# APPLICATION OF HYDROPONIC TECHNOLOGY TO THE YIELD AND QUALITY OF PURWOCENG "VIAGRA FROM ASIA"
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# *APLIKASI TEKNOLOGI HIDROPONIK PADA YIELD DAN KUALITAS PURWOCENG "VIAGRA DARI ASIA"*

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**ABSTRACT** *Purwoceng (Pimpinella pruatjan Molkenb) is a medicinal plant native to Indonesia known as Indonesian Viagra from Java. The decline and scarcity of Purwoceng is an important obstacle in meeting the demands of harvesting from the original habitat without conservation and the extreme climatic conditions in the Dieng plateau. Therefore, it is necessary to apply controlled cultivation technology, namely hydroponic technology with drip irrigation in the greenhouse, to increase the yield and quality of Purwoceng. This study aimed to obtain the effect of hydroponic methods and hydroponic nutrition (EC) on the yield and quality of Purwoceng. The study was conducted from December 2020 to March 2021 at a greenhouse of ± 1500 m above sea level. The experiment used a randomized block design with three replications. Each replication consisted of 15 plants. Hydroponic type, which was recirculating drip, non-circulating drip, and nutrient concentration which were 1000 ppm, 1500 ppm, and 2000 ppm. The harvest weight (aerial part and root), moisture, ash, crude fat, crude fiber, water extractive, and ethanol extractive content, and the contaminant (microbial and heavy metal) content, were analyzed. In conclusion, to produce high-quality Purwoceng, a hydroponic system could be used using recirculating drip and 1000 ppm nutrient dose.*

**ABSTRAK**
*Purwoceng (Pimpinella pruatjan Molkenb) adalah tanaman obat asli Indonesia yang dikenal dengan nama Viagra Indonesia dari Jawa. Penurunan dan kelangkaan Purwoceng merupakan kendala penting dalam memenuhi tuntutan panen dari habitat aslinya tanpa konservasi dan kondisi iklim ekstrim di dataran tinggi Dieng. Oleh karena itu, perlu diterapkan teknologi budidaya terkontrol yaitu teknologi hidroponik dengan irigasi tetes di rumah kaca, untuk meningkatkan hasil dan kualitas Purwoceng. Penelitian ini bertujuan untuk mengetahui pengaruh metode hidroponik dan nutrisi hidroponik (EC) terhadap hasil dan kualitas Purwoceng. Penelitian dilakukan pada bulan Desember 2020 hingga Maret 2021 di rumah kaca ± 800 m di atas permukaan laut. Percobaan menggunakan rancangan acak kelompok dengan tiga ulangan. Setiap ulangan terdiri dari 15 tanaman. Jenis hidroponik yaitu recirculating drip, dan non-circulating drip, serta konsentrasi nutrisi 1000 ppm, 1500 ppm, dan 2000 ppm. Berat panen (bagian udara dan akar), kadar air, abu, lemak kasar, serat kasar, ekstraktif air, dan ekstraktif etanol serta kandungan kontaminan (mikroba dan logam berat) dianalisis. Kesimpulannya untuk menghasilkan purwoceng yang berkualitas, sistem hidroponik dapat digunakan dengan menggunakan recirculating drip dan dosis nutrisi 1000 ppm.*

## INTRODUCTION

Purwoceng (*Pimpinella pruatjan Molkenb*) is a medicinal plant native to Indonesia from the highlands of Central Java, Indonesia (*Syahid et al., 2005; Nuryadin and Nabiila, 2018*). Traditionally, Purwoceng is used as an aphrodisiac and increases stamina. This traditional knowledge was supported by the report that Purwoceng extract tends to increase testosterone levels in male rats, indicating its functions as an aphrodisiac (*Arjadi et al., 2019; Bhagawan and Kusumawati, 2020*). In addition, Purwoceng has diuretic, anti-bacterial, and anti-fungal properties and can increase stamina, similar to ginseng plants (*Anwar, 2001*).

