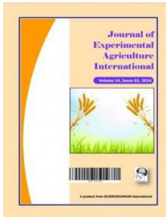

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Occurrence of Different Kinds of Diseases in Sesame Cultivation in Myanmar and Their Impact to Sesame Yield

Yu Yu Min[1*] and Koki Toyota[2]

[1]*Department of Agricultural Microbiology, Yezin Agricultural University, Nay Pyi Taw, Myanmar.*
[2]*Graduate School of Bio-Applications and Systems Engineering, Tokyo University of Agriculture and Technology, 2-24-16, Nakacho, Koganei, Tokyo 184-8588, Japan.*

Authors' contributions

This work was carried out in collaboration between both authors. Author YYM designed the study with author KT and wrote the first draft of the manuscript. Authors YYM and KT finalized the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

We surveyed diseases of sesame in 10 farmers' fields at Nay Pyi Taw, Myanmar and did interviews 25 farmers for the occurrence of diseases and its impact on yield in Magway, the major sesame growing area in Myanmar. We found phyllody, charcoal rot (root and stem rot), Alternaria leaf blight, powdery mildew, and leaf curl, based on on-site symptoms and their microscopic observation in Nay Pyi Taw. The disease incidence ranged from 5% to 30% in phyllody, from 10% to 30% in charcoal rot (root and stem rot) and 10% to 40% in Alternaria blight, while leaf curl and powdery mildew were not observed abundantly. According to interviews conducted in Magway, 60% of the farmers suffered from phyllody disease symptoms, 80% from charcoal rot, 48% from Cercospora, 28% bacterial leaf spot and 24% diseases with the symptoms of leaf roll. Most farmers (84%) noticed combinations of diseases symptoms either phyllody or charcoal rot/black and stem rot or Cercospora leaf spot and/or bacterial leaf spot. Yield losses ranged from 5 to 50% by phyllody, from 10 to 75% by charcoal rot (root and stem rot), from 5 to 50% by Cercospora leaf spot, and 5% by

**Corresponding author: E-mail: yumindin@gmail.com;*

bacterial leaf spot. Other abnormal symptoms such as discoloring of root, seedling death and leaf yellowing were also observed and the yield losses ranged from 5 to 50%.There were no significance relations between the actual yield and yield losses estimated by each disease. A half of farmers (54%) burnt the crop residues after harvest, while 45% directly buried them in their fields including plant parts infected with diseases. Although there was no difference in sesame yield between these two practices, the average yield was higher by 15% in farmers with the burnt practice. Only a few farmers applied fungicides. Potential constraints to cause yield reduction and necessary actions to increase sesame yield are discussed.

Keywords: Alternaria; charcoal rot; control measures; disease incidence; phyllody; yield loss.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is the major oilseed crop in Myanmar for both export and domestic consumption. Myanmar stands the second largest producer of sesame in the world [1]. Sesame is cultivated two times a year: May to August as the monsoon crop and September or October to December as the cool season cultivation. The total sesame sown area in 2017-2018 was 1.6 million ha, in which 829,000 t of sesame was produced with the yield of 0.54 t ha^{-1} [2]. The sesame yield in Myanmar is low compared with that in other major sesame producing countries such as 1.41 t ha^{-1} in China, 0.90 t ha^{-1} in Bangladesh and 0.78 t ha^{-1} in Ethiopia [1]. In Myanmar, 80% of the sown area is within the central dry zone, which comprises parts of Mandalay, Sagaing and Magway regions and makes up the major growing area for oilseed crops.

Sesame is damaged by a number of fungal, bacterial and viral diseases, such as *Cercospora sesami*, *Cylindrosporium sesami*, *Alternaria seasami*, *Pseudomonas sesami*, *Macrophomina phaseoli*, *Phytophthora parasitica*, *Oidium* spp., *Erysiphe cirhoracearum*, *Phytophthora nicotianae* var. *sesame* and *Helminthosporium sesamiare* [3]. Considerable yield losses due to diseases have been reported; yield losses of 45% by the powdery mildew, *Luveillutataurica*, 55%-90% by phyllody disease caused by phytoplasma [4,5], 5-100% by *M. phasiolina*, 22-53% by Cercopspora leaf spot [6]. A disease complex of powdery mildew with dry root rot disease, which is caused by the fungi *Macrophomina* and *Oidium*, results in low productivity of sesame in India [7].

