dark at room with the temperature of 25 °C for 48 hours. Then observed for sporulating fungi under a light microscope. Any sporulating fungus was identified and a conidium was picked up with a needle for multiplication on PDA. By continuous subculture, the individual fungal strains were re-isolated in order to obtain a pure culture. The fungi were confirmed to their genus based on their conidial morphology and growth characteristics such as the form, length and arrangement of conidiophores, size, septation and chain formation of conidia (Stchigel, 1999). The observations were then referred to the identification keys based on Sunil et al. (2005) and Manoharachary et al. (2016).

Statistical analysis

The data on plant growth and the count number of insect obtained was analysed using R-statistical software version 3.4.0 (R Core Team, 2017). All data of response variables were transformed when necessary to meet the assumptions of normality and homoscedasticity. The mean value with standard error for each plant traits was calculated.

RESULTS AND DISCUSSION

Plant traits

The measurement on plant traits is a common practice to assess the events occurs during plant growth and it is eventually important in the prediction of yield of crop (Hokmalipour and Darbandi, 2012). In this experiment, the data on plant traits (Table 1) was collected to investigate the performance of hybrid sweet corn variety Sweet King 516 grown at BRIS soil area in UniSZA Kampus Besut, Terengganu. It is important to measure the performance and adaptability of hybrid corn at this unfertile area as it correlate to the plant resistance and persistency against pest (Mitchell et al., 2016). Our data shows the performance and adaptability of hybrid sweet corn variety Sweet King 516 is comparable to the local hybrid sweet corn grown at other BRIS soil area at Terengganu done by Nordin et al. (2018).

Table 1. Corn crop traits measurement.

Plant traits measurement	Mean ± SE
Straw dry weight	202.27 ± 10.32 g
Ear height	52.30 ± 4.36 cm
Ear length	29.00 ± 1.23 cm
Ear dry weight	120.29 ± 2.97 g
Grain dry weight	29.39 ± 1.11 g

Mean ± Standard Error (SE) for straw dry weight, ear height, ear length, ear dry weight and grain dry weight.

Fig. 1 shows the height of plant was increased from the first day of transplanting until day 49. There is no strange pattern on the plant height was observed in this experiment, thus the growth of plant can be considered as normal. The rate of plant height is varied depending on the growth of stages of plant (Tajul et al., 2013) and may influence the attachment of the plant roots to the soil (Nordin et al., 2018).

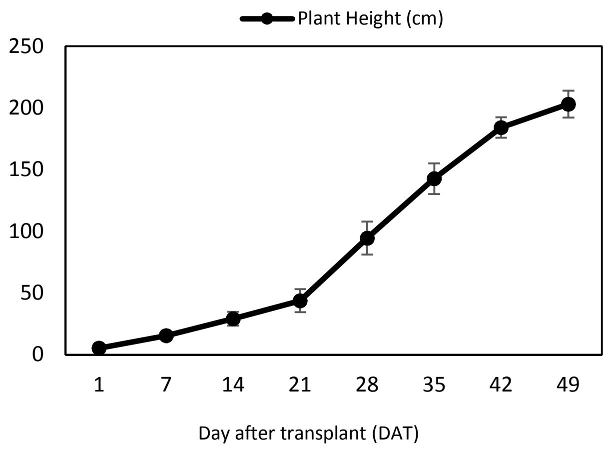

Fig. 1. Plant height of hybrid sweet corn variety Sugar King 516 at BRIS soil area.

Insect associated with corn at BRIS soil area

Total of 557 insects were collected in this survey. Insect pest consisted of 234 individuals from 13 different species, while another 323 individuals was identified as natural enemies. The insect pest was grasshopper (family Acrididae), katydid (family Tettigoniidae), sweet potato bug (*Physomerus grossipes*- family Coreidae), derbid plant hopper (*Proutista moesta*- family Derbidae), cotton stainer (*Dysdercus* sp- family Pyrrhocoridae), largid bug (*Physopelta* sp- family Largidae), corn leaf hopper (*Peregrinus maidis*- family Delphacidae), corn rootworms (*Diabrotica virgifera*- family Chrysomelidae), green chafer beetle (*Anomala albopilosa*- family Scarabaeidae) and tussock moth (*Orgyia* sp- family Erebidae). The number of insect pest according to the family as shown in the Figure 2.

The symptom of damage caused by insects are varies depending on their feeding behaviour (Bernays and Chapman, 2007). Types and numbers of insect attacks plants are also differs depending on plant age through all stages of plant growth (War et al., 2018); and different parts are inevitably subject to attack by various groups of insects (Meihls et al., 2012). Insect pest collected in this study can be categorized into two feeding behaviour; sap sucking insects (family: Coreidae, Derbidae, Pyrrhocoridae, Delphacidae and Chrysomelidae) and chewer (family: Acrididae, Tettigoniidae, Chrysomelidae, Scarabaeidae and Erebidae).

