Growth of papaya cv. Callina seedlings on four types of planting media supplemented with different doses of AB-MIX nutrient solution

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Abstract. The growth of papaya cv. Callina seedlings on four media (soil+compost (1:1); soil+compost+husk charcoal (1:1:1); soil+compost+coco peat (1:1:1); or soil+compost+Albasia sawdust (1:1:1)) supplemented with four doses of AB-MIX nutrient solution (0 ml; 15 ml; 30 ml; or 45 ml AB-MIX every three days per plant) was studied. The seeds were planted in the media in polybags and placed in a screen house of Faculty of Agriculture, the Jenderal Soedirman University from February 2018 until April 2018. The treatments with 3 replications were arranged in a Randomized Complete Block Design. Results showed that plant height, number of leaves, stem diameter, and leaf area were affected by the interaction between planting media and doses of AB-MIX solution. Overall the growth of seedlings on soil + compost supplemented with 45 ml of AB-MIX nutrient solution every three days per plant was the best; the growth of seedlings on soil+compost+Albasia sawdust was the worst; application of AB-MIX solution on soil+compost+Albasia sawdust did not improve the height and diameter of seedlings, but the application of 30 ml and 45 ml AB-MIX nutrient solution on soil+compost+Albasia sawdust increased the leaf number and leaf area of papaya seedlings.

1. Introduction
Papaya (Carica papaya L.) plants produce fruits all year around [1]. Export of this fruits from Indonesia to others countries in 2006 was 100.8 t equal to US $47,797 [2]. Production of this fruits in 2009 to 2014 was 772,844 t, 675,801 t, 958,251 t, 906,305 t, 909,818 t, and 840,112 t respectively [3]. In 2017, the production was 870,099 t from 9,964,795 plants [4]. Based on the data of production in 2017, it could be calculated that the average productivity was 87 kg per plant per year. One of some factors affecting low productivity was low quality of seedlings planted by farmers.

Callina is one of high yielding papaya varieties. Its productivity was 57.4 to 67.6 kg per plant per four months [5], which was equal to 172.2 to 202.8 kg per plant per year. By providing ready stock good quality Callina seedlings for planting, it may increase the productivity and production of papaya in Indonesia.

Planting media and fertilizers were two of many factors affecting germination of seeds and growth of seedlings. Papaya seeds were planted directly in soil on nursery beds or in media in polybags. Then, 1-2 moth old papaya seedlings were transplanted on the field. Some media commonly used by farmers and plant hobbies were soil, compost, rice husk charcoal, coco peat, and sawdust. It was used singly or a mixture of two or more components. Good media were specifically designed to physically support
plant growth, allow for maximum root growth, and supply roots with water, air, and nutrients needed by the plants [6].

Compost is used to describe all organic matter that has undergone long, thermophilic, aerobic decomposition [7]. The physical and biochemical properties of compost used as growing media vary greatly, depending on the materials used, the method adopted, and the stage of maturity [8]. However, the physicochemical of the compost was highly dependent upon the material to be composted [9]. Nitrogen content (%) and bulk density of compost increased with the increase in compost age and total nitrogen release decreased with increasing compost age [10]. Incorporation of compost mostly improved plants growth, but in some cases, media containing more than 50% compost had negative effect on plant growth and flowering [7].

Rice husk is the outermost part of the rice seeds which is a hard layer and a waste material from rice milling [11]. Incorporation of fresh rice husk in soil inhibited the growth of the rootstocks Carrizo citrange and Swingle citrumelo [12], in contrast incorporation of parboiled rice husk and rice husk charcoal had beneficial effect on rice growth and yield since it had a potential to reduce the acidity of the soil, increased the saturated hydraulic conductivity, saturated water content, plant available water and field capacity but decreased the bulk density of soil [13]. Although the mechanism whereby rice husk charcoal improves crop yield was not clearly understood, since the effect varied from soil to soil, it was found that the rice husk charcoal increased the soil pH, thereby increasing the available P, the aeration in the crop root zone was improved, the water-holding capacity of the soil was improved, and there was an increase in the level of exchangeable K and Mg. Many biochar-based substrates produced plants with shoot dry mass greater than or equal to the control [15].