However, Purwoceng plants are currently experiencing scarcity due to using Purwoceng without any efforts to conserve/rejuvenate Purwoceng (*Balittro, 2000; Nuryadin and Nabiila, 2018*). This triggers fluctuations in Purwoceng production, which becomes a problem in meeting demand.

Purwoceng planted in open land in its natural habitat also has problems with the frost season, which can kill plants, and now Purwoceng is categorized as a rare and protected species *(Bhagawan and Kusumawati, 2020*). Therefore, the application of cultivation technology to increase the production and continuity of Purwoceng needs to be done as a development effort. In vitro cultivation started in 1990 to produce callus for both cultivation and in-vitro conservation, especially using root induction techniques (*Malda, Suzán and Backhaus, 1999; Srivastava et al., 2022*). However, the seed supply and suitable land to apply the ex-vitro root induction techniques in in-vitro culture are still constrained.

Our team used hydroponic technology and planted the Purwoceng in greenhouses. The greenhouse is provided a controlled environment for increasing yield and quality and reducing the scarcity of Purwoceng. Hydroponic technology is a cultivation technology that gets the best results, is controlled, and can be harvested according to plan *(Giurgiu et al., 2014*). Hydroponic technology has also been used for medicinal plants *(Ahmadi et al., 2021; Zarinkamar et al., 2021*), including Purwoceng (*Sumarni et al., 2017*).

Hydroponic technology with drip irrigation watering techniques can be an option for planting Purwoceng on medium plains. Drip irrigation is a technique of watering and providing nutrients for plants that are economical in a hydroponic system. Drip irrigation was proven to give the highest yield for zucchini plants (*Sałata et al., 2012*) and also Purwoceng, which reached 511 grams at the age of 70 days after planting (DAT) (*Sumarni et al., 2017*), and it is necessary to develop hydroponic techniques to obtain hydroponic techniques suitable for Purwoceng plants. Hydroponic applications with drip irrigation provide water and nutrient savings and high yields (*Morgan and Kadyampakemi, 2012*). From the things mentioned above, it is necessary to study the application of hydroponic techniques with drip irrigation for Purwoceng production in medium plains in the context of continuity, conservation, and increase in yield and quality.

The principle of drip irrigation is to provide water and nutrients in the form of drops that drip periodically according to the plant's needs through a PE pipe with the help of a pressure pump. According to *Wang et al., (2020)*, a drip irrigation system can save water use due to soil evapotranspiration reduction. Droplets on the system are directed right at the root area of the plant so that the plant can directly absorb the water and nutrients provided. Drip irrigation systems can be divided into recirculating drip irrigation and nonrecirculating drip irrigation. Recirculating drip irrigation is a system that utilizes runoff nutrient solutions to be reused as nutrients for plants. Meanwhile, nonrecirculating drip irrigation is a drip irrigation system that does not reuse runoff solutions as nutrients for plants. This study aimed to obtain the best hydroponic methods and hydroponic nutrition (EC) to produce a high-yield and quality Purwoceng.

## MATERIALS AND METHODS

The study was conducted from December 2020 to March 2021. The research location was in a greenhouse on the Lembang medium plain ± 1500 m above sea level. The experiment used a randomized block design with three replications. Each replication consisted of 15 plants. The factors were hydroponic type and nutrition concentration as seen in Table 1.