In Myanmar, different symptoms in sesame cultivation have been reported by the Department of Plant Pathology, Yezin Agricultural University. They are virescence, yellowing floral sterility and stem proliferation, dark brown rounded to irregular lesions on leaves, and dirty white powder etc. However, in-depth investigations have not been undertaken in Myanmar until now and there is no sufficient information on the major threat of sesame cultivation, making it difficult to develop suitable disease control measures. Available information in Myanmar is only the studies by Win et al. [8] who worked on phyllody disease and by Wai et al. [9] who did varietal screening against charcoal rot disease caused by *M. phaseolina*.

In order to properly manage diseases in the field, it is necessary to know the incidence and distribution of each sesame disease and their impact on production. In Myanmar, sesame is cultivated by smallholder farmers with minimum inputs. Therefore, expanding knowledge of sesame diseases to local farmers is very important for the development of effective disease control tactics in sustainable agriculture. The aims of this study were to observe the prevalence of sesame diseases and evaluate its control practices by smallholder famers. In this study, we firstly identified different diseases through microscopic examination of specimens collected from sesame fields in Nay Pyi Taw and then evaluated their incidence. Then, we interviewed smallholder famers in Magway regions, one of the major sesame growing areas, on disease occurrence and the impact on sesame yield, and their management practices.

2. MATERIALS AND METHODS

2.1 Disease Specimen Collection

Specimens were collected from four different sesame fields at the flowering time of sesame, in the middle of June 2016 in Yezin, Pyinmana located in Nay Pyi Taw areas. The appearance of aboveground disease symptoms which were likely to be charcoal rot, Alternaria blight, powdery mildew, phyllody and leaf curl was carefully observed and recorded in each field with photographs of the disease symptoms. Then, the specimens collected were put into a plastic bag and taken to the laboratory for microscopic examination.

2.1.1 Microscopic examination

Microscopic examination was done in the laboratory of Plant Pathology at Yezin Agricultural University. Specimens were collected from symptoms on the fresh leaf specimens with dark brown color round to irregular zonate lesions, dirty white powdery substance on leaves and black dots on stems and carefully checked for the presence of spores and spore fruiting body of pathogens under low and high-power objective lens (10x and 40x) [10].

For charcoal rot disease, firstly the bark of diseased stems of sesame was peeled off and placed onto a drop of sterilized water on a slide and checked under microscope. For mycelium observation, a drop of sterilized water was placed on a clean glass slide and the bark of diseased stems of sesame was peeled off and cut into small pieces and surface sterilized with 95% ethyl alcohol for 30 seconds and transferred into 10% sodium hypochlorite for one minute. Then, the specimens were washed into sterilized water for three times and finally the pieces were dried and transferred onto water agar and incubated at room temperature. After three days of incubation, the mycelium formation of *Macrophomina phaseolina* name was confirmed.

For Alternaria leaf blight, a drop of sterilized water was placed on a clean glass slide. A small amount of fungal spores taken from the dark brown irregular lesions on the leaves was placed into a drop of water drop and covered with a cover slip. Morphological characteristics of conidia and conidiophores of the causal organism were checked and then identified.

For powdery mildew, a drop of sterilized water was placed on a clean glass slide. Three to five pieces of thin cross section leaves collected from plant parts showing dirty whitish fungal patches were cut with sterilized razor blade and put in a water drop on the slide and covered with a cover slip. Shape, color, spore size of conidia and conidiophores were observed under the microscope.

