Organic cultivation of medicinal crops in the efforts to support the sustainable availability of Jamu raw materials

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Abstract. Jamu is an Indonesian herbal medicinal product, as part of the traditional natural health care of Indonesia's national cultural heritage. Jamu raw material consists of a single preparation or combination of several types of nutritious medicinal plants, collected from nature and cultivated by farmers. Nowadays, medicinal crops farmers rarely apply organic cultivation on their land. Along with the increase in public awareness and the global demand of efficacious but safe herbal products, the organic cultivation of medicinal plants is a necessity. In organic farming, crop cultivation relies on the use of organic (natural) ingredients and avoids the use of synthetic chemical inputs (pesticides, herbicides, fertilizers), and genetically modified organism seeds. The integrity of the material produced is guaranteed by third parties through the issuance of organic certificates after going through a series of audit processes on documents and production processes in the field and storage area known as organic certification. Certification of organic plant cultivation in Indonesia has been regulated in SNI 6729: 2016 concerning the Organic Farming System. Many researches found that medicinal plants cultivated organically could improve efficacious compounds. Research to compile GAP (Good Agricultural Practices) for medicinal plants cultivated organically in Indonesia needs to be encouraged to support the sustainable supply and efficacious of Jamu raw materials.

Keywords: Herbs, health, medicinal plants, organic, sustainable

Introduction

Jamu is an Indonesian herbal medicinal product that is part of the traditional natural health care of Indonesia's national cultural heritage. Indonesian people have been using jamu to treat various diseases since long. Jamu, as traditional medicine, arising from experiences of the past and embedded in the culture of society, and it constantly changes and develops as required. It is being developed to a rational form of therapy, from herbal practitioners to drugs in pharma industries [1]. Although modern medicine is becoming increasingly important in Indonesia, jamu is still very popular in rural as well as in urban areas. Even now jamu is being developed from traditional handling to industrial (larger scale) production.
The raw material of jamu consists of one ingredient or a combination of several nutritious medicinal plants, both collected from nature or cultivated by farmers. Parts of plants used as medicine which contain active ingredients are taken from leaves, stems, rhizomes and roots. In general, the active ingredient content includes saponin, flavonoid, tannin, steroid, alkaloid, triterpenoid and their derivatives. These active compounds will provide some pharmacological and efficacious effects including: anti-inflammatory, antimicrobial, anesthesia, sedative, anticancer, antirheumatic, antithyroid, blood circulation, antihypertensive, antidiabetes, immunostimulating agent, antiviral and cardioprotective agent, gastroprotective agent, increase stamina and skin smoothing. Medicinal plants are again in great demand in modern civilization to extract various natural products for human welfare.

There are 31 medicinal crops of Indonesia that are demanded more than 1.000 tones/year for traditional medicine (jamu) industry, spices and export. Some of these crops (18 species) are cultivated and the others (13 species) are harvested directly from their natural habitat, such as forest [2]. In 2017, fifteen medicinal plants used in large scale and had the highest harvest area were ginger, galanga, east indian galangal, turmeric, Zingiber aromaticum, java turmeric, black turmeric, chinese keys, sweet root/calamus, java cardamom, indian mulberry, phaleria macrocarpa, verbenaceae, king of bitter, aloe vera (Table 1). Five types of rhizomes plants having the largest production are ginger, followed by turmeric, galanga, East Indian Galangal and Java Turmeric. While on non rhizome plants, Java cardamom had the highest production followed by Aloevera, Phaleria macrocarpa, Indian mulberry, King of bitter and Verbenaceae.

Table 1. Production of 15 medicinal plants in Indonesia (2017)

| Rhizome plant          | kg   | Non rhizome plant          | kg   |
|------------------------|------|---------------------------|------|
| 1 Ginger               | 216,586,662 | 1 Java Cardamom         | 90,787,405 |
| 2 Galanga              | 63,536,065  | 2 Indian Mulberry       | 4,629,225   |
| 3 East Indian Galangal | 36,655,028  | 3 Phaleria Macrocarpa    | 5,460,471   |
| 4 Turmeric             | 128,338,949 | 4 Verbenaceae           | 376,347    |
| 5 Zingiber aromaticum | 7,728,410   | 5 King of Bitter        | 1,612,170   |
| 6 Java Turmeric        | 24,561,046  | 6 Aloevera              | 10,331,221  |
| 7 Black Turmeric       | 6,407,704   |                          |      |
| 8 Chinese Keys         | 4,291,516   |                          |      |
| 9 Sweet Root           | 433,381     |                          |      |

Source : [3]

In Indonesia, the cultivated medicinal plants have not implemented good and safe cultivation. Various negative impacts of continuously using synthetic inputs on human health and environmental security have been reported by researchers in many countries. Along with the increase in public awareness and the global trend of demand for herbal products which in addition to efficacious but safe, organic cultivation of medicinal plants is also a necessity. In organic farming, crop cultivation relies on the use of organic (natural) ingredients and avoids the use of synthetic chemical inputs (pesticides, herbicides, fertilizers), and genetically modified organism seeds.