In our study, the highest number of insect pest that attacks corn plant was the larvae of tussock moth (132 individuals). This insect appears after the plant started to produce fruits and its attack cob of the corn. As a result, the quality of grain was reduced and devalued the appearance of the cob. Tussock moth is an uncommon insect pest that attack corn and did not listed as one of the major insect pests in Malaysia. However, the larvae of the moth from Erebidae family is well known can cause serious losses in tree orchards, urban parks and home lots where it often completely defoliates ornamental and shade trees (Schowalter and Ring, 2017).

We only collected 34 individuals of *P. maidis* (corn planthopper) and 13 individuals of *D. virgifera* (corn rootworm) during the experiment. Both of these insect species were recognized as an economically important pest of corn (Singh and Seetharama 2008; Meinke et al. 2009). Corn planthopper breaks through the plant vascular tissue to feeds on the sap exuded. The symptom of damage cause by this insect includes wilting, yellowing of the leaves, stem weakness, and even death. Corn planthopper is known to be a vector of at least two viral diseases of maize (Tsai, 2008) where this secondary infection may lead to the plant death. On the other hand, adults of rootworm feed primarily on corn silk, pollen and kernels on exposed ear tips. This insect made a damage on plants by scraping away the green surface tissue and leaving a window-pane appearance.

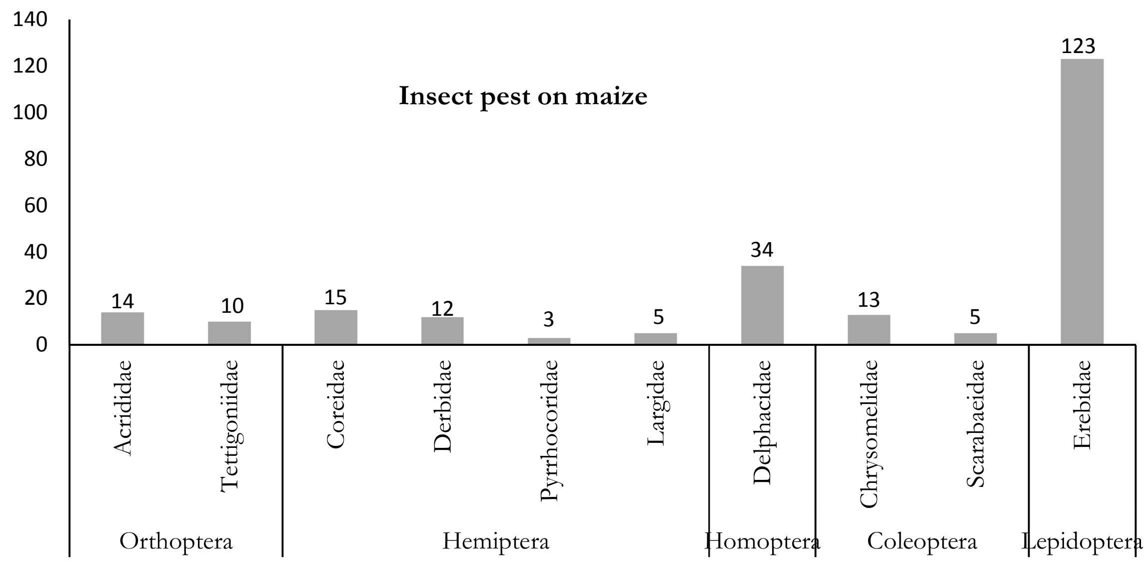

Fig. 2. Insect pest collected on maize plant.

Three species of insect natural enemies was identified in this survey. Asian lady beetles (*Harmonia axyridis*- family Coccinellidae) was the most abundance natural enemies collected in the experiment (310 individuals). We also collected 10 individuals of transverse lady beetle (*Coccinella transversalis*- family Coccinellidae) and three individuals of assassin bug (family Reduviidae). Lady beetles is a common predatory insect that used in biological control program worldwide (Evans, 2009). Adult and immature of lady beetles predate many types of insect by chewing the whole body of their pray. Assassin bug is known as a terrestrial ambush predator. This insect uses their long rostrum to suck out the fluid from the body of their prey (Wheeler, 2001).

In this experiment, we also surveyed the symptom of damage made by the stem borer (*Ostrinia furnacalis*- family Crambidae). This nocturnal insect is considered one of the most destructive insect pests of corn (Kojima et al., 2010; Tan et al., 2011). It was difficult to control this insect as the adult flies at night, thus the simple's way to access their presence is by evaluating and counting their symptom of damage. This insect attacks all parts of the plant. Late-instar larvae bore into the stem or branches of corn plant or webbed groups of florets or branches. They bore in the shank and cob in the ear or feed on silk or kernels. The stalk is the most common feeding site for final-instar larvae. From the observation during the experiment, the mean number of holes made by *O. furnacalis* was (4.26 ±0.25) holes per plant. Depending on this number, the damage caused by the attack of stem borer in this experiment can be classified as severe.

