

Utilization of dry leaf litter for tree tending of urban forest and their production at the arboretum of FOERDIA-Ministry of Environment and Forestry, Bogor, West Java, Indonesia

D Prameswari

Centre for Forest Research and Development, Jl. Gunung Batu 5 Bogor, Indonesia

E-mail: diana_eko@yahoo.com

Abstract. Dry leaf litter are commonly found under forest stands or at arboretum areas in Urban forests. These dry leaves may be used as mulch and fertilizer for tree tending in urban forests. The objective of the paper was to determine the production of leaf waste in the Centre for Forestry Research and Development (CFRD) Arboretum and to identify the characteristics of the compost from those dry leaf litter. The dry leaf litter as mulch is commonly used to maintain newly planted trees or young trees aged less than three years. In this study, the size of dry leaf mulch applied around tree is 50 cm x 50 cm and thickness of dry leaf mulch is about 20 cm. Through this method weeds can be suppressed, so weeds around the planted trees are minimized. Data on weekly production of dry leaf litter at CFRD Arboretum was collected and was found that the production could reach about 0.0043 ton per ha. The dry leaf mulch was processed for compost production and its characteristics were discussed.

1. Introduction

Many urban forests can be found in large cities in the world. The area of urban forests varies from small areas which cover less than one ha till more than five ha. There are many advantages of urban forests. An urban forest is defined as a forest or a collection of trees that grow within a city, town or a suburb. It may include every kind of woody plant vegetation that grows in and around human settlements areas. In a detailed sense which is also sometimes called a forest park, it describes areas where ecosystems are inherited from leftovers or remnants of the wilderness. Activities of caring and the management of urban forests is known as urban forestry. Urban forests can be in the form of public-owned municipal forests, however it may also be located outside the town or city to where the urban forests belong [1, 2].

Urban forests actually play an important role in the ecology of human habitats in many ways such as to filter air, water, sunlight, provide shelter to animals and recreational areas for people. They also influence local moderate climate, slowing wind and storm water, and shading homes and businesses to conserve energy. Urban forests are critical in cooling the urban heat island effect, thus the forests potentially reducing the number of unhealthy ozone days that plague major cities in the world in peak summer months [3].

An arboretum also consists of trees in addition to other plants such as ferns, lianas and grasses. A lot of arboreta are located in big cities. One of the arboreta in Bogor is the Arboretum owned and managed by the Forestry and Environment Research Development and Innovation Agency (FOERDIA). It is an old arboretum in the city located in a forestry research centre under the Ministry of Environment and Forestry Indonesia.

The arboretum produces leaf litter every day and more leaves are produced during the strong wind. Those leaf litter may be used for tending young trees or newly planted seedlings in form of a dry leaf mulch. Those dry leaf mulch can be used directly by putting them around the tree base or by putting the leaves in a net bag and then put them around tree base. There are many advantages of using dry leaf mulches. Other uses of leaf waste from the arboretum include producing compost. The produced



composts can be used as growth media for seedlings procurement. In addition, they may also be utilized as organic fertilizers for newly planted trees or young plants. However, the production of leaf litter in the CFRD Arboretum is no yet known.

The objective of this paper was to determine the production of leaf waste in the CFRD Arboretum and to identify the characteristics of compost from those dry leaf litter.

2. Dry leaf mulch

Mulch is a type of material that originates from agricultural wastes which are by purpose put on the soil of agricultural surface [4]. Fundamentally, there are three classifications of mulch i.e.:

- Organic mulch i.e.waste from agricultural plants e.g. paddy straw, corn stems, banana leaf,
- Grass, saw dus and dry leaf mulch that belong to organic mulch
- Non organic mulch in the form of stones, bricks, gravel small stones, big stones
- Sinthetic chemical mulch i.e.: transparent plastic mulch, black plastic mulch and black silver plastic mulch (known as MPPH)

According to [5] mulching is a material put around trees to suppress weed through physical weight and having additional advantage in the form of reducing water from the soil surface. The use of organic mulch in the form of leaves had been applied by pepper farmers for pepper plantation in the Island of Bangka, Indonesia. Leaves and young branches were collected and scattered among the pepper plantation with a width of 30-50 cm. Pepper production has increased after giving leaf mulch because there were no weed and also added fertilization after the leaves were decomposed [6, 7].

