Gall rust disease incidence of Falcata (*Paraserianthes falcataria* (L.) Nielsen) in Falcata – based agroforestry systems in Misamis Oriental, Philippines

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Abstract. Falcata – based agroforestry systems in eastern part of Misamis Oriental is affected by gall rust disease caused by *Uromycladium tepperianum* (Sacc,) considered as one of the most destructive disease. The objectives of this study at Misamis Oriental, Northern Mindanao were to (i) determine the status of gall rust disease incidence in selected eastern municipalities and city of Northern Mindanao, and (ii) determine the factors and its relationship with gall rust disease.

The sampling intensity was 10% or 1,000 m² of one hectare at each site. Twenty temporary sample plots per municipalities and city were identified and assessed with a total of 140 plots. Each plot contained 15-70 trees for observation. Gall rust disease incidence per municipalities and city varies ranging from occasional to very common. Across site the incidence is considered common (25->50%). Elevation, spacing and age were associated with reduction or increase in gall rust disease incidence in these parts of Northern Mindanao.

Keywords: Gall rust, falcata, incidence, agroforestry, disease

1. Introduction

Sustainable and profitable management of Falcata-based agroforestry systems necessitates information on pests and diseases. Start-up Falcata-based agroforestry farmers, development and extension officers, and even experienced Falcata – based agroforestry farmers need to grasp the extent of gall rust disease incidence. Few studies on this aspect of management had been implemented and published in Mindanao, usually studies were confined on one site or municipality. The need to control spread cannot be overstated in this part of the country. The disease was first reported in 1990 as an epidemic outbreak in Mindanao Island; by 1995 the disease had spread throughout the Philippines, including Luzon and...
Visayas islands [1]. More than two decades had passed since the last reported incidence and little is known on the extent of infestation in this part of Northern Mindanao.

Timber yield quantity and quality depend on the state of tree health. Aside from the problem on site mismatch, diseases also affect plant health. Gall rust disease (GRD) threatens to derail the livelihoods of agroforestry farmers. Agroforestry farmers, more so those in low average income municipalities are especially at risks because of inherent environmental factors limiting their capacity to avoid infection. The disease has caused severe damages to Falcata from sapling to mature trees in the intercropped and multistorey agroforestry farms [2][3][4][5]. Several plantations were infected by *U. tepperianum* in Malaysia and Indonesia [1].

To reduce pressure on natural forest, increase rate of carbon sequestration, promote “trees on farm” and protect tree farmer’s investments, there is a need to study pests and diseases. Agroforestry farmers engaged in this enterprise need to be protected to be able to produce required quantity and quality of products. Best quality products from this agroforestry system will provide agroforestry farmer leverage for higher price. In effect, encourage more integration of trees and establishment of agroforestry systems. A study was conducted to determine the status of gall rust disease incidence (GRDI) in selected Eastern municipalities and city in Misamis Oriental and determine the factors and its relationship with GRDI.

2. Materials and Methods

2.1 Study site
Registered and unregistered Falcata-based agroforestry farms were randomly selected in Gingoog City and selected municipalities of Misamis Oriental: Medina, Talisayan, Balingoan, Kinoguitan, Sugbongcogon and Claveria. An approximately 140 Falcata–based agroforestry farms (20 farms per municipality/city) were visited for the collection of primary data required in determining GRDI. The minimum area to be considered a site is 0.25 ha or 2,500 m² per site. If two or more Falcata farms were owned by a single farmer but situated in different location then each site was considered as separate sites.

2.2 Plot establishment
The sampling intensity was 10% of one (1) ha. A rectangular temporary sample plot was established with a dimension of 20 m x 50 m or 1000 m² (Figure 1).