Coco peat is shredded coconut husk. The fiber has a total pore space of 98% and an air-filled pore space of around 70% while the dust had a total pore space of 86–94% and an air-filled pore space of 9–14% [8]. It was considered as a good growing media component with acceptable pH, electrical conductivity and other chemical attributes but it has been recognized to have high water holding capacity which causes poor air-water relationship, leading to low aeration within the medium, thus affecting the oxygen diffusion to the roots [16] However, the physicochemical characters of the coco peat were varies considerably depending on the origin of the material.

Sawdust is a by-product woodworking operation such as sawing and sanding. The physicochemical characters of the sawdust were varies considerably depending on the origin of the material. Most fresh sawdust contained high tannin which inhibited the germination seeds and growth of seedlings [17]. In addition, it has high carbon to nitrogen ratio, rapid decomposition of whitewood sawdust with volume loss of up to 50 percent in one year, causing slumping and sometimes an enormous loss of air porosity. The microbes causing this decomposition have a high soluble nitrogen requirement, necessitating heavy applications of nitrogen fertilizer [8]. It was found that sawdust taken from the varieties of oak and chestnut contained tannin in sufficient quantities to cause the tannin poison. On the other hand, sawdust obtained from the conifers and hemlock had no detrimental effect to root growth [18]. The germination of Falcataria moluccana seeds on sand, coco peat, composted sawdust, or soil was 87.33%, 83.67%, 80%, 69.3% respectively [19].

AB-MIX is trade name of completed fertilizer formulation. AB-MIX contain essential nutrients needed by plants. AB-MIX nutrient solution commonly was used in hydroponic systems. Nutrient A stock contains calcium nitrate, Fe and potassium nitrate, while nutrient B stock contains KH2PO4, mono ammonium phosphate, potassium sulfate, magnesium sulfate, manganium sulfate, cupro sulfate, zinc sulfate, boric acid, ammonium hepta molybdate or sodium molybdate [20].

Concentration and dosage of nutrient solution applied to plants were crucial to the plant. The growth of Brassica sp. on hydroponic on 1100 ppm AB-MIX nutrient solution was better than that of on 1050 ppm or 1150 ppm AB-Mix solution [21]. Other found that plant growth of Alyssum was maximized when plants were fertilized with 1.0×concentration of Hoagland solution, resulting in a final growing medium EC of 2.1 dS m$^{-1}$. Maximum shoot dry mass of Celosia was obtained when plants were fertilized with 0.5 to 1.0×concentration of Hoagland solution, resulting in a growing medium EC of 1.1–2.5 dS m$^{-1}$. Growth of Dianthus was best with a 1.0×concentration, resulting in a
grown medium EC of approximately 3.7 dS m\(^{-1}\). However, Dianthus had the most flowers when fertilized with a 2.0×solution. The concentration of nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), boron (B), and iron (Fe) in the shoots of Dianthus increased, while the concentrations of molybdenum (Mo) and zinc (Zn) decreased with increasing fertilizer concentration. Gomphrena and Stock preferred high fertilizer concentrations (1.0 to 2.0×), which resulted in maximum dry mass of both species, and the most flowers on Gomphrena. The growing medium EC associated with the best growth of Gomphrena and Stock was relatively high (2.3–6.5 dS m\(^{-1}\)). Dry mass of Zinnia was maximal with a 0.5×fertilizer concentration and a growing medium EC of 1.0 dS m\(^{-1}\). Flower diameter of Zinnia decreased with increasing nutrient concentrations [22]. The concentration of AB-MIX applied during vegetative phase may differ from that of generative phase [23].

In this experiment the growth of Callina papaya seedlings on four media supplemented with different doses of AB-MIX nutrient solution was evaluated. The study aimed to find the best combination of media and doses of AB-MIX nutrient solution for the growth of papaya seedlings.