**Table 1**

**The experiment design**

| **Hydrophobic type (N)** | **Nutrition concentration (ppm) (D)** | | |
|---|---|---|---|
| | **1000 (D1)** | **1500 (D2)** | **2000 (D3)** |
| **Recirculating drip (N1)** | D1N1 (4C) | D2N1 (4B) | D3N1 (4A) |
| **Non-circulating drip (N2)** | D1N2 (3C) | D2N2 (2B) | D3N2 (1A) |

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The Purwoceng seedlings were obtained from Dieng Plateau farmers in Central Java which was 1.5 months old. Seedlings were given acclimatization treatment for four days before being transplanted into the installation to be used for research. The type of hydroponics used is presented in Figure 1. The controlled conditions during planting in the greenhouse are the growing media, nutrient volume, temperature, and light intensity. After 240 days after planting (DAP), the aerial part and roots of Purwoceng were harvested. The growth and yield of Purwoceng plants which included plant height, number of leaves, harvest data (fresh weight of plants, fresh weight of aerial part, fresh weight of roots, dry weight of aerial part, dry weight of roots, and dry weight of plants) were analyzed by F test. and Duncan's Multiple Distance Test (DMDT) level 5%.

**Fig. 1 - The hydroponic type in this research. Left: nonrecirculating drip, right: circulating drip**

The harvest materials are divided into two parts, the aerial part, and the root part, which are traditionally used. The dried harvest materials were then used to determine their quality, such as the moisture content, ash content, fat content, fiber content, water extractive content, and ethanol extractive content.

For *Moisture Content Determination*, the sample was kept in a hot air oven at 105 ºC until dried. After cooling, the sample was placed in a desiccator and weighed to determine the moisture content.

For total *Ash Content Determination*, the sample is burned and put in a furnace at 45ºC for about three hours till no more organic components. Then, the ash's weight and content are determined *(WHO, 1998*). Crude Fat Determination, samples are refluxed with petroleum ether for 6 hours at 40–60°C in a Soxhlet extractor. Then, the extract was dried and weighed. The extracted content is the fat content.

*Crude Fibre Content Determination*, samples extracted with petroleum ether. The remaining residue was then boiled with 2% $H_2SO_4$ and NaOH solution for 30 minutes. The mixture was then filtered, and the residue was washed with boiling water and dried at 130 ºC for two hours. Finally, the residue was ignited at 550 °C and weighed. The water extractive and ethanol extractive content were measured using the cold maceration method *(WHO, 1998*). About 4.0g sample was macerated with 100ml of the solvent (water for water extractive content and ethanol for ethanol extractive content) for 24 hours. The filtrate then separated and evaporated to dryness on a water bath; continue with the drying process at 105°C for 6 hours. After cooling, the rest extract was weighed.

The safety of the harvest plant materials is also determined. It includes microbial safety, arsenic, and heavy metal safety. The microbial safety was determined based on WHO method no 18 (Determination of microorganism, WHO 1998), including total viable aerobic count (total plate count, TPC), yeast, and coliform. The arsenic and heavy metal content were determined using the WHO method no 17 (Determination of arsenic and heavy metal, WHO 1998).

## RESULTS

### 1. Growth of Purwoceng plants cultivated in highland greenhouses

Purwoceng could grow well in hydroponic (drip recirculating and drip nonrecirculating) systems in altitudes only 1500m above sea level (asl). The growth performance is comparable with Purwoceng planted in the highlands as their natural habitat (higher than 2000 m) (Figure 2). The number of leaves and the number of branches is comparable. The leaves number, branches number, and leaves area of all groups are almost identical.

However, only Purwoceng cultivated at hydroponic drip nonrecirculating, and 2000ppm of concentration gave the significantly lowest leaves number, branches number, and area of leaves (Table 2).

(a) (b) (c)

**Fig. 2 - Purwoceng cultivated in (a) recirculating drip at 1500 m s), (b) nonrecirculating drip at 1500 m asl, and (c) in its natural habitat higher than 2000 m asl**

**Table 2**

**The effect of drip irrigation hydroponic treatment and nutrient concentration on the growth of Purwoceng**

| Treatment combination | Growth per week | | |
|---|---|---|---|
| | $\bar{x}$ Number of leaves | $\bar{x}$ Number of branches | $\bar{x}$ Leaf area |
| | [n] | [n] | [cm$^2$] |
| D1N1 | 5.66 | 1.69 | 6.679 |
| D2N1 | 8.56 | 2.44 | 9.587 |
| D3N1 | 7.80 | 2.09 | 7.098 |
| D1N2 | 8.49 | 2.02 | 9.084 |
| D2N2 | 7.49 | 1.36 | 6.142 |
| D3N2 | 8.31 | 1.51 | 4.903 |