2.1.2 Occurrence of sesame diseases in Nay Pyi Taw

A total ten sesame fields were surveyed for the occurrence of phyllody, charcoal rot, Alternaria leaf blight in northern part of Nay Pyi Taw area in 2016. Out of ten fields, four fields from Pyinmanar, three from Pobbathri and three from Zeyathiri township were selected. Aboveground symptoms, in particular appearance of each disease, were carefully checked across the field using the diagonal method of sampling. Sesame was planted with a spacing of 36 x 36 cm in the field. We walked in the field diagonally and checked the occurrence of each disease every 7 m. The percentage of infected plants was recorded based on the visual examination. Disease incidence was calculated on the basis of percent plant infected in total plant populations. Symptoms of charcoal rot/root and stem rot disease; black dots on the stems, Alternaria leaf blight, powdery mildew and phyllody were observed in several sesame fields as shown in plates 1, 2, 3 and 4. Except for phyllody disease, microscopic examination of above ground symptoms of charcoal rot/root and stem rot, Alternaria blight and powdery mildews were checked using the infected leaf and stem samples. The presence of pathogen spores: pycnidia and pycnidiospores of *M. phaseolina* on the bark of sesame stems (Plate 1), Alternaria spore when fungal spores were taken from black color lesions on leaves (Plate 2) and pathogens of *Oidium* with hyaline barrel shaped spore after making cross section of white powdery mildews appearance on sesame leaves (Plate 3) were observed.

2.2 Evaluation of Awareness of Sesame Diseases and Control Measures by Smallholder Farmers in Magway

The large proportion of farmers is engaged in sesame production throughout the year in Magway Township. Photographs were prepared for typical disease symptoms of Charcoal rot, phyllody, Alternaria leaf blight, leaf curl, Cercospora leaf spot and bacterial leaf spot with their causal agents. Using the photographs and questionnaires, a disease survey was conducted in three villages in Magway Township during the harvesting period in August 2016. A total of 25 farmers were surveyed on their knowledge of sesame diseases. When the disease symptoms were noticed by farmers in their fields, the effect on sesame yield and control measures were interviewed. Additional information on farm experience, cultivation practices, inputs and constraints on sesame production and management practices was also collected.

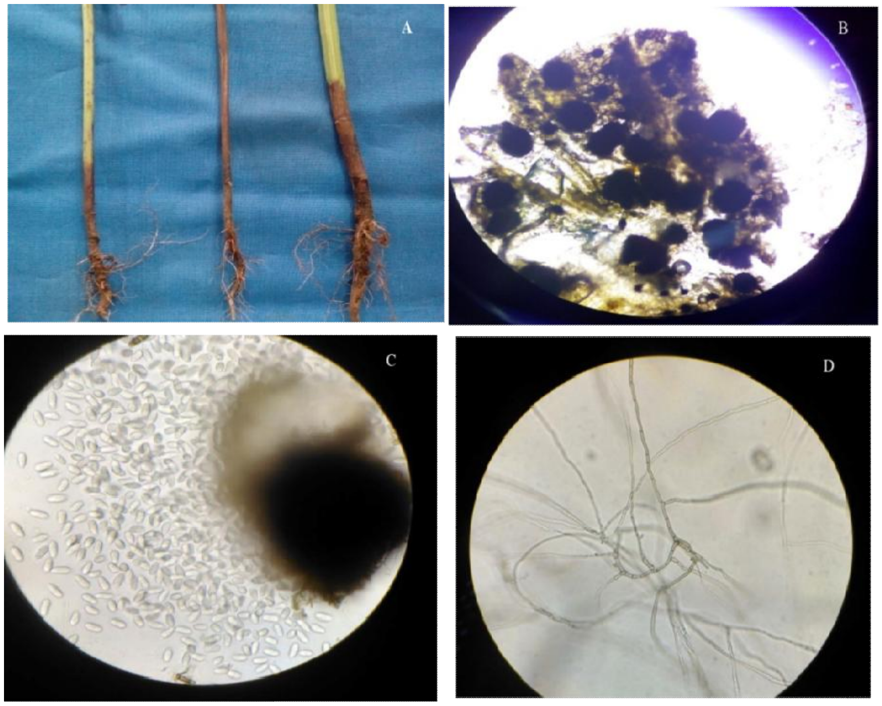

Plate 1. (A) Elongated brownish dark lesions on stem, (B) Pycnidia formation on bark of sesame stem, (C) Pycnidia and pycnidiospores of *M. phaseloina* (40x), (D) Hypha of *Rhizoctonia bataticola* (40x)