2. Methods

The experiment was carried out in a screen house, Faculty of Agriculture, Jenderal Soedirman University, Purwokerto from February until April 2018. This was a 4 × 4 factorial experiment in randomized complete block design. The first factor was types of media, namely (soil + compost (1:1); soil + compost + husk charcoal (1:1:1); soil + compost + coco peat (1:1:1); or soil + compost + Albasia sawdust (1:1:1). The second factor was doses of AB-MIX nutrient solution applied, i.e. 0 ml, 15 ml, 30 ml, and 45 ml AB-MIX nutrient solution applied every three days per plant. There were two polybags for each experimental unit, and there were three replications for each treatment.

Callina seeds, compost, rice husk charcoal, and coco peat were bought in an agricultural shop, namely Suteja in Purwokerto. Albasia sawdust were bought from an Albasia sawmill in Kebocoran village, Purwokerto. The soil was ultisol. The soil was air dried, then it was passed through a 0.5 cm wire sieve. The size of the polybags was 10 cm x 15 cm. Measured variables were plant height, stem diameter, leaf diameter and leaf area. The F test was used to find the differences at 5% error level, followed by LSD at the same error level.

3. Results and discussions

Table 1 showed that the plant height, diameter of stem, leaf number and leaf area of papaya seedlings grew on media soil + compost + albasia sawdust were the worst. Application of AB-MIX nutrient solution up to 45 ml every three days per plant on this media did not increase the plant height and diameter of stem significantly, but the application of 30 ml or 45 ml AB-MIX nutrient solution on this media increased leaf number and leaf area of the seedlings. In contrast, application of AB-MIX nutrient solution every three days per plant on the others media increased the measured variables significantly. Over all the growth of the papaya seedlings based on plant height, diameter of stem, leaf number and leaf area were the best on media soil + compost supplemented with AB-MIX nutrient solution up to 45 ml every three days per plant.

High water-soluble tannin of the albasia sawdust might be the reason why the growth of seedling on media soil + compost + albasia sawdust was the worst and addition of AB-MIX nutrient solution could not improve the growth of the seedling planted on this media. Our finding supports statement that tannin inhibited seed germination and growth of the plants [17]. The other possibility was that high nitrogen was needed for decomposition of fresh albasia sawdust by decomposer microorganisms [8]. In contrast, plant height, number of leaves, stem diameter and leaf area of seedlings grown on other media increased with the increasing doses (up to 45 ml) of AB-Mix nutrient solution.
Table 1. Multiple comparison of each measured variables using Least Significantly Different.

| Treatments                      | Variables          |
|---------------------------------|--------------------|
| Media                           | Doses AB-MIX (ml Every 3 Days per Plant) | Plant Height (cm) | Stem Diameter (cm) | Leaf Number (Sheet) | Leaf Area (cm²) |
| Soil + compost                  | 0                  | 9.39 d           | 0.42 efg           | 9.5 d               | 164.82 de       |
|                                 | 15                 | 11.80 bc         | 0.51 ede           | 10.33c              | 309.61 c        |
|                                 | 30                 | 14.54 a          | 0.62 ab            | 11 ab               | 459.46 b        |
|                                 | 45                 | 15.10 a          | 0.66 a             | 11.5 a              | 638.18 a        |
| Soil + compost + rice husk charcoal | 0                  | 9.77 cd          | 0.43 efg           | 7.84 f              | 163.13 de       |
|                                 | 15                 | 8.87 de          | 0.37 gh            | 9.5 d               | 219.40 d        |
|                                 | 30                 | 13.63 ab         | 0.61 abc           | 10.5 bc             | 403.61 b        |
| Charcoal                        | 45                 | 12.47 b          | 0.56 bcd           | 10.5 bc             | 482.01b         |
| Soil + compost + coco peat      | 0                  | 6.79 ef          | 0.28 h             | 7.17 g              | 71.87 fgh       |
|                                 | 15                 | 9.46 d           | 0.4 fg             | 9.17 d              | 189.69 de       |
|                                 | 30                 | 10.38 cd         | 0.47 def           | 9.5 d               | 318.04 c        |
| Coco peat                       | 45                 | 11.67bc          | 0.5 de             | 10.34c              | 470.84 b        |
| Soil + compost + Albasia sawdust| 0                  | 3.50 g           | 0.14 i             | 3.5 i               | 7.38 h          |
|                                 | 15                 | 4.02 g           | 0.17i              | 6.5 h               | 57.12 gh        |
|                                 | 30                 | 4.13 g           | 0.16 i             | 7.5 fg              | 129.41 efg      |
| Albasia sawdust                 | 45                 | 4.77 fg          | 0.17i              | 8.5 e               | 154.49 def      |

