Development of conceptual design and simulation of dapog system rice seed seedling machine for production scale

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Abstract. Providing a match seeds that could be used to transplanter tray is needed. Therefore the design of an automatic machine that provides rice seedling rolls with better quality and uniformity in a short time, using lower labour amount and fit to the transplanter machine must be conducted. The objective of this research was to design an effective and efficient rice seed dapog system seedling machine for Kubota Transplanter and test through conceptual model simulation. The result showed that the tray must move with a velocity of 10 cm/s (conveyor axis rotation velocity of 13 RPM), the feeder of soil, seeds and cover soil rotation velocity of 8 RPM, 2.5 RPM, and 4 RPM respectively, to create a dapog system rice seed. Simulation test result showed that the movement of each designed component could fulfil the seedling process. Static conceptual model simulation result showed that the highest stress value was 118.77 N/mm², maximum deformation was 2.23 mm, and the lowest FoS value was 12.92. Since the occurred stress value was smaller than the maximum stress value of frame material of 745 N/mm², it could be concluded that the frame could load the machine.

1. Introduction
Rice is the staple food for Indonesian which makes rice cultivation is widely conducted in Indonesia. The demand for rice as staple food continues to increase, and rice covers 80% or more of total consumption as the staple food of Indonesian societies [1]. Indonesia has 8.19 million hectares of rice field in 2016. Rice cultivation process consists of several stages where each stage will determine the plant quality, one of the operations is the seedling stage that is an activity of sowing rice seeds in media in the purpose to create a maximal growth of the seeds. Nowadays, the rice seeds seedling process is conducted in the seedling area then continue with the transplanting stage that moving the seeds to planting area (rice field). Transplanting stage could be performed by two methods namely manual method and mechanic method using transplanter machine.

There are trays in transplanter machine which function as the rice seeds container that will be transplanted which have a specific form. Therefore, to provide an easier method of rice cultivation, the seedling stage is conducted in a particular seedling box which commonly called dapog system seedling [2]. An appropriate seedling method can be used by dapog system [3]. The size of the dapog box consist of two parts namely outside and inside part. The outside part dimension is 60cm length, 31 cm wide and 4 cm height; moreover, the inside part dimension is 58 cm length, 28 cm wide and 3 cm height [4].

Total of 175 and 185 dapog seeds is needed to fulfil a hectare of rice field which means the dapog system seedling will use a lot of time and workforces. Besides, several steps should be conducted before
transplanting using transplanter machine such as root cleansing. A good root system and uniform seeds could support the rice transplanter performance [5]. Therefore, an automatic machine that could provide rice seedling rolls with better quality and uniformity in a short time and a lower amount of labour is needed. A design of dapog rice seeder model for laboratory scale has been conducted [3] with an average productive capacity of 360 trays/hour. The objective of this research was to design an effective and efficient rice seed dapog system seedling machine for Kubota Transplanter in production scale and to test through conceptual model simulation.

2. Materials and Methods

2.1 Tools and materials
This research was divided into several stages namely literature study, problem analysis, design, and simulation stage. The designed machine in this study is a development design from the laboratory scale dapog rice seeder model [3]. CAD solid work application was used to simulate the designed machine using conceptual model simulation. Consequently, the conceptual model then tested using static analysis to analyse the material strength toward load and motion analysis to analyse the design precision of each machine component dimension to work appropriately with the seedling needs. Several parameters were analysed including stress, deformation level and FoS of machine frame conceptual model to analyse the frame material strength in loading the machine and the movement suitability of the rice seed seedling dapog system conceptual model component in fulfilling the needs.

3. Results and Discussion

3.1 Specification
Figure 1 showed the conceptual model design of dapog system rice seed seedling machine which consists of several parts namely hopper, feeder, upper and lower machine frame, belt conveyor, pulley and v-belt, gearbox 70:1 and electrical motor. There is no additional soil and seed levelling equipment in the designed machine since the feeder could correctly divide the soil, seeds, and fertilizer + soil which resulted in a uniform rice seed dapog system.

From calculation, hopper dimensions were 457.27 mm height, 286 mm length, 206 mm wide and plate thickness of 3.2 mm. Furthermore, the hopper was connected to the each of 3 feeders (soil, seeds and fertilizer and soil), with diameter of 150 mm and length of 280 mm, then attached to the frame using four bolts, and the capacity of each hopper was 10 kg. Moreover, the upper and lower machine frame which used angle bars with dimensions of 50mm x 30mm x 3mm and 50mm x 50mm x 5mm, respectively. The overall machine frame dimensions were 1120 mm length, 506 mm wide and 880 mm height. Besides, the conveyor belt rotated on an axis (13 RPM) with a diameter of 12 cm which moved the tray in the velocity of 10 cm/s. Total four pairs of pulleys and four v-belts were used in the machine design, the scheme of dapog system rice seed seedling machine power transmission showed in Figure 2.
3.2 Model design simulation

3.2.1 Motion simulation. Based on the calculation, conveyor belt axis, soil feeder, rice seed feeder, and the cover soil feeder must move with rotation of 13 RPM, 8 RPM, 2.5 RPM, and 4 RPM, respectively to create a tray of dapog system rice seed seedling. The result of motion simulation showed that the tray moved in the velocity of 5.8 cm/s (conveyor axis rotation of 13 RPM), the soil, rice seed, and cover soil
feeder rotated in 8 RPM, 2.5 RPM, and 4 RPM, respectively, which showed that each machine component was working appropriately.

3.2.2 Static simulation. Based on the calculation, the total load on the machine frame was 183.774 kg (1837.741 N) which consisted of a total mass of 3 hoppers, materials inside the hoppers, feeders, and pulleys. The static simulation was conducted to analyse the frame strength toward the load.

- Upper frame
  - Stress static test
    Figure 3a showed the result of the simulation, the highest stress occurred in the upper frame was 11.768 N/mm² (red). Since the highest stress value was smaller than the maximum tensile stress, i.e., 745 N/mm², it could be concluded that the upper frame could endure the machine load.
  - Deformation test
    Deformation test was conducted to analyse the deformation of the frame that was caused by stress. The value of frame deformation showed by stress colour code; blue code showed the lowest deformation until red code which showed the highest deformation. Figure 3b showed the result of the simulation, the maximum deformation on the upper frame design was 2.23 mm (red).
  - Factor of safety (FoS) test
    FoS test was conducted to analyse the safety level of the frame to be used as a holder of the load. A safe frame design must have FoS value more than 2. The result of the simulation could be seen in Figure 3c. The lowest upper frame FoS was 12.92 (orange) which showed that the frame design was safe to be used.

![Figure 3](https://via.placeholder.com/150)

*Figure 3. (a) Result of the upper frame static stress test ; (b) Result of upper frame static displacement test ; (c) Result of upper frame FoS test*
• Lower frame
  a. Stress static test
  Figure 4a showed the result of the simulation, the highest stress occurred in the lower frame was 17.379 N/mm² (green). Since the highest stress value was smaller than the maximum tensile stress, i.e., 745 N/mm², it could be concluded that the upper frame could endure the machine load.
  b. Deformation test
  Figure 4b showed the result of the simulation, the maximum deformation on the lower frame design was 0.53 mm (red).
  c. Factor of safety (FoS) test
  The result of the simulation could be seen in Figure 4c. The lowest lower frame FoS was 33.69 (orange) which showed that the frame design was safe to be used.

4. Conclusion
After simulated by using graph model simulation, the design of dapog system rice seed seedling machine for Kubota Transplanter was efficient and could continue to fabrication stage.

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