Advantage of using mulch

- Capable in suppressing weed grown around newly or young planted trees.
- Decomposed dry leaf mulch will become fertilizer for the plants, making plants grow better and faster compared with those without mulch
- Soil temperature under dry leaf mulch is lower which attract more worms coming under the mulch
- The condition of the soil suface under the dry leaf mulch is better because rain water does not directly touch the soil
- Using the dry leaf mulch can increase soil humidity around the tree base that supports the existence of the microorganism and fungi around the surface roots
- Tending trees by using dry leaf mulch is environmentally friendly because it reuses local materials (dry leaf).

Some weaknesses of using dry leaf mulch for large scale areas are well identified such particularly as the technique is not efficient due to the difficulty in collecting the dry leaves. However, for small scale gardens, parks or arboretum it is applicable.

The method to use dry leaf mulch for tending young plants or newly planted plants is performed as mentioned follow:

- Select seedlings to be tended with a dry leaf mulch
- Clean the weed around tree base in the area of 50 x 50 cm
- Put the dry leaf mulch around plant base with a size of 50 x 50 cm and width of 20 cm.
- For large leaves, they should be chopped to sizing to about 5-10 cm long so that no sun light can reach the forest floor causing no light for weed.
- Usually dry leaf will decompose in 5-6 months, and after that, dry leaf mulch must be added again [8].

Figure 1 shows an *Elaeocarpus serratus* seedling aged 2 years given with dry leaf mulch, while figure 2 shows *Cryptocarya massoy* seedling aged 1 year given with net bags of dry leaf mulch so that the dry leaf mulch will not be exposed to the wind.



Figure 1. *E. serratus* seedling aged 2 years is given dry leaf mulch.



Figure 2. *C. massey* seedling aged 1 year is given net bag dry leaf mulch.

3. Arboretum of CFRD-Ministry of Environment and Forestry

The area of this arboretum was 5 (five) ha divided into 27 blocks. Each block was planted with tree species and bordered by road network and office building. It is located beside Cisadane river at an altitude of 250 m above sea level with a 4.962 mm average annual rainfall. Some important native tree species are *Pinus merkusii*, *Diospyros celebica*, *Shorea* spp., *Eusideroxylon zwageri* (iron wood), *Dryobalanops aromatica*, *Fagraea fragrans*, *Ficus variegata*, *Eucalyptus* spp., and *Falcataria moluccana*, Exotic tree species are *Hymenia courbaril* and *Khaya antiothea* [9].

The tree species condition at the Arboretum of Gunung Batu Bogor, generally grows well. Trees with a dbh ≥ 10 cm (dbh) which amounts up to 1.178 stems, consists of 55 families and 246 species. Species which are mostly found at the field for example the *Shorea selanica* Blume, *Shorea stenoptera* Burck., *Shorea javanica* Koord. & Valet., *Hopea sangal* Korth., *Hopea odorata* Roxb., *Hopea bancana* (Boerl.) van Slooten (*Dipterocarpaceae*), *Castilloa elastica* Cerv. (*Moraceae*), and *Strombosia javanica* Blume (*Olacaceae*) [10]. One of the trees, which is *Terminalia kaernbachii* Warb, aged 52 years in the arboretum of FCRD (figure 3).

The soil material is in the form of a mountain stone, originating from Salak mountain consisted of floating stone sands, forming brown reddish Latosol which is similar with Typic Dystrudepts. Even though they belong to one classification, between Lungur position and dissection there are some characteristic different. General characteristic of soil at Arboretum location, soil morphology: deep till very deep solum, fine texture, dark colour which tends to be a brown reddish colour, very fertile consistency, stout structure, rather angle with good structure development

Site condition in the form of a fertile soil consistency, a low aggregate stability level, topography at a very steep dissect slope, causing certain parts of land at the Arboretum vulnerability level to cause erosion. At the river edge area, having low soil aggregate until the low layer, lower permeability from soil at upper sequent/ lungur part, having bigger run off with a very steep slope is potential to become a landslide [10].

