Application of liquid organic fertilizers for supporting organic arabica coffee development at Sub-district of Sukasada, Buleleng, Bali, Indonesia

I K Kariada\(^1\)\(^2\) and K D Arsana\(^1\)

\(^1\) Assessment Institute for Agricultural Technology (AIAT), Jl. BY Pass Ngurah Rai, Pesanggaran, Denpasar Selatan, Bali

E-mail: ketutkariada1@gmail.com; igkomangdana@yahoo.com

Abstract. Sub-district of Sukasada is one of arabica coffee centre in Buleleng District of Bali. This coffee areas has been developed for organic coffee with the certification from Geographical Indication (GI), Control Union (CU) and Rain Forest certifications. Area which has been covered around 400 Ha under 7 Farmers Group to support the sustainability of organic coffee development. It is important to implement onfarm research for developing local specific eco-friendly technology. Research was implemented in 2018 at Wanagiri village, Sukasada subdistrict of Buleleng. The purpose of research was to increase the yield of coffee through producing and applying the liquid fertilizer from liquid waste of wet processing. Research design used was block design, with four treatments and 4 replications in each treatment have 20 plants as samples. Coffee variety of Kopyol was used for treatment with age already 5 years after planting. Trial components are : P0 = farmers way (5 kg/tree), P1 = 200 ml bio urine/tree + 5 kg compost/tree, P2 = 100 ml bio urine/tree + 100 ml liquid organic fertilizer from liquid waste of wet coffee processing + 5k compost/tree, P3 = 200 ml liquid organic fertilizer from liquid waste of wet coffee processing + 5 kg compost/tree, P4 = 200 ml wet organic fertilizer + 5 kg compost/tree. Variables measured was number of productive branch, number dompol per productive branch, number of seed per dompol, and production per hectare through taxation method. From the above treatments, P3 provide the highest yield 0.87 kg OSE coffee/tree/year, followed by P2 0.82 kg, P1 0.59 kg, P4 0.56 kg and the lowest was from P0 0.51 kg OSE coffee per tree per year.

Keywords: appropriate technology, organic coffee, organic liquid fertilizers, taxation

1. Introduction

Coffee plants are annual plants that are commonly developed in tropical regions such as in Asia and in the African region. Coffee as an international drink is always available in every corner of the region and is sometimes a drink that has cultural values such as greeting guests or sometimes closing the event. While the main value added of coffee is to have value from the social and economic aspects. Benefits from the social aspect, coffee plants created employment for 83,672 farmer households [1], both for the main actors namely farmers, traders, traders and other actors. Another role of coffee is its cultivation in mountainous areas so that it is also directly conservation of land and water.

\(^2\) To whom any correspondence should be addressed (ketutkariada1@gmail.com)
Coffee development in Bali is a smallholder plantation business managed by most farmers who live in rural areas through “subakabian” (dry land farmers organization) where around 74.34% is robusta coffee and 25.66% arabica coffee. Currently, production of Bali coffee is informed still low 0.5 kg/tree/year. With the low level of production of Balinese arabica coffee, it is very necessary to implement action effort to improve the quality of farmers arabica coffee. Some important steps are through improving coffee cultivation and the application of enough organic fertilizers to crops. Others are through replanting or developing new high yielding varieties that replacing old plants with young plants or also possible rejuvenation, right handling of pruning and shading system, and implementing a proper harvesting and processing system, and finally handling liquid waste from wet processing for producing liquid organic fertilizer [2]. However, it is understood that Bali coffee quality product is still low standard [3]

With the low level of production of Bali arabica coffee, it is important to implement a study with objective to improve production of farmers coffee. Some important steps are through improving coffee cultivation and the application of enough organic fertilizers to crops. Others are through replanting or developing new high yielding varieties [4] that replacing old plants with young plants (rejuvenation), right handling of pruning and shading system, and implementing a proper harvesting and processing system, and finally handling liquid waste from wet processing for producing liquid organic fertilizer. Based on this, it is necessary to implement research on improving coffee quality production throughout the season and creating added value at each level of coffee processing.

2. Methodology

2.1. Location and time of implementation
Research was implemented at Leket Sari farmers group at Wanagiri village, Sukasada Sub-district of Buleleng Bali. All farmer members are coffee farmers and own average one hectare of land for coffee development. Research was implemented in fiscal year 2018 in collaboration with KP4S IARD Bogor.