The hydroponic treatment did not affect the fresh-weight harvest product, but the different nutrient treatments significantly affected fresh and dry weight (Table 3). This is because the hydroponic type and the nutrients' EC interact with fresh and dry weight. The best treatment that produces the highest total plant fresh weight is obtained from the plant cultivated in 1500 ppm nutrient dose and non-circulating drip irrigation hydroponic type 211.81 gram. This total plant fresh weight was not significantly different with 2000 ppm nutrient dose and non-circulating drip irrigation hydroponic type, 1000 and 1500 ppm nutrient dose and recirculating drip irrigation hydroponic type. The highest aerial part fresh weight was obtained from nutrition with a dose of 1500 ppm and non-circulating irrigation of 85.88 grams, and the highest root fresh weight was obtained from the non-circulating hydroponic type with a dose of 1500 ppm.

**Table 3**

**Interaction between hydroponic type treatment and nutrient dose (EC) on fresh weight characters of leaves, roots, and plants**

| Treatment combination | Aerial part weight | | Root weight | | All plant weight | |
|---|---|---|---|---|---|---|
| | [g] | | [g] | | [g] | |
| D1N1 | 72.54 | ab | 126.21 | a | 198.75 | a |
| D2N1 | 61.79 | ab | 103.13 | a | 164.92 | ab |
| D3N1 | 59.21 | b | 60.67 | b | 119.88 | b |
| D1N2 | 25.92 | c | 14.25 | c | 40.17 | c |
| D2N2 | 77.43 | ab | 134.38 | a | 211.81 | a |
| D3N2 | 85.88 | a | 124.42 | a | 210.29 | a |

*Note: Numbers followed by the same letter in one column are not different in DMDT level 5%*

The interaction between hydroponic-type treatment and nutrient dose (EC) on aerial part, roots, and plant dry weight is shown in Table 4. The results showed that the highest plant dry weight was obtained from a nutrient dose of 1500 ppm and non-circulating drip irrigation, which was 16.93 grams. This result is consistent with the fresh weight of all plants (Table 3). Furthermore, the highest aerial part dry weight was obtained from the non-circulating drip irrigation hydroponic type and a dose of 1500 ppm (10.64 grams), while the highest root dry weight was obtained from the non-circulating drip irrigation hydroponic type with a nutrient dose of 1000 ppm (7.31 grams).

Drip irrigation is an efficient source of energy and water in the irrigation system. This technique delivers the required and appropriate amount to the plant roots and is applied periodically to reduce excessive evaporation from the area around the roots (*Bansal et al., 2021*) and can increase production (*Parthasarathi et al., 2018; El-Mageed et al., 2022*). In addition, non-circulating drip irrigation can reduce the impact of plant contamination from fungi/pathogens that attack and maintain the growing media's humidity, thereby optimizing plants' metabolic processes and the effectiveness of mineral nutrients absorbed by plants (*Moghadam et al., 2020; Esteves et al., 2022*).

**Table 4**

**Interaction between hydroponic type treatment and nutrient dose (EC) on the dry weight of aerial part, roots, and plants**

| Treatment combination | Aerial part weight(g) [g] | | Root weight (g) [g] | | All plant weight (g) [g] | |
|---|---|---|---|---|---|---|
| D1N1 | 6.65 | abc | 5.65 | ab | 12.30 | a |
| D2N1 | 5.33 | bc | 6.93 | a | 12.26 | a |
| D3N1 | 6.29 | abc | 4.19 | b | 10.48 | ab |
| D1N2 | 8.50 | ab | 7.31 | a | 15.81 | a |
| D2N2 | 10.64 | a | 6.29 | ab | 16.93 | a |
| D3N2 | 3.24 | c | 1.51 | c | 4.75 | b |

*Note: Numbers followed by the same letter in one column are not different in DMDT level 5%*

### 2. Quality of harvest materials

The harvest materials determined their quality using specific proximate analysis such as moisture, ash, fat, and fiber content. In addition, the water and ethanol extractive content are also determined to find how many components could be extracted from the harvest materials.