![Figure 1. Establishment of 20 m x 50 m sample plot.](image)

2.3 Data collection
The farms of randomly identified farmers were visited for assessment (Figure 2b) from August 2018 to January 2019. The primary data collected were GRDI and local site conditions: coordinates, age of Falcata, elevation, intercropped agricultural crops and other cultural management practices
implemented. The coordinates of each identified sites and elevation was recorded using a geographic positioning system (etrx 10/75csx, Garmin) (Figure 2a). These data includes the latitude and longitude of the site. Age of Falcata was reckoned from the date of establishment. The elevation of each site was determined using GPS (etrx 10/75csx, Garmin). Spacing was determined by direct measurement. Data were collected once in each sample plot.

Figure 2. a. Recording the coordinate, elevation, aspect, temperature, and barometer. b. Assessment of diseases in Falcata - based agroforestry system.

2.4 Assessment of gall rust disease incidence
For disease identification, each plantation was surveyed for the presence of diseases. Trees within the plot were evaluated closely and documented (Figure 3). The location (i.e. stem, branch, knots) and position of the infection was recorded. Samples were collected from each site.

Figure 3. a. Gall in the trunk. b. The shape of gall in the twig. c. Gall in the branch.
2.5 Data assessment and analysis

Assessment of disease incidence (DI) for each plot was calculated using equation (1) [1] where DI is disease incidence per plot; n is number of infected trees in a plot; N is total number of trees in a plot:

\[
DI = \frac{n}{N} \times 100\%
\]  

(1)

| Value for disease incidence | Incidence status       |
|-----------------------------|------------------------|
| < 10                        | Rare                   |
| 10 - <25                    | Occasional             |
| 25 - <50                    | Common                 |
| 50 - <75                    | Very Common            |
| > 75                        | Widespread             |

Table 1. Gall rust disease incidence on *P. falcataria* in Misamis Oriental, Philippines.

The GRDI is influenced by the interaction of many factors ranging from host, environment and pathogen [1]. In order to determine the relationships between GRDI and local environmental conditions (i.e. elevation, spacing and age), a correlation (STATA v. 10, StataCorp) was used. Percentage, mean and correlation analysis was conducted using the statistical package of the STATA v. 10.

3. Results and Discussion

3.1 Gall rust disease incidence

Mean gall rust disease incidence was common (47 %) in Misamis Oriental (Table 2). The mean incidence across sites ranges from occasional (23.4 %) found in agroforestry systems evaluated at Talisayan to very common (63.6 %) found in agroforestry systems evaluated at Gingoog City. The sites were these agroforestry systems were found are characterized as having an elevation ranging from 152 masl to 975 masl, in trees ages 1 yr to 9 yr, and spacing between 6 m² to 16 m². Relative to the sites assessed, the municipality of Claveria are highest in terms of elevation and age on the average. It also had the widest spacing compared to other municipalities and city. Also, the municipality of Claveria which is situated at 975 masl have plots with incidence status considered as widespread (all 20 plots infected with gall rust disease).
Table 2. Gall rust disease incidence, biological and physical characteristics by municipalities and city.

| Location      | GRDI (%) | Status           | Elevation (masl) | Age (yr) | Spacing (m²) | Agroforestry system                  |
|---------------|----------|------------------|------------------|----------|--------------|-------------------------------------|
| BALINGOAN     | 24.0     | Occasional       | 230              | 3        | 9            | Intercropping, alley cropping       |
| CLAVERIA      | 56.9     | Very Common      | 975              | 6        | 16           | Intercropping, woodlot, alley       |
|               |          |                  |                  |          |              | cropping, multistorey              |
| GINGOOG CITY  | 63.6     | Very Common      | 458              | 3        | 12           | Multistorey, alley cropping,        |
|               |          |                  |                  |          |              | boundary planting, taungya          |
|               |          |                  |                  |          |              | Intercropping                       |
| KINOOGUITAN   | 49.4     | Common           | 213              | 4        | 6            | Alley cropping, multistorey         |
| MEDINA        | 51.7     | Very Common      | 235              | 4        | 9            | Alley cropping, multistorey, woodlot|
| SUGBONGCOGON  | 60.3     | Very Common      | 440              | 4        | 8            | Alley cropping, multistorey, woodlot|
| TALISAYAN     | 23.4     | Occasional       | 152              | 4        | 12           | Intercropping, multistorey, alley  |
|               |          |                  |                  |          |              | cropping, boundary planting         |
| Mean          | 47.0     | Common           | 386              | 4        | 10           |                                     |