Certification of organic plant cultivation

In producing jamu, the materials used must be legally certified organically to ensure their safety. In Indonesia the organic farming system has been regulated in SNI 6729: 2016. The integrity of the material produced is guaranteed by third parties through the issuance of organic certificates after going through a series of audit processes on documents and production processes in the field and storage area known as organic certification. The application of organic cultivation so far does not conflict with various regulations that regulate the production of raw materials and the use of Jamu in health services.
Organic Farming System is an attitude or behavior of the farmer in implementing farming system by Concerning the ecological balance, by utilizing natural/organic ingredients and without using synthetic chemical inputs (fertilizer, pesticide, and others), and not using Genetically Modified Organism product. Concerning the ecological balance, environmental and human health, utilizing local resources (local wisdom).

Organic farming system requirements

- **Land use**
  
  History of land use for the past 3 years must be recorded definitely, when was the last use of synthetic chemicals (fertilizers and pesticides) and when to start organic farming. Changing land management from conventional/organic to organic farming requires a conversion period to support soil fertility status. For medicinal crops as annual crops needs a minimum of 12 months, while for perennial crops a minimum of 18 months. There is no conversion period while medicinal crops were planted in native land or not cultivated land.

  To cultivate ginger is recommended on the land that has never been planted by Zingiberaceae. This is to avoid the increasing population of seed borne and soil borne organisms in the area, especially *Ralstonia solanacearum*, *Meloidogine incognita*, dan *Fusarium oxysporum* [4].

- **Contamination Prevention**
  
  Contamination may come from agricultural equipment used, contiguous conventional land, water sources, and post-harvest processes.

  - **Equipment**
    
    Agricultural equipment must be separated between equipment used for conventional farming using chemical inputs with organic farming. It needs Standard Operational Procedure to clean the equipments tools that have been used for conventional agriculture

  - **Water sources**
    
    Water pollution occurs if the source of water that enters organic area, passes through or comes from non-organic land, households, industrial wastewater disposal, irrigation canal. To prevent that condition, it is necessary to make a filter pond with an area of 0.1% of the cultivated area with a minimum depth of 60 cm. The aquatic plants should be planted in the ponds to reduce water contaminant, such as *Eichhornia crassipes*, *Pistia stratiotes*, *Ipomoea aquatic*, and others.

  - **Air pollution**
    
    The effect of spraying pesticides from adjoining non-organic area can be minimized by making natural or artificial barrier or buffer zones. Barrier height must be dense and higher than medicinal plants. While the ‘buffer zone’ was planted with similar medicinal plants but different varieties or other plants with a width of at least 2 m. Buffers zones include trenches, drainages, river, or roads that are at least 3 m wide [5].

- **Seed**
  
  The seeds should be come from plants that are organically cultivated, or those that are have special treatment before planted, which aims to minimize mixing with chemicals (coated seed). It is strictly prohibited to use GMO seeds. The seeds are washed and soaked in warm water before sowing to remove the coated layer of the seeds.

- **Soil Fertility Management**
  
  Fertilizer application for medicinal plants is recommended from natural ingredients (organic material). Organic fertilizers will prevent the residues problem and maintain the stability of soil nutrients. This is different from chemical fertilizers which are quickly absorbed by plants but are suspected to have
pharmacological effects [6]. Some sources of organic materials that can be used for organic fertilizer can come from agricultural, industrial and household activities (Table 2).

Organic material used must be composted or fermented using microbial decomposers and other materials. Manure as a result of animal waste decomposition, could provide better availability of nutrients, improve the chemical, physical and biological properties of the soil, so the plant roots can develop optimally to absorb nutrients and water for plant growth and production [7].

To improve the quality of organic fertilizer, fermented organic fertilizer can be made in solid and liquid form, and can be mixed with humic compounds, bioactive compounds (amino acids, vitamins, growth stimulants), and beneficial microbes (Trichoderma, Mycorrhiza, N-fixing bacteria, P, etc.). POC (liquid organic fertilizer) is a solution of the organic materials fermentation from plant residues and animal waste (solids and urine), which is able to provide nutrients faster (can be used directly by plants), and can be applied frequently [8].