The moisture content of the aerial part and root are not significantly different. It means that the treatment is not affected the moisture content. Moisture content mostly depends on the drying process. The moisture content in this research is about 10 – 11% (Table 5 and 6), which is higher than the previous report (about 9 – 10%) (*Rusmin, 2017*).

The ash content is also not affected by the treatment, which is from 8.46 to 12.22%. This content is the same as the previous report, from 10.25 – 12.60% (*Rusmin, 2017*). Fat content is also not significantly different among the treatment, aerial part, and root. However, the fat content in the aerial part is higher than in the root part. Different from the crude fat content, the crude fiber content varied among the treatment. The concentration of nutrition is affected by fiber content. The higher the nutrition concentration, the higher the fiber content found in the aerial part (Table 5). The lower the nutrition concentration, the higher the fiber content found in the root (Table 6). The highest fiber content is found in roots with a hydroponic recirculating drip system and 1000 ppm nutrition concentration.

**Table 5**

**Quality of aerial harvest materials in each treatment combination**

| Treatment combination | Moisture content [%] | Ash content [%] | Fat content [%] | Fiber content [%] | Water extractive content [%] | Ethanol extractive content [%] |
|---|---|---|---|---|---|---|
| D1N1 | 11.16 | 9.18 | 1.29 | 1.46a | 21.55b | 7.88 |
| D2N1 | 11.82 | 10.65 | 1.05 | 5.34b | 19.54b | 7.14 |
| D3N1 | 11.43 | 12.22 | 1.08 | 7.55b | 17.75ab | 6.38 |
| D1N2 | 11.52 | 11.54 | 1.04 | 1.37a | 13.25a | 5.22 |

| Treatment combination | Moisture content | Ash content | Fat content | Fiber content | Water extractive content | Ethanol extractive content |
|---|---|---|---|---|---|---|
| | [%] | [%] | [%] | [%] | [%] | [%] |
| D2N2 | 10.64 | 10.98 | 1.40 | 4.65b | 14.50a | 6.84 |
| D3N2 | 10.51 | 11.96 | 1.07 | 6.87b | 15.22a | 7.13 |

**Table 6**

**Quality of root harvest materials in each treatment combination**

| Treatment combination | Moisture content | Ash content | Fat content | Fiber content | Water extractive content | Ethanol extractive content |
|---|---|---|---|---|---|---|
| | [%] | [%] | [%] | [%] | [%] | [%] |
| D1N1 | 11.16 | 9.18 | 1.29 | 1.46a | 21.55b | 7.88 |
| D2N1 | 11.82 | 10.65 | 1.05 | 5.34b | 19.54b | 7.14 |
| D3N1 | 11.43 | 12.22 | 1.08 | 7.55b | 17.75ab | 6.38 |
| D1N2 | 11.52 | 11.54 | 1.04 | 1.37a | 13.25a | 5.22 |
| D2N2 | 10.64 | 10.98 | 1.40 | 4.65b | 14.50a | 6.84 |
| D3N2 | 10.51 | 11.96 | 1.07 | 6.87b | 15.22a | 7.13 |

From an industrial point of view, water and ethanol extractive content is the most important quality. The industry produces the extract and then prepares the final product using the extract. The higher the extractive content, the quality of the material become better. The aerial part's water extractive content is higher than the root. The hydroponic type is affected by the water extractive content. The recirculating drip gave higher water extractive content compared with a non-circulating drip. The water extractive content in the aerial part of this research (13.25 – 21.55%) is lower than the previous report (26.55 – 46.25%, *Rusmin, 2017*).