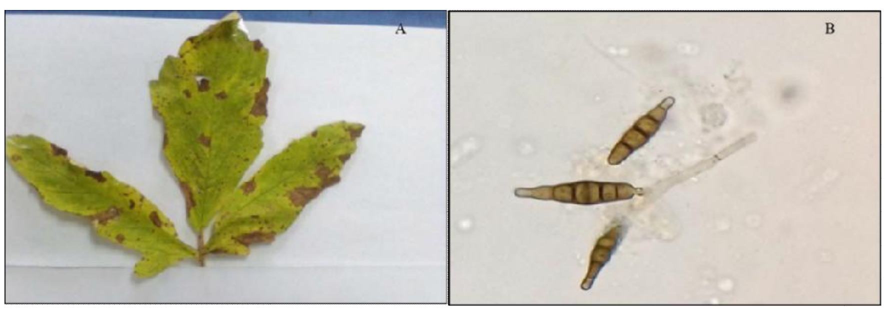

Plate 2. (A) Dark brown irregular lesions with concentric ring on sesame leaves, (B) Conidia of *A. sesami* taken from dark brown lesions leaves (40x)

3. RESULTS

3.1 Occurrence of Sesame Diseases and Its Incidence in Nay Pyi Taw

Disease symptoms of phyllody, charcoal rot and Alternaria blight were most frequently observed in all survey fields. The disease incidence (DI) % of phyllody, charcoal rot (stem rot), and Alternaria blight ranged from 5%-30%, 10%-30% and 5%-40%, respectively (Table 1). Symptoms of leaf curl, powdery mildew were not abundantly observed in Nay Pyi Taw area and their incidences were not assessed.

3.2 Observation of Sesame Diseases and Control Measures by Smallholder Farmers in Magway Region

3.2.1 Cropping patterns

According to the results of present questionnaires survey, 84% of the farmers (21 out of 25) cultivated sesame alone in the monsoon cultivation and 16% of farmers did sesame with pigeon pea or other kinds of pulses. Black sesame (Sinyadar 13) was the most popular variety with yields of 245-735 kg ha^{-1}.

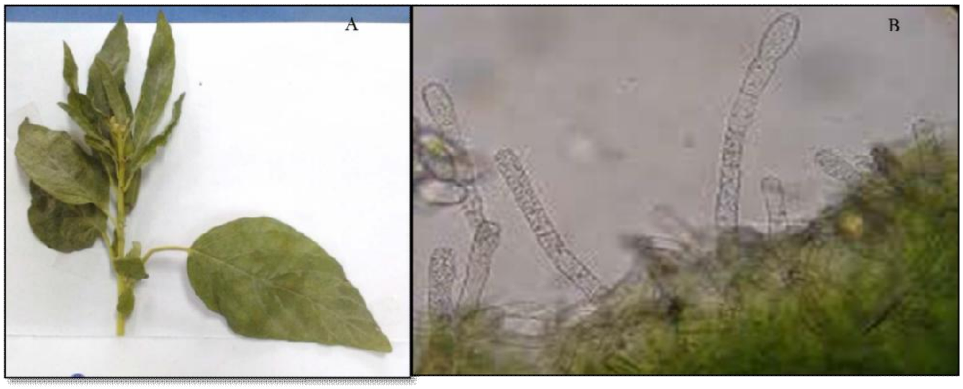

Plate 3. (A) Dirty white podwery on sesame, (B) Condia and condiophores of *Oidium* spp. (40x) after cross section of leaves with dirty white spot

Plate 4. Transformation of flora parts into green leafy structure

Table 1. Occurrence of sesame diseases and their incidence (%) in Nay Pyi Taw area

Field no.	Phyllody disease	Black stem rot	Alternaria leaf blight
1	0	20	10
2	20	15	30
3	10	10	20
4	5	25	15
5	10	30	5
6	20	25	20
7	30	15	30
8	20	10	40
9	10	20	30
10	15	30	25
Avg.	14	20	22.5

3.3 Incidence of Sesame Diseases and Yield Loss

Sixty percent of the farmers interviewed (15 out of 25) noticed phyllody disease symptoms in their fields, 80% charcoal rot, 48% Cercospora, 28% bacterial leaf spot and 24% diseases with the symptoms of leaf roll (Fig. 1). Most farmers (84%) confirmed simultaneous presence of phyllody or charcoal rot/black and stem rot or Cercospora leaf spot and/or bacterial leaf spot (Fig. 2). All disease symptoms were apparently noticed by farmers 30 days onwards after sowing. In case of phyllody, yield losses ranged from 5 to 50%, while symptoms of stem rot and Cercospora leaf spot brought yield losses ranging from 10 to 75% and 5 to 50%, respectively. A little yield reduction (5%) was caused by the symptoms of bacterial leaf spot. (Fig. 3a,b,c,d).