Plant disease

Two species of fungal pathogen that attacks corn in this experiment were identified as *Fusarium* sp. (Fig. 3) and *Puccinia* sp (Fig, 4). *Fusarium* sp. were found cause stem rot while *Puccinia* sp. cause leaf rust. *Fusarium* sp. can infect any part of the corn and severe infection by this fungus causing reduced growth, rotted leaf sheaths and internal stalk tissue and brown streaks in the lower internodes. This pathogen also can reduce the value and quality of crops by massive accumulation of Fusarium mushroom mycelia masses on grains and corn cobs as well as contamination with specific mycotoxins such as deoxynivalenol (DON) zearalenone (ZEA) and fumonisin (FUM) (Richard et al., 2007). Rust cause by *Puccinia* sp is a very common disease in corn plantation; but cause no real economic damage to the plant. The symptom of infection commonly observed as deposits of powdery rust-coloured or brown spores on plant surfaces.

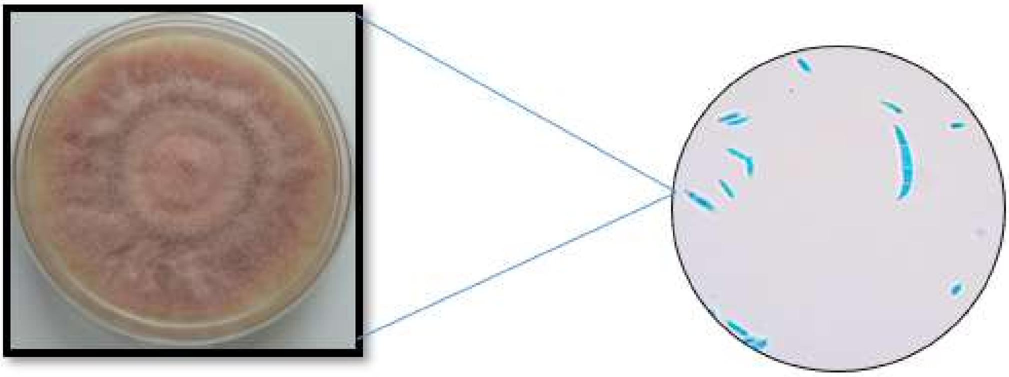

Fig 3. : Conidiophore of *Fusarium* sp.

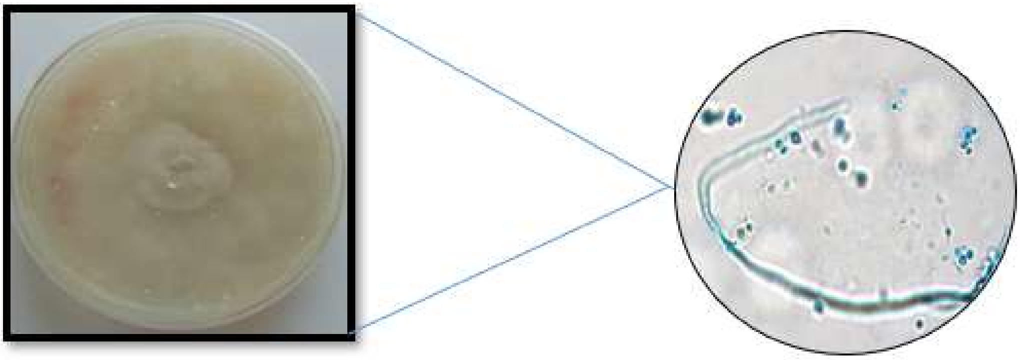

Fig 4. *Conidiophore of Puccinia* sp.

CONCLUSION

Corn crop was infested by many insect pests and attacked by numerous plant diseases during its entire growth period. However, insect pest infestation was balanced with the appearance of natural enemies such as predatory insect and parasitoid. The species of insect that attacks plants may depends on the location and the surrounding environment. In our experiment, we found out the most abundance insect that attacks corn plant is tussock moth. The larvae of this moth are the main pest of tree or shrub. This insect was not reported as an economic important pest of corn or other plant crop in Malaysia. Tussock moth might be there and infested on acacia plant before the area was cleared and cultivated with corn. This insect may switch their host from acacia plant to corn since it has an ability to attack many types of plant. On the other hand, the pathogen that attack corn plant is common in the environment where the spores of these fungus can be transferred either by the wind or by water. As a consequence, the growth of corn crop might be affected, but the damage is depending on how severe the attack is. Result obtained from this study will educate the farmers about threat from pest and disease that may give a damage to their plant crop. Although the effort to improve the fertility of BRIS soil is important in getting the best crop yield, the focus on pest management should also be considered.

ACKNOWLEDGMENTS

Authors would like to thank the UniSZA farm workers for their help during this experiment.

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Zakaria, Abd Jamil. Personal communication. April 19th, 2018.

How to cite this paper:
Sulong, Y., Zakaria, A.B., Salmah, M., Sajili, M.H. & Ngah, N. (2019). Survey on pest and disease of corn (*Zea Mays Linn*) at BRIS soil area. Journal of Agrobiotechnology*, 10*(1S), 75-87