Gall rust developed in twigs, branch and stems. The result implied that gall rust disease appears in agroforestry farms located both at low and high elevation. The incidence across sites is lower than reported incidence [6] at 92% for Falcata in Gingoog City. As mentioned, heavy infections occur at elevations ranging from 275 to 500 masl. However, the study inferred otherwise. Very common status had been observed even at elevations lower than 275 masl. Some authors [6] [1] stressed that successful infection and spread of gall rust disease is dependent upon the favorable conditions for growth and development of causal agent (U. falcatarium). Elevation may be a determinant to gall rust disease incidence in this part of Misamis Oriental as it influence other environmental factors like wind speed, temperature, humidity, rainfall [6][1]. Mostly, agroforestry systems were established in sloping and elevated areas were Falcata is integrated with various crops to optimize available area. These conditions favours infection and spread of gall rust disease. Relative humidity ≥ 90%, low wind speed (about 30 to 50 km/h/day), fog, steep slope, and being surrounded by high and dense vegetation were the dominant factors leading gall rust disease spread at Brumas Estate, Tawau, Sabah, Malaysia [1].

Generally, gall rust disease incidence is occasional in the municipalities of Balingoan and Talisayan. This could be attributed partly to elevation. The mean elevation of Talisayan is only 152 masl (40 masl to 556 masl) while only 230 masl (107 masl to 519 masl) in Balingoan. [6] supported this observation with their study on Falcata at Gingoog City. They found out that slight infections generally occur at lower elevations ranging from 1 masl to 250 masl.

3.2 Relationships between gall rust disease incidence and local site conditions

Gall rust disease incidence was weak and positively associated with age (Table 3). Study on prevalence of gall rust in falcata in Gingoog City and Malaybalay City showed that gall rust disease incidence increases with an increase in age [4]. However, a study [6] showed that falcata at seedling and sapling stage have average to high intensity of infestation resulted to deformation of trees and heavy defoliation and few death. One explained that it occurs in all growth stages from seedling to the standard tree [7].
Spacing is also weak and negatively associated with gall rust disease incidence (Table 3). The negative association of GRDI with spacing can be explained by its influence on relative humidity and wind speed. High relative humidity and slower wind speed promote gall rust disease development [8]. On the other hand, low temperature and high moisture level favor disease development [9].

Elevation was found to be strongly and positively associated with gall rust disease incidence in this part of the province (Table 3). Similar results have been found with previously published studies [10][6]. Topography was also an important determinant of gall rust disease incidence at Brumas Estate [1] and Gingoog City and Malaybalay City [5].

Table 3. Correlation coefficient (R) between gall rust disease incidence and the predictor variables under different agroforestry systems.

| Gall rust disease incidence (%) | Elevation (masl) | Age (yr) | Spacing (m²) |
|--------------------------------|------------------|----------|--------------|
| Gall rust disease incidence (%) | 1.000            |          |              |
| Elevation (masl)               | 0.5805           | 1.0000   |              |
| Age (yr)                       | 0.1765           | 0.3830   | 1.0000       |
| Spacing (m²)                   | -0.0018          | 0.1917   | 0.0874       | 1.0000       |

4. Conclusion

At the time of monitoring, the level of gall rust disease incidence in these sites varies across municipalities and city. The interaction between local site condition and cultural management practices were determined by the level of incidence. Elevation, spacing and age were significant conditions that increase or decrease gall rust incidence.

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