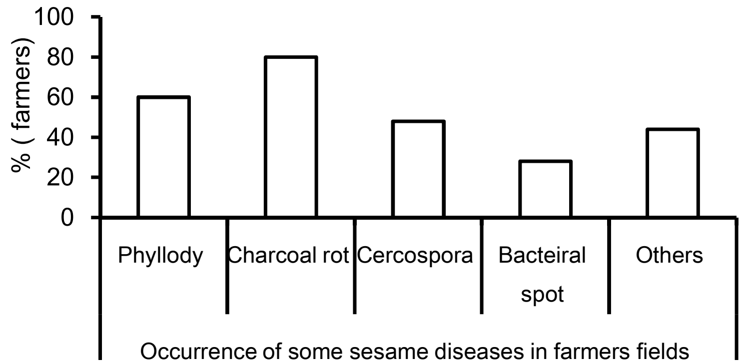

Fig. 1. Percentage of farmers reporting from sesame diseases based on interviewing a total of 25 farmers in Magway

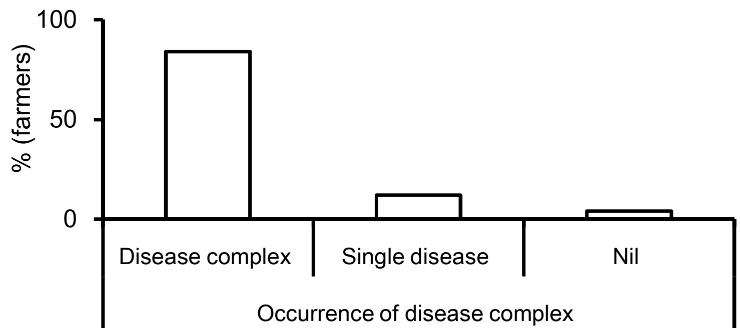

Fig. 2. Ratio (%) of farmers (total 25) who suffered from sesame diseases complex

No one answered that they noticed the symptoms of powdery mildew and Alternaria leaf blight on their sesame. Some farmers additionally reported the occurrence of abnormal symptoms showing red-colored root and seedling death, root rot, and leaf yellowing in their fields around 20 to 40 days after sowing. These occurrences seemed to reduce sesame yield by 5 to 50% when these symptoms were observed in their fields (Fig. 3e). No significant correlation was found between the actual yield and yield loss estimated for phyllody, charcoal rot, Cercospora, bacterial leaf spot and other diseases that were reported by famers in Magway (Fig. 3a,b,c,d,e).

3.4 Strategies Used to Manage Sesame Diseases by Smallholder Farmers in Magway Region

In the survey areas, 54% of farmers burned sesame crop residues while 45% farmers directly buried them in the soil including plant parts infected with diseases. Although there was no difference in sesame yield between these two practices, the average yield was higher by 15% in farmers with the burnt practice (Fig. 4a,b). Only a few farmers applied fungicides such as carbendazim for charcoal rot/black rot of stem and imidacloprid for phyllody diseases to the field.

4. DISCUSSION

The present study revealed that sesame cultivation in Nay Pyi Taw and Magway, Myanmar was adversely affected or reduced by mixtures of diseases that are caused by *Candidatus Phytoplasma*, *Macrophomina*, *Alternaria*, *Oidium*, *Cercospora* and *Xanthomonas* etc. Among the diseases, phyllody and charcoal rot diseases were prominent in both areas. According to Gupta et al. [6], sesame phyllody disease caused by *Phytoplasma* can be prevalent throughout the year and is transmitted by the insect vector (*Orosius albicinctus*). Although their study did not mention disease incidence and yield losses, the present study showed disease incidence of phyllody ranging from 5 to 30% and yield losses by up to 50% in Magway.