Values in the same column followed by same letter means no significantly different.

There was linear relationship between the measured variables (the plant height, stem diameter, leaf number, and leaf area) and the doses of AB-MIX applied. However, the slope of the regression was varied for each measured variable and for each medium. Figure 1. showed that on media soil + compost, plant height = 0.132 AB-MIX + 9.728; On media soil + compost + rice husk charcoal, plant height = 0.085 AB-MIX + 9.253; On media soil + compost + coco peat, plant height = 0.103 AB-MIX + 7.245. On media soil + compost + Albasia sawdust, plant height = 0.026 AB-MIX + 3.516.

Figure 2. showed that on media soil + compost, stem diameter = 0.005 AB-MIX + 0.429; On media soil + compost + rice husk charcoal, stem diameter = 0.004 AB-MIX + 0.398; On media soil + compost + coco peat, stem diameter = 0.005 AB-MIX + 0.297.; On media soil + compost + Albasia sawdust, stem diameter = 0.000 AB-MIX + 0.149.

Figure 1. Plant height of papaya cv. Callina seedlings on different media supplemented with different doses of AB-MIX nutrient solution.
Figure 2. Diameter of stem of papaya cv. Callina seedlings on different media and doses of AB-MIX nutrient solution

Figure 3. showed that on media soil + compost, leaf number = 0.044 AB-MIX + 9.583; On media soil + compost + rice husk charcoal, leaf number = 0.06 AB-MIX + 9.253; On media soil + compost + coco peat, leaf number = 0.065 AB-MIX + 7.566; On media soil + compost + Albasia sawdust, leaf number = 0.106 AB-MIX + 4.1.

Figure 4. showed that on media soil + compost, leaf area = 10.46 AB-MIX + 157.5; On media soil + compost + rice husk charcoal, leaf area = 7.605 AB-MIX + 145.9; On media soil + compost + coco peat, leaf area = 8.835 AB-MIX + 63.81; On media soil + compost + Albasia sawdust, leaf area = 3.424 AB-MIX + 10.05.
Our finding that the growth of papaya seedlings on soil + compost + albasia sawdust was the worst was not supported by the finding that germination of *Falcataria moluccana* in sawdust media was not inhibited [19] as these differences may result from that the *Falcataria* seeds were planted in decomposed sawdust and papaya seeds were planted in fresh sawdust.

Without AB-Mix application, the growth of papaya seedlings on media soil + compost in ratio 1:1 was better than that of on other media. But media soil + compost + rise husk charcoal. This finding supported the finding that the growth of *Andrographis paniculata* seedlings [24], *Diospyros celebica* seedlings [25], and *Gonystylus bancanus* seedlings [26] on media soil + compost was good.

4. Conclusions

The growth of Callina seedlings on soil + compost media supplemented with 45ml AB-MIX nutrient solution every three days was the best; The growth of Callina seedlings on soil + compost + Albasia sawdust media was the worst; Application of 45ml AB-MIX nutrient solution every three days on the soil + compost + Albasia sawdust media did not increase the plant height and stem diameter of Callina seedlings significantly. Application of AB-MIX 30 and 45 ml every three days per plant increased leaf number and leaf area of papaya cv Callina seedlings grown on soil + compost + Albasia sawdust media.

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