**Table 2.** Common sources of organic material used as organic fertilizer

| No. | Source of organic ingredients | Types of organic matter |
|-----|------------------------------|-------------------------|
| 1   | Agriculture                  |                         |
|     | Plant waste and residues     | Rice straw and husks, weeds, leaves, stems and corncobs, all vegetative parts of plants, banana stems, coconut coir |
|     | Animal waste and residues    | Solid waste, liquid livestock waste, animal feed waste, bone meal, fluid from biogas process |
|     | Green manure                 | Glinicidia, *Sesbania grandiflora*, Leucaena leuephala, Centrosoma, Azolla, blue algae, seaweed, water hyacinth, water weeds |
|     | Water plants                 | Microorganisms, mycorrhizae, rhizobium, biogas |
|     | Nitrogen fixing              |                         |
| 2   | Industry                     | Sawdust, paper, bagasse, oil palm, food canning, slaughtering animals |
| 3   | Household waste              | Waste                   |
|     | Waste                        | Household and residential waste |

Sources : [9].

**Pest Control**

Indiscriminate use and improper handling of synthetic pesticides in agriculture have caused ecotoxicological effects on the environment and poisoning farmers ([10]; [11]). Synthetic pesticides are prohibited for pest control in medicinal plants, material preservation, sanitation and material storage. Bio pesticides from beneficial plants should be used to produce safety consumption of medicinal plants.

Some plants used as pest control, namely: whiteweed (to suppress the pest Dysdurus, Tribolium, grasshoppers); *Tinospora crispa* as an anti-insect; glicridia (controlling Spodoptera sp., Aphid, and Coccidea); *Piper betle* (controlling Dysdurus); *Zingiber Aromaticum* to control Udaspes sp.; *Cosmos caudatus* (controlling Aphid, Dysdurus, and *Plutella xylostella* caterpillars); Tephrosia vogelii (controlling Aphid, Crocidoloma, Epilachna, and Thrrips); *Vitex trifolia* (controlling *Achaea janata*, *Plutella sp.*, *Spodoptera sp.*, and *Sitophilus sp.*); *Sapindus rarak* (insecticidal, contact poison); and *Acorus calamus* (controlling caterpillars) ([12]; [13]; [14]; [15]; [16]).

Extracts of jatropha, glicrisidia, turmeric, and andrographis gave mortality level of *S. litura* larvae around 20% at 6 days after treatments. Leaf clove oil at 4% and ageratum oil at 0.5% gave around 50 and 90% mortalities, respectively Jatropha, long pepper fruits, and cosmos extracts performed
antifeedant properties which were shown on decreasing weight of the larvae [17]. The clove, the crown of god, Cintronella oil, and turmeric as raw materials of molluscicides were the most effective extract to control the golden snail, with 100% mortality rate and percentage of >90% inhibition of eating [18].

Table 3. Mortality of Spodoptera litura larvae after treated with clove leaf oil and Ageratum oil

| Treatments (%) | Larvae mortalities (day after application) |
|----------------|-------------------------------------------|
|                | 1  | 2  | 6  |
| Clove leaf oil | 0  | 0  | 0  |
|                | 1  | 0  | 1.7|
|                | 4  | 58.3| 58.3| 58.3|
| Ageratum oil   | 0  | 0  | 0  |
|                | 1  | 5.0| 71.7| 100|
|                | 4  | 78.3| 100| 100|

Source: [17]

Effect of organic and biofertilizer for some medicinal crops

Actually, the yield of biomass, herb, rhizomes from medicinal plants can increase without the use of chemical fertilizers. Studies on medicinal plants indicate the maximum yield and quality in the use of organic fertilizers and biological achieved. Containing organic matter, increasing soil water holding capacity, improving plant hormone-like activity, increase nutrient uptake by plants, and generally improve the chemical and physical structure of plant litter, including the reasons for increasing the yield of organic fertilizers it has been reported [19].

Humus has better nutrient content than manure, especially C-organic, exchangeable Ca, Mg, and K. White ginger (5 months after planting) grown in a polybag with 5 cm humus thickness had about the same number of leaves, tillers, and fresh weight of rhizomes, with the application of 20 tons manure/ha. Whereas the application of 10 cm humus thickness as topsoil, produced those parameters 1.5 times better than 20 tons/ha [20]. The application of chicken and cow dung on Pimpinella pruatjan grown in Cianjur (sandy soil, 1.500 m asl.), West Java, resulted higher levels of sitosterol, whereas compost and goat fertilizer produce higher levels of stigmasterol. Chicken manure applications produce higher leaf, root, and total plant weights than goat manure, cow manure, and compost [21]. The application of goat manure and chicken manure fertigation on Murraya paniculata resulted high steroids, medium saponins, and low tannins, low flavonoids, and low alkaloids of leaf bioactive ingredients [22].