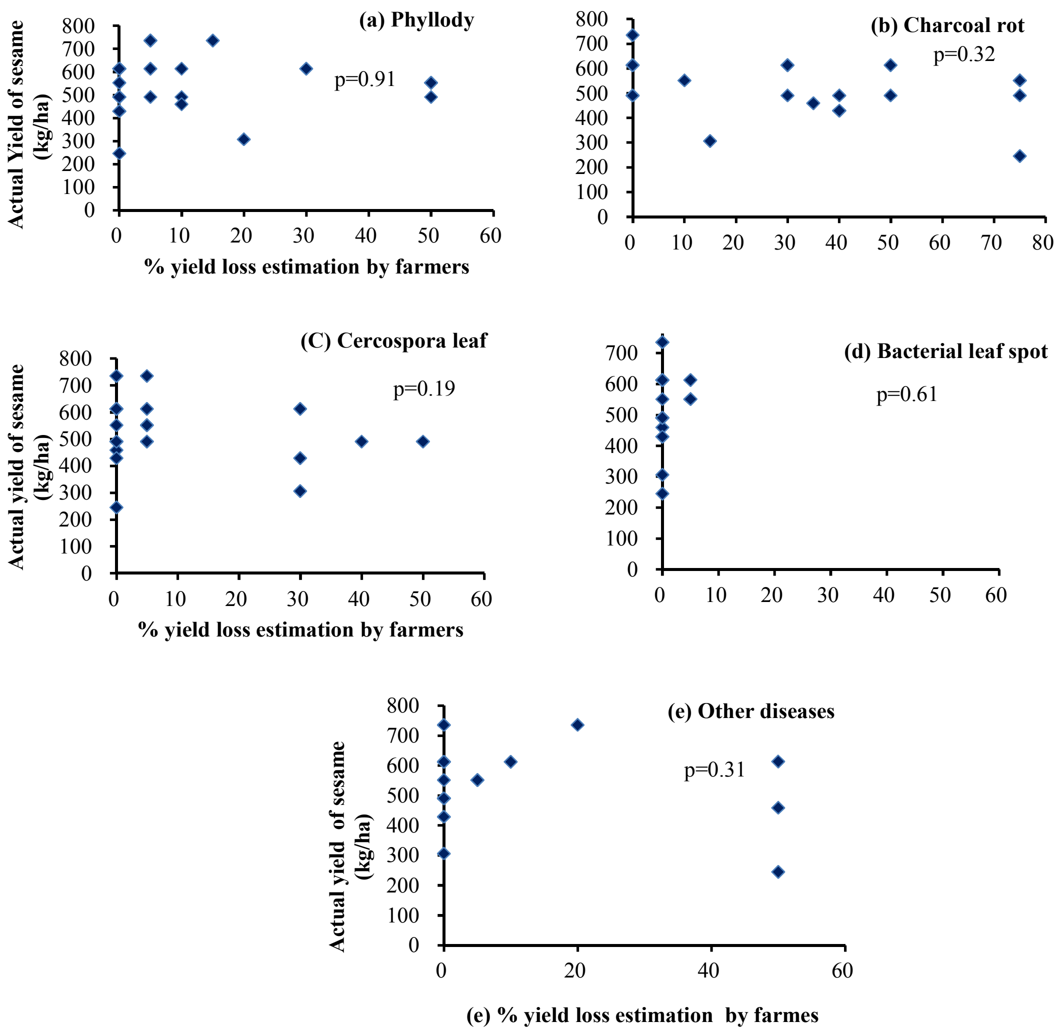

Fig. 3. Relationship between estimated yield loss due to (a) phyllody, (b) charcoal rot, (c) Cercospora leaf spot, (d) bacterial leaf spot, (e) other diseases reported by farmers and their actual sesame yield in Magway

In general, root rot caused by *M. phaseolina* is the most devastating disease in many sesame producing countries such as India and Pakistan [11,12,13]. Murugesan et al. [14] reported that 1% increase in the incidence of *M. phaseolina* reduced seed yield by 1.8 kg ha^{-1}. In this study, 30% of disease incidence was recorded by charcoal rot disease and almost all the farmers experienced a yield reduction up to 10 to 75% when they noticed charcoal rot symptoms in their fields, indicating that the disease incidence of *M. phaseolina* and its yield losses would be the largest in sesame cultivation.