2.2. Materials and Method
Liquid waste from cherry need to be processed by using indigenous micro organism (IMO) for producing liquid organic fertilizer. In processing, it is required some materials and tools such as material for producing media for IMO at the beginning a.i. red palm sugar, mature papaw fruit, waste of bamboo leaf, rice water, and coconut water, a bucket of water for storing media liquid to collect microbes as a
fermentor, liquid storage, and cover. For field research also required such as bucket, stick mixer, scoop, sprinklers for spraying wet fertilizer, scales, measure tools, land cultivation tools, etc. In producing media for IMO, all materials were mixed and diluted with natural water where in all (each one kg for all material) need 15 liter rice water for 14 days fermentation [5]. This is the first step of producing IMO which finally will be used to process fermentation for liquid waste of wet coffee cherry processing. When fermented liquid is ripe after 14 days storing, then bio fertilizer has been produced. It is ready to be applied for coffee crops, beside its contain some microbes, this liquid aslo contain macro and micro nutrients [6], bio substances grow like gibberellin, sitokinin, GA, auxin [7]. In field study, the assessment was carried out on farmers’ coffee land with an area of 1 ha which began in FY 2018. The assessment was carried out using a randomized block design with 4 treatments and 4 replications and in each treatment there were 20 sample plants. The variety used was Kopyol coffee which is more than 5 years old.

The composition of treatment was P0 (farmer way 5 tons compost/ha); P1 (200 ml bio urine/tree + 5 tons compost/ha); P2 (100 ml bio urine/tree + 100 ml organic liquid fertilizer from coffee waste/tree + 5 tons compost/ha); P3 (200 ml organic liquid fertilizer from coffee waste/tree + 5 tons compost/ha); P4 (200 ml Super Gold liquid organic fertilizer + 5 tons compost/ha). All liquid fertilizers were diluted 5 times. The production components observed included number of productive branches per plant, number of dompol per productive branch, number of seeds per dompol. To calculate data, it was used Taxation Method in order to estimate dried OSE seed production (kg/ha or kg/plant). The data obtained is stated in Tables and graphs to see differences in treatment. In taxation calculation, the following component has to be considered such as:

1. Harvest of coffee should be coffee cherry.
2. Criteria in estimation follows the following components:
   a. Number of plants per hectare
   b. Number of productive branches per plant
   c. Number of collections per productive branch
   d. Number of fruits per dompolan
   e. Seed index 120/100 g
   f. Fruit yield (20%) for Robusta and 18% for Arabica.
3. Formulation of data calculation is as follows:
   \[
   \text{Production per hectare of dried bean coffee} = \frac{\text{Number of plants per hectare} \times \text{number of productive branches} \times \text{number of dompol per branch} \times \text{number of fruits per dompol} \times \text{seed index (120/100)} \times 18\% \text{ arabica fruit yield}}{100}\]
   With this formula, dried coffee production (OSE) with a moisture content of 12% can be predicted.

3. Results and Discussion
The volume of liquid waste from wet coffee processing is high and has been a big problem for farmers in the coffee development area. This liquid waste damages the environment, crops/plants and provide unhealthy smell, if the coffee plants or other crops are exposed to this waste then in two weeks the coffee plants/other crops die. The economic value of this liquid waste does not exist because it cannot be directly utilized. Naturally the process of degradation of liquid waste in the soil takes a long time, which is about 4-6 months and the land can be planted again. The disadvantage of small-scale intensive agriculture is that it requires a very short interval of time the land can be planted again and requires optimal fertilizer. Therefore, land improvement efforts are often not carried out by farmers in pursuing planting schedules. However, within short-term liquid waste of coffee processing water can be processed into thousands of liters of mass liquid bio fertilizer that is profitable industrial value.

In the initial process of processing waste into liquid organic fertilizer, [8] explain that the process of making microbial growth media is needed which is provided through some ingredients. The ingredients needed as a media of fermentors called IMO or MOL were isolated from raw material such as 1 kg coffee skin, 1 kg brown sugar, very ripe papaya fruit 1 kg, bamboo leaves with moldy one bundle, 0.25
kg rice bran, rice washing water 15 liters, and 2 liters of old coconut water. Furthermore, these materials are destroyed and accommodated to produce a solution of microbial growth media. The media is pressed for 14 days if it produces a good smell and the media is successful and vice versa if the stench means failure and can be made new again. After the microbes are successfully bred, the media of this solution is used to ferment the liquid waste if the coffee is wet processing. At the time of fermentation the media is reactivated by giving 100 grams of brown sugar per liter diluted 5 to 10 times and stirred to be evenly distributed, left for 1-2 hours. After that the media solution is used to ferment coffee waste. The volume for fermenting waste is at least 1 liter of IMO/MOL for 1000 liters of waste. Then after the waste is stirred so that the microbes are evenly distributed then the media is tightly closed with a tarpaulin and pressed for 14 days. While the process of wet coffee that produces very large waste as follows:

In the washing process (figure 1), it requires a large amount of water, where for one liter of washing the coffee after natural fermentation requires 3 liters of water. It means that if the capacity of 200 tons after pulper will produce waste of around 360 tons of liquid waste. In the process of product certification, this waste becomes a major finding, which can ultimately affect the market. To deal with this problem, waste processing technology is introduced (figure 2).