Different from water extractive content in the aerial part, the ethanol extractive content in this research is higher (5.22 – 7.88%) than in the previous report (4.02 – 4.42%, *Rusmin, 2017*). However, the ethanol extractive content in the root part is lower than in the aerial part (Table 5 and 6). This is because the root part had lower extractive component content but higher fiber content, so this part is a fiber source. The results showed a tendency to increase the water and ethanol extractive content while the nutrient dose was low. It means that the extractive content produces more in lower nutrients. The low nutrient is a stress for Purwoceng, so this plant produces more secondary metabolites than high doses of nutrients.

Combining the dry weight of harvested materials in Table 4 and the extractive content in Table 5 and Table 6, the productivity of extractive content in each plant of cultivation treatment could be summarized in Table 7. For example, the high extractive content in root was found in the root that treated with 1000 ppm nutrient dose with recirculating drip could be applied to produce 1.22 g water extractive content/plant and 0.45 g ethanol extractive content/plant. On the other hand, to produce high extractive content in the aerial part, a 1500 ppm nutrient dose with a non-circulating drip could be applied to produce 1.54 g water extractive content/plant and 0.73 g ethanol extractive content/plant.

**Table 7**

**The productivity of extractive content of all treatment combination**

| Treatment combination | Water extractive content | | Ethanol extractive content | |
|---|---|---|---|---|
| | Aerial part | Root | Aerial part | Root |
| | [g/plant] | [g/plant] | [g/plant] | [g/plant] |
| D1N1 | 1.43 | 1.22 | 0.52 | 0.45 |
| D2N1 | 1.04 | 1.35 | 0.38 | 0.49 |
| D3N1 | 1.22 | 0.74 | 0.40 | 0.27 |
| D1N2 | 1.13 | 0.97 | 0.44 | 0.38 |
| D2N2 | 1.54 | 0.91 | 0.73 | 0.43 |
| D3N2 | 0.49 | 0.23 | 0.23 | 0.11 |

### 3. Safety of Harvest Product

Microbiological safety was determined in each experimental group, aerial part, and roots. The determined microbiological safety includes total plate count (TPC), coliform, and mold/yeast. The results are shown in Table 8.

Based on the data in Table 8, it can be concluded that there is a diversity of measurement results for total plate number, coliform content, and yeast/mold content. Most of the samples showed the presence of microbes, and two herbal samples showed a negative test. From the positive, it appears that all samples of Purwoceng are still safe for consumption. This is based on the results of all samples showing the total plate number (TPC), the value of the coliform content, and the number of molds/yeasts below the standard, referred to as BPOM Regulation No. 13 of 2019 *(BPOM, 2019)*.

Based on these regulations, the TPC for chopped products brewed with hot water or boiled before use is the maximum value of 5 x $10^7$ colonies/gram. The Purwoceng sample showed a range of TPC values of 1.2 x $10^2$ to 3.7 x $10^2$ colonies/gram, namely the root sample of D2N2 treatment.

According to BPOM Regulation No. 13 of 2019, the molds/yeast number for chopped products that are brewed with hot water and boiled before use is the maximum value of 5 x $10^5$ colonies per gram. The highest value of the Purwoceng sample for the molds/yeast number was 4.9 x $10^2$, namely the D1N2 treatment root sample. For the coliform number, the limit of its presence for chopped products, according to the regulation, is $10^3$ colonies/g. The D1N1 treatment root sample shows the highest coliform number in the Purwoceng sample of 2.9 x $10^2$. Coliforms are only found in roots and not in the aerial part. In conclusion, all harvest materials are safe from microbial contaminants.