The purpose of the Arboretum establishment is as a collection for various tree species from all over Indonesia and they are planted individually or in groups. The objective of the arboretum is to conduct research, education, germ plasm conservation and limited recreation. The development of Bogor at present is less controlled causing less green open areas. Therefore the role of the FOERDIA arboretum can be increased to become part of the city's green open area, as a part of the Bogor Botanical Garden which also underwent heavy pressure from the city development of Bogor. Figure 4 displays a signboard of the FOERDIA Arboretum in Bogor.



Figure 3. Tree of *Terminalia kaernbachii* Warb. age 52 years In Arboretum of FCRD.



Figure 4. A signboard FCRD arboretum, in Bogor.

4. Material and method

Research was conducted at the Arboretum of FOERDIA-Ministry and Environment and Forestry, Bogor. The general characteristics of this research area is elongated ridges at the low slope of Salak Mountain. The topography is a flat surface (0-8 %) with the dissection level of the steep very steep, slope > 40%.

These materials are obtained from the FOERDIA Arboretum, Bogor. Material consisted of litter, 2 years old *E. serratus* seedling, one year old *C. massoy* seedling, analytical balance, bag, plastic bag, net, litter net, meter, oven and charcoal.

The working procedure

Measurement plot with a size of 20 x 20 m. The treatment was given dry leaf mulch directly surrounding the seedling base and indirectly using the net bag which also surrounds the seedling base. The Size of the mulch is 50 x 50 cm with a width of 20 cm.

The collection of litter from the tree arboretum was done and then measure their wet weight (the litter fell from the tree were weighted) and dry weight (sample the litter dried from the oven were weighted again) and with the water content. The measured parameter included litter biomass. Measurement and counting of litter biomass were conducted as follows:

- All the litter exists in a 2 x 2 m sub plot which were collected and weighted.
- Litter sample as much as 500 g respectively was taken and then they were put inside the plastic bags which had been labelled according to the location of the collection.
- Those litter samples were put in the oven for 48 hours at 70°C to obtain biomass
- How to make compost manually (natural) without grinding
- Dry leaves 100 kg, cow dung 30 kg, wet grass mixed (stirred) until flattened and then doused with one bottle EM4 with the function as a permentation (decomposition process). After fully mixed, it was then put into the holes that have been provided. Every 2 weeks they were once again stirred in the hole so that the process is maximum. After being decomposed, (disintegrated) removed and were given wind /aerials so the water content is small. Afterward, they are sieved until they are smooth then mixed with rice husks (charcoal),. Fermentation period is 2 months.

5. Data analyses

The dry leaves from the plot were collected every day and weighed to determine the average litter production a week. Dry leaf production which have been processed becoming compost as litter biomass were then analyzed in a soil laboratory to identify its composition.

6. Results and discussion

Litter is a dead material, located on the soil surface and undergoes a process of decomposition and mineralization. Components including in the litter are the leaf, twig, small branch, bark, flower and fruit [11]. Litter production can be used as one of the reference to know the amount of plant contribution to the fertility of the soil. The more the litter is produced the more the decomposed so that they can increase soil fertility status. Based on the measurement of dry leaf production for four weeks which was collected every morning in a day, it was known that the average dry leaf production per week was 0.0043 ton per ha. The highest production in the first week (0.0048 ton per ha), while the lowest production in week 4 (table 1).

Table 1. The production of dry leaf from CFRD Arboretum in Bogor

Week	Production of Dry leaf (ton/ha)	Remark
1	0.0048	Dry leaf collection were conducted every morning
2	0.0044	
3	0.0042	
4	0.0040	
Average	0.0043	

The difference in production was caused by the differences in the structure and composition. This is in accordance with [12] where litter was produced by the forest with a different amount and composition based on the structure and diversity of the plant species compiler. The low litter production at the stand was caused by an unoptimal plant growth or even there were no plantation maintenance. Based on the result of research [13], the litter wet weight of *A. mangium* is 9.75 ton/ha, while the dry weight of *A. mangium* is 2.017 ton/ha.

The longer the time period of the decomposition, the lower the rate of litter decomposition per period, while the higher the rain fall, the faster the decomposition rate. To improve the characteristics of soil chemicals, it can be conducted by the way of mulching i.e. returning the humus to the planting hole and close the surface of the soil around the plant with litter and existed humus.