**Figure 1.** Wet process of arabica coffee at Sukasada Buleleng

**Figure 2.** The process of processing coffee liquid waste into liquid organic fertilizer

As in this figure 2, it can be seen that liquid waste fermentation is done by using MOL fermentor to produce liquid organic fertilizer. Fermentation is carried out for 2 weeks, after which liquid waste from coffee waste has been produced. To find out the content of this liquid fertilizer, microbiological analysis
was carried out at the Micro Biology of Udayana University and analysis of soil samples from the study location to determine the soil fertility rate.

**Table 1.** The micro-organisms contained in liquid fertilizer from fermented liquid waste from wet coffee

| No. | Parameter            | Result (CFU) |
|-----|----------------------|--------------|
| 1   | Aspergillusniger     | $4 \times 10^4$ |
| 2   | Bascillussubtilis    | $6 \times 10^4$ |
| 3   | Rhizobium sp.        | $8 \times 10^4$ |
| 4   | Streptomyces sp.     | $18 \times 10^4$ |
| 5   | Pseudomonas fluoresc | $15 \times 10^4$ |
| 6   | E. coli              | 0 (na)       |
| 7   | Trichoderma sp.      | 0 (na)       |

Source: [9] CFu = coloni form unit. Na = not available.

Table 1 above shows that processed coffee liquid waste contains soil enhancing microbes which are able to degrade organic materials in the soil to decompose such as Aspergillusniger, Bascilluss ubtilis, Rhizobium sp., Streptomyces (degradation of organic matter tissue), phospor release (Pseudomonas Sp.) to be available in the soil. Kariada, et. al. (2016) [6] also carried out microbiological and chemical analysis on the solution of wet coffee liquid waste from PetungBangli hamlet and obtained results that showed that the fermentation contained soil enhancing microbial agents and macro micro elements that support soil fertility such as the following in table 2.

**Table 2.** Results of analytical lab analysis of fermented wet coffee processed wastewater

| Parameter   | Unit | Result               |
|-------------|------|----------------------|
| N           | Mg/l | 0.0311 (low)         |
| P           | Mg/l | 20.930 (high)        |
| K           | Mg/l | 304 (High)           |
| Mg          | Mg/l | 3.45 (average)       |
| Ca          | Mg/l | Na (not available)   |
| C – organic | Mg/l | 0.141 (low)          |
| Na          | Mg/l | 64.8 (high)          |
| Zn          | Mg/l | Na (not available)   |
| Cu          | Mg/l | 0.105 (average)      |
| Fe          | Mg/l | 0.533 (low)          |
| Co          | Mg/l | 0.0131 (low)         |

Source: [10].

Similarly, table 2 shows that liquid waste also contains some nutrients that are needed by plants. High P, K, Mg and Na elements indicate that the main macro elements needed by plants can be available and there are also trace elements, namely micro elements which are needed by plants in a small part. Thus, the liquid waste which has interfered in the certification process turns out to be a liquid organic fertilizer that is good for plants. While fermentation is also done in cow urine as shown below in figure 3.
In this study soil analysis was also carried out to determine soil conditions when applying fertilizer treatment to coffee. The results of soil analysis are presented in the following table:

**Table 3.** Results of soil analysis in the study of organic liquid fertilizer in the village of Wanagiri Sukasada, Buleleng

| No | Type of analysis | Data analysis | Remark          |
|----|------------------|---------------|-----------------|
| 1  | pH tanah         | 6.2           | Somewhat sour   |
| 2  | DHL (mmhos/cm)   | 0.28          | Very low        |
| 3  | C-Organik (%)    | 3.46          | High            |
| 4  | N-total (%)      | 0.38          | Medium          |
| 5  | P-tersedia (ppm) | 111.37        | Very high       |
| 6  | K tersedia (ppm) | 718.30        | Very high       |
| 7  | Tekstur          |               |                 |
|    | Pasir (53.53 %)  | Sandy         |
|    | Debu (40.24 %)   | Dust          |
|    | Liat (6.23 %)    | Clay          |

From table 3, it turns out that the soil conditions in the study area is good enough if microbes are introduced into the soil. Medium organic C levels will become a place of energy for microbes to degrade organic materials that have not yet decomposed. High levels of P also have the possibility of many occluded P so that the role of the microbe Pseudomonas sp. will release the P that is absorbed. This will provide nutritional support to coffee plants so that plants grow well and support in aspects of coffee flowering. While the high element of Potassium will also strengthen the roots and the quality of the fruit. The provision of liquid fertilizer in this study is very appropriate because it will directly provide stimulation for the development of soil enhancing microbes. [11] also stated that the role of fermented liquid fertilizer provided good coffee results in a small-scale "super imposed trial" study at the farm level of Petung Village Sub-District of Kintamani, Bangli hamlet, and was significantly different from the application of fertilizers that did not contain microbial soil enhancers.