**Table 8**

**The microbiology content of the harvested product**

| Treatment combination | Aerial part | | | Root | | |
|---|---|---|---|---|---|---|
| | Total Plate Count (colony/g) [colony/g] | Coliform (colony/g) [colony/g] | Total Plate Count (colony/g) [colony/g] | Coliform (colony/g) [colony/g] | Total Plate Count (colony/g) [colony/g] | Coliform (colony/g) [colony/g] |
| D1N1 | 1.6 x $10^2$ | negative | negative | 2.3 x $10^3$ | 2.9 x $10^2$ | Negative |
| D2N1 | 1.7 x $10^3$ | negative | negative | 3.0 x $10^3$ | <10 | 2.5 x $10^2$ |
| D3N1 | Negative | negative | negative | 1.4 x $10^3$ | Negative | <10 |
| D1N2 | 2.4 x $10^2$ | Negative | 2.3 x $10^2$ | 2.4 x $10^2$ | 1.6 x $10^2$ | 4.9 x $10^2$ |
| D2N2 | 1.2 x $10^2$ | negative | negative | 3.7 x $10^2$ | negative | 1.6 x $10^2$ |
| D3N2 | negative | negative | negative | 3.0 x $10^2$ | <10 | 2.5 x $10^2$ |

The harvest materials' metal content analysis (Pb, Cd, and As) showed diversity (Table 9). Lead levels in the samples were in the range of 0.24 and 1.93 mg/kg. Cd was undetectable to 0.12 mg/kg, while As was undetectable to 0.72 mg/kg. Based on the reference to the BPOM regulation No. 13 of 2019 for chopped or simplified products, the safety requirements for heavy metals Pb, Cd, and As are 10, 0.3, and 5 mg/Kg, respectively. Based on this, it can be concluded that all samples are safe from contamination by the three metals. Lead metal was more dominant in the roots, arsenic metal in the aerials part, while cadmium did not show dominance in both parts of the sample.

**Table 9**

**The heavy metal content of the harvested product**

| Treatment combination | Aerial part | | | Root | | |
|---|---|---|---|---|---|---|
| | Pb [mg/Kg] | Cd [mg/Kg] | As [mg/Kg] | Pb [mg/Kg] | Cd [mg/Kg] | As [mg/Kg] |
| D1N1 | 0.17 | 0.01 | 0.65 | 1.37 | undetectable | undetectable |
| D2N1 | 0.56 | 0.02 | 0.48 | 1.93 | 0.12 | undetectable |
| D3N1 | 0.71 | 0.01 | 0.72 | 0.25 | undetectable | undetectable |
| D1N2 | 0.24 | 0.02 | 0.65 | 0.96 | 0.02 | 0.48 |
| D2N2 | 0.24 | undetectable | 0.30 | 1.25 | undetectable | undetectable |
| D3N2 | 0.36 | 0.01 | 0.28 | 0.85 | 0.01 | 0.11 |

*Note: LOD As: 0.008 mg/kg; LOD Cd: 0.00011mg/kg*

The presence of heavy metals in plants can come from the growing media. *Zarinkamar et al. (2021)* reported the presence of Cd content in flower parts of *Matricaria chamomilla* L. flowers grown in hydroponics media contaminated with Cd. The Cd content in flowers increases with Cd contaminants in the hydroponic media solution.

## CONCLUSIONS

Drip hydroponic irrigation system is able to provide control of the growth environment for purwoceng plants well at lower altitudes (1500 m above sea level) than their natural habitat. The resulting growth performance is comparable to that of Purwoceng planted in the highlands as its natural habitat (higher than 2000 m). Recirculating and nonrecirculating drip hydroponic irrigation with a concentration of nutrients from 1000 – 2000 ppm could grow Purwoceng outside their natural habitat. Non-circulating drip irrigation with 1500 ppm of a nutrient is the best treatment to produce high water and ethanol extractive content in the aerial part, and circulating drip irrigation with 1000 ppm of the nutrient is the best treatment to produce high water and ethanol extractive content in the root of Purwoceng. All treatments produce safe harvest products based on microbial and metal contaminants (Pb, Cd, and As).

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