We did not identify the actual disease incidence and severity of each disease in farmer fields in Magway, instead, we asked farmers for their yield and knowledge on sesame diseases. Most of the farmers in Myanmar are living in rural areas and outskirts and thus understanding of their perceptions and knowledge on constraints of sesame production are very important to analyze the impact of diseases on sesame yield and efficiency of their control measures. However, it was difficult to conclude contribution of diseases to yield loss directly in this study, because there were no significant relations between actual sesame yield and yield loss estimated by each disease (Fig. 3a,b,c,d,e).

Low yields have been attributed to several factors, e.g. variety, agronomic practices, soil salinity, poor drainage, poor planting methods(broadcasting), weeds, diseases and

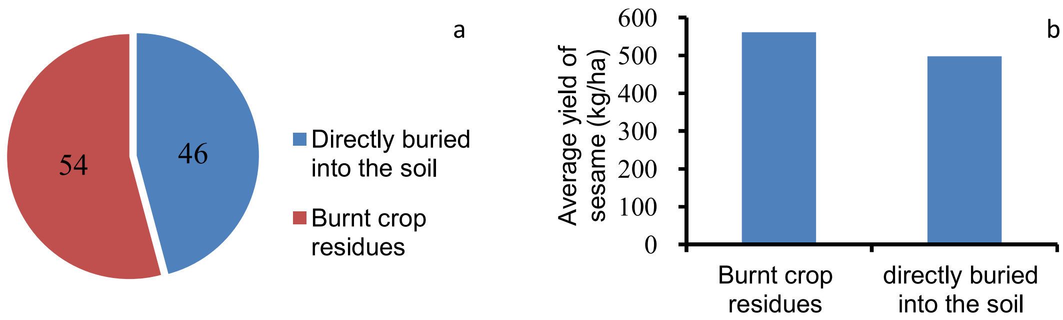

Fig. 4. Percentage of farmers with different crop residue managements (a) and sesame yield in each management type (b). Results in a total of 24 farmers in Magway

insect pests [4,15]. In Magway region, sesame has been rotated with pulses for more than 20 years and is the major income source for small scale farmers. It is grown as a single crop or intercropped with pigeon pea. Most of the farmers used sources of sesame seeds from their local markets while others purchased seeds from the Department of Agriculture in Magway township. Cowdung manure and basal fertilizers are applied during land preparation. Insecticides to control leaf roll were sprayed within 15 to 45 days after sowing if necessary. Although the recommended rate of balanced fertilizers was 125 kg urea (58 kg N) ha^{-1}, 125 kg triple super phosphate (23.5 kg P) ha^{-1} and 62 kg potash (32.5 kg K) ha^{-1} for sesame production, the practical application rates varied among the farmers.

One or several of these reasons could probably affect low yields in Myanmar. Most of the famers seemed to lack the knowledge on the proper use of fertilizers throughout the crop growing season. Recently, the presence of pigeon pea cyst nematode *Heterodera cajani* has been confirmed in sesame cultivated fields in Magway (unpublished data). Therefore, improper fertilization and/or the nematode might cause damage and thus yield reduction. Densities of cyst nematodes in sesame cultivated fields relation to yield are now under investigation.

Although farmers noticed abnormal symptoms, sometimes serious ones, in their fields, most farmers did not take an action. This is because farmers did not either pay attention to diseases or know effective control measures. At present, chemical fungicides are the first choice for farmers to combat diseases because of their easy applicability and immediate therapy [7]. In the present study, farmers did not clearly recognize the name of chemicals even though they used them. Fungicides still play a vital role in the control of the diseases due to the lacks of certified disease-free sesame seeds and proper sanitation in their fields.

5. CONCLUSION AND RECOMMENDATION

Based on the microscopic examination of symptoms appearance, diseases of charcoal rot, Alternaria blight, powdery mildew and their causal agents were detected. Limited knowledge on sesame diseases was noticed among farmers except for charcoal rot disease (locally called 'Yoeme'). There is a need for more studies on crop loss assessment by individual diseases in Myanmar. The use of chemical fungicide is the only control way to practice so far. Farmers are lacking in enough knowledge on the management of infested crop residues and on proper application of fungicides. Therefore, proper trainings or extension service for sesame diseases and fungicide use should be provided to smallholder sesame producers. In addition, a holistic approach to control diseases should be conducted in order to improve sesame yield qualitatively and quantitatively.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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