In the study of increasing coffee production at Leket Sari farmer group, Wanagiri Village, several activities have been carried out in accordance with the assessment methodology. Analysis based on the calculation using method of **Taxation** [12] is shown in the following table 4.
Based on table 4 above it turns out that coffee production can be improved if given good and correct fertilization. Good fertilization is the quality of fertilizers which lab analysis shows microbial contents of various types and contains macro and micro elements. Correct fertilization is given fertilizer capable of being produced by the farmers themselves so that in terms of production costs can be suppressed properly and the liquid fertilizer does not contain artificial chemical elements. From the treatment it turns out that the average production per tree based on Estate Crops services information is 0.5 kg/tree/year as is true in treatment P0 (0.51 kg/tree/year), while the best treatment is P3, which is liquid fertilizer from fermented liquid waste by coffee wet (0.87 kg/tree/year), followed by P2 treatment, namely mixing of biological liquid fertilizer from coffee liquid waste fermentation with bio urine (0.82 kg/tree/year) followed by P1 treatment of bio urine (0.59 kg/tree/year) and treatment P4, namely the provision of biological liquid fertilizer from the market gives results (0.56 kg/tree/year). In accordance with the objectives of the study, it can be suggested that the use of liquid fertilizer from coffee liquid waste fermentation will be able to provide good results and efficiency because farmers can be made very efficient. For this reason, it is necessary to empower farmers to increase their human resource capacity.

4. Conclusions
Based on the objective of the study in order to increase production, the results of observing the parameters with the Taxation estimated count, it turns out that coffee production can be increased if good and correct fertilization is given. From the treatment it turns out that the average production per tree per year in treatment P0 is the lowest, which is 0.51 kg/tree/year, while the best treatment is P3, which is liquid fertilizer from wet coffee fermented liquid fermentation which is 0.87 kg/tree/year.

5. Recommendations
In accordance with the objectives of the study, it can be suggested that the use of liquid fertilizer from coffee liquid waste fermentation will be able to provide better results and efficiency because farmers can produce their own fertilizer. This means that in the environment of organic agriculture development, all inputs for crops should be produced in-situ, and external inputs have to be avoided.

6. References
[1] Estate Crops Services Office of Bali Province 2008 Preparation of Books Specifications for Protection of Geographical Indications of Kintamani Arabica Coffee, 17 p.
[2] Kariada I K, Aribawa I B, Widya Ningsih M A and Putu Sweken E 2017 The final report of Dissemination of Technology innovation for Arabica Coffee at Wanagiri Village, Sukasada, Buleleng. AIAT Bali.
[3] Pidada D 2008 Analysis of Added Value from Processing of Kintamani Arabica Coffee. Magister Thesis of Agribusiness Programme, Dayana University. Bali.
[4] Kariada I K, Sukadana M, Widyaningsih M A and Patra G L W 2017 Production of Arabica Coffee Seedling. Wanagiri Village, Sukasada, Buleleng, AIAT Bali.
[5] Kyan C H 2004 Natural Farming Guidance Book (Korea).
[6] Kariada I K, Aribawa I B, Duwijana N, Sigma A and Widyaningsih M A 2014 Final report m-P3MI Gianyar, 2014. BPTP Bali.

[7] BBSDLIP 2008 *Report on Waste Management Training in the Gianyar Prima Tani Area* (Collaboration with BPTP Bali).

[8] Kariada I K and Aribawa I B 2018 *Process of Producing Wet Fertilizer from Liquid Waste of Wet Coffee Processing* [Patent] AIAT Bali.

[9] Micro Biology Lab. Udayana University 2016 Results of analysis of Sukasada Buleleng Coffee Liquid Waste Sample. Udayana University, Bali.

[10] Analytical Lab Analysis. Udayana University Bali.

[11] Final Report of Diseminating Technology Innovation for Arabica Coffee at Petung Village, Batur Tengah, Sub-district of Kintamani, Bangli. AIAT Bali.

[12] Final Report of Research on Application of liquid Organic Fertilizers on Production of Arabica Coffee. Wanagiri Village, Sub-district of Sukasada, Buleleng Bali. KP4S Collaboration IARD Word Bank Assistance. AIAT Bali. AlBetween 2005 Agribusiness Management (Teaching Materials), Denpasar. Agribusiness and Agricultural Economics Study Program. Agriculture Social Economics Department. Faperta. Udayana University.