Application of arbuscular mycorrhizae fungi (AMF) and biofertilizer are suggested to be used in order to improve the effective growth and yield of several medicinal plants, such as Hemigraphis colorata, Tinospora cordifolia, Ocimum basilicum, Gymnema sylvestre, Coleus amboinicus, Bacopa moninierii, and Artemisia vulgaris [23]. Application of AMF could increase fresh and dry weight of big white ginger rhizome by 32.6% and 54.65%, fresh weight of red ginger rhizome by 41.9% and small white ginger by 137.56%, and increase nutrient P uptake of rhizomes by 68.7% [24].

Several studies have demonstrated that plant associated with AMF can increase the quality of plant. The mycorrhizal inoculation of Scutellospora herogama and Gigaspora decipiens resulted higher oleoresin production of ginger fresh weight by 3.48% and 1.58%, while the control was 0.99% (Table 4) [25]. The highest quercetin content of two perennial sow thistle accessions was produced by AMF2 inoculation, 1.15% from Bogor accession and 1.13% from Manoko accession (Table 5). Moreover, perennial sow thistle extracts of AMF2 treatment could inhibit the growth of cervical cancer cells in vitro much more profound than control (67.27 µg mL-1) with IC50 [26]. Inoculation of AMF
significantly increased the growth, nutrient uptake, biomass and asiaticoside content of asiatic pennywort (Table 6) [27].

The medicinal Vinca (Caharanthus roseus) plants inoculated with the bacterium Pseudomonas fluorescense increased biomass production and alkaloid content of the plant was under stress conditions [28]. Endophytic bacteria consortia can promote growth and andrographolide content on king bitter plant. The increament of andrographolide content 0.35 to 0.62 % on endophytic bacteria consortia treatment [29].

### Table 4. Rhizome fresh biomass and levels of oleoresin after 210 days of micropropagated ginger plants.

| Treatment               | Fresh biomass (g) | Content of total extracted oils (g) | Yield of oleoresin (%) |
|-------------------------|-------------------|------------------------------------|------------------------|
| Control                 | 0.1454±0.2333     | 0.0131                             | 0.99                   |
| Phosphate               | 0.3471±0.1836     | 0.0469                             | 1.35                   |
| Mix 4 AMF               | 0.2730±0.1994     | 0.0251                             | 1.02                   |
| *Scutellospora sp*      | 0.1000±0.0240     | 0.0348                             | 3.48                   |
| *Gigaspora decipiens*   | 0.2166±0.2113     | 0.0340                             | 1.58                   |
| *Acaulospora koskei*    | 0.3331±0.2445     | 0.0344                             | 1.02                   |
| *Entrosphospora colombiana* | 0.1466±0.1488   | 0.0096                             | 0.72                   |

Source: [25]

### Table 5. Total quercetin content and yield of perennial sow thistle at two harvesting time

| Treatment               | Quercetin content (%) | Quercetin yield (mg/plant) |
|-------------------------|-----------------------|----------------------------|
| **Bogor accession:**   |                       |                            |
| Control                 | 1.04                  | 127.05                     |
| AMF1                    | 1.10                  | 140.01                     |
| AMF2                    | 1.15                  | 136.89                     |
| AMF3                    | 1.08                  | 115.97                     |
| **Manoko accession:**  |                       |                            |
| Control                 | 1.08                  | 116.27                     |
| AMF1                    | 1.10                  | 121.83                     |
| AMF2                    | 1.13                  | 121.82                     |
| AMF3                    | 1.04                  | 109.03                     |

Source: [26]

### Table 6. Effect of AMF inoculation and organic fertilizer application to the asiaticoside content of centella

| Treatment         | G0  | G1   | G2  | G3  | G4  | G5  | G6  |
|-------------------|-----|------|-----|-----|-----|-----|-----|
| Organic fertilizer/AMF |     |      |     |     |     |     |     |
| NonAMF            | 1.72| 1.65 | 1.36| 1.31| 1.24| 1.54| 1.78|
| AMF               | 2.16| 2.07 | 1.46| 1.93| 1.71| 2.00| 1.83|

Note: G0= Control G2= Rock Phosphate (RP) G4= Manure+RP
Conclusion

Organic medicinal plant cultivation can play a role in supporting the sustainable supply and efficacious of Jamu raw materials, improving public health and the environmental safety.

To produce the sustainability of raw material medicinal plants for herbal medicine industry that meets the standards of organic agriculture, the socialization of organic agriculture to medicinal plant farmers needs to be done, followed by registration and certification of their products.

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