6.1. Soil and compost chemical analyses

In this study the leaf litter can be processed to become compost by mixing with cow dung, EM 4 and fresh grass for a processing time of two months. The soil and compost chemical analyses at the FOERDIA arboretum are displayed in table 2.

Chemical characteristics of soil fertility: pH (soil acidity level), acid till very acid, organic carbon low till moderate, nutrient capacity moderate, saturation base low till moderate with exchange bases content: K and Na low, Ca and Mg moderate till high, K and P low with a very low level of availability. Soil physic characteristics: the aggregate stability is not stabil. The porosity related with the soil permeability was figured by fast drainage pores moderate until high. At the dissected slope, it is distributed rather different than soil, there were rough material contents which distribute at the cross section above the layer, and aggregate stability and the permeability which was lower [10]. Materials to make soil in the form of fire from the mountain rock originated from the Salak mountain eruption which was composed by pumice rock, forming of a Brown-reddish latosol soil which is equivalent to the Typic Dystrudepts. Eventhough it still belongs to one classification, between the Lungur and the dissect there was several different characteristics. General characteristic existed at the Arborettum, soil

morphology: soil solum deep till very deep, fine texture, dark color tended to be brown reddish, consistency very fertile, stout structure rather angle with a robust structure development.

The Site condition in the form of fertile soil consistency, at a low aggregate stability level, topography at a dissected slope is very steep, causing certain land parts of the arboretum having a large vulnerability to erosion. At the river edge which has a low stability level of soil aggregate till the low layer, lower permeability from soil at the upper sequent/part of Lungur having a larger run off with a very steep slope and potential for landslide to occur.

Compost materials have been influenced by the availability of microorganisms as well as affected by the characteristics of raw materials. The availability of microorganisms in this study was carried out by giving an EM-4 solution according to the physiological properties of work belonging to 5 groups of microorganism types i.e.: *Lactobacillus* sp., *Phototropic bacteria*, *Actinomyces* yeast and *Aspergillus* sp. *Fungi Penicillium* sp. and *Rhizopus* sp. Several factors which affect the composting process includes the temperature, degree of acidity (pH), moisture, C and N ratio, and compost quality [14, 15]. Moreover, according to [16, 14] the level of compost maturity can be identified from primary criterion of the compost maturity level which is the plant growth influenced by giving the compost, while the secondary criteria are C/N ratio, temperature, water content, colour, and material structure.

To accelerate the composting processes, it is common to use EM4. The study result indicated that the C/N 33.05 ratio was in the high category, while the P, Ca, Mg, K contents were relatively low. The pH 6.12 was in acid condition. Based on this nutrient analysis, the compost can be used as organic fertilizer. Table 2 displays the chemical characteristic of soil in general soil.

Table 2. Soil and compost chemical analyses at the Arboretum of CFRD.

Analyses	Growth media	
	Soil ⁽¹⁾	Compost
pH H ₂ O	4.7	6.12
pH KCL	3.80	5.84
C, %	2.25	25.78
N, %	0.29	0.78
C/N	7.76	33.05
P ₂ O ₅ , mg/100 g	79.00	191.00
K ₂ O, mg/100 g	32.00	84.00
P ₂ O ₅ Bray 1, ppm	7.30	101.09
Ca, me/100mg	5.86	0.16
Mg, me/100mg	1.58	0.12
K, me/100mg	0.64	0.56
Na, me/100mg	0.07	0.14
Total, me/100mg	8.15	0.98
CEC, me/100mg	21.80	34.45
KB, %	37.00	42.52
Al, me/100 g	1.48	tr
H ⁺ , me/100 g	0.36	0.2
Texture		
Sand (%)	5.00	
Dust (%)	19.00	
Clay (%)	76.00	

Remarks :

tr = cannot be measured

⁽¹⁾= [1]

7. Conclusions

Average weekly production of dry leaves at the FOERDIA Arboretum in Bogor was 0.0043 ton per ha. The highest production was in the first week, while the lowest production in the fourth week. Dry leaf mulch can be processed as compost or organic fertilizer.

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