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## Growth and yield of five Indonesian new superior varieties of soybean in dry climate rainfed rice fields

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# Growth and yield of five Indonesian new superior varieties of soybean in dry climate rainfed rice fields

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**Abstract.** Indonesian new superior varieties of soybean are continually released as an effort to increase soybean productivity. Some new superior varieties such as Devon 1, Dena 1, and Dega 1 were not widely known by the stakeholders. This research aims were to investigated the growth and yield of five Indonesian new superior varieties of soybean in the dry climate rice field. The experiment was conducted from March to July 2018 in Segala Anyar Village of Central Lombok Regency, West Nusa Tenggara Province, Indonesia. The experimental design was used non-factorial randomized block design with the soybean varieties as treatments (Devon 1, Dena 1, Anjasmoro, Argomulyo, and Dega 1). Each treatment was repeated four times. The parameters observed included plant height, number of branches, number of leaves, number of sections, number of pods, and soybean production. Data were collected from 10 crop samples for each replication during vegetative phase 1 and 2. The results showed that the soybean varieties had a significant effect on plant height, number of branches, number of sections and production. The crop could not produce optimally during field experiment due to lack of water in the pod-filling phase. Generally, it could grow well and has ability to produce yield.

**Keywords:** Dry climate, growth, new superior varieties, soybean, yield

## 1. Introduction

Soybean (*Glycine max* L.) is one of the Indonesian strategic commodities, which contain high protein and become a raw material for various processed foods such as tofu, tempeh, soymilk, soy sauce, and bean sprouts. Recently, Indonesian soybean production has not been able to meet domestic needs; therefore it still relies on importation. The main obstacle of soybean production in Indonesia is low productivity. Indonesian soybean production in 2017 was 539 tons with productivity of 1.5 tons/ha [1]. Meanwhile, some governmental efforts to increase soybean production include increasing planting area, use of new superior varieties as well as use of certified seeds. Soybean can be grown in ricefields or dry land and do not require a lot of water. Soybean planting in ricefields is generally carried out in the dry season (DS) I and II, and on dry land in the rainy season (RS) [2].

Rainfed ricefields are potential land for planting soybean on DS I after rice. It is states that planting soybean after rice crop is a form of efficiency in the utilization of rainfed ricefields [3]. West Nusa Tenggara (WNT) Province is the third soybean producing area in Indonesia after East Java and Central Java Provinces with cultivation in paddy fields (58%) and dry land (42%) [4]. Rainfed lowland ricefields in WNT in 2017 was 65,179 ha, generally planted one to two times a year [5]. The area for

developing soybean in rainfed lowland areas is included in Central Lombok Regency, which cultivated during DS I. Besides the expansion of planting areas, the use of new superior varieties was also carried out to increase soybean productivity. It was stated that varieties that had been widely known by farmers in WNT Provinces until 2012 included Anjasmoro, Wilis, Grobogan, and Argomulyo [4]. Meanwhile, the new superior varieties (NSV) of soybean that have been released by Indonesian Legumes and Tuber Crops Research Institute (ILETRI) in the past five years include Devon 1 (2015), Dena 1 (2014), and Dega 1 (2015). These varieties were not widely known by farmers in WNT Province. The province of WNT has the potential to develop those varieties, especially in rainfed rice fields. However, before further development, an adaptation test for those NSV of soybean is needed to obtain information regarding their growth in rainfed lowland rice fields and varieties that have high potential yield.

## 2. Materials and methods

This research was conducted during the first dry season (DS I) in rainfed lowland rice fields from March to July 2018, located in Segala Anyar Village of Central Lombok Regency. The experimental design was using a non-factorial randomized block design, consisting of the treatment of five soybean varieties, namely Devon 1, Dena 1, Anjasmoro, Argomulyo, and Dega 1. Each variety was repeated four times, therefore there were 20 experimental plots in total. Farming steps were included sowing preparation, planting and maintenance, control of plant pests and diseases, and harvesting. No tillage planting was applied. The rice straw from previous rice crop was left on the ground, and then flattened. The experimental plot was made with a size of 5 m x 7 m with a sowing spacing of 15 cm x 40 cm. Sowing was done manually with a depth of 2-3 cm, two seeds per hole. NPK fertilizer was applied with dosage of 100 kg/ha as well as one litre/ha of liquid fertilizer. NPK fertilizer was applied before spreading of straw mulch, while liquid fertilizer was applied at the age of 20, 30, 45, and 60 days after sowing (DAS).

Watering was carried out during flowering and pods filling. Weeding was conducted 2-3 times, depending on the condition of the weed. Harvesting was conducted by cutting the base of the stem. It was done when 75% (at a minimum) of the leaves of the plant begin to turn yellow, dry and fall out and the pods were brown. The 2 m x 5 m sampling plot was made to determine the production of pods produced. Observation of plant growth was carried out during the vegetative phase 1 (3 weeks after sowing), vegetative 2 (4 weeks after sowing), and generative phase with observation variables including plant height, number of branches, number of leaves, number of nodus, number of pods, weight of 100 grains, and the production of the soybean. Data were taken from 10 plant samples for each experimental plot. Furthermore, the data obtained were analysed using SAS program. The treatment that has a significant effect, then followed by Duncan test at  $\alpha=5\%$ .

## 3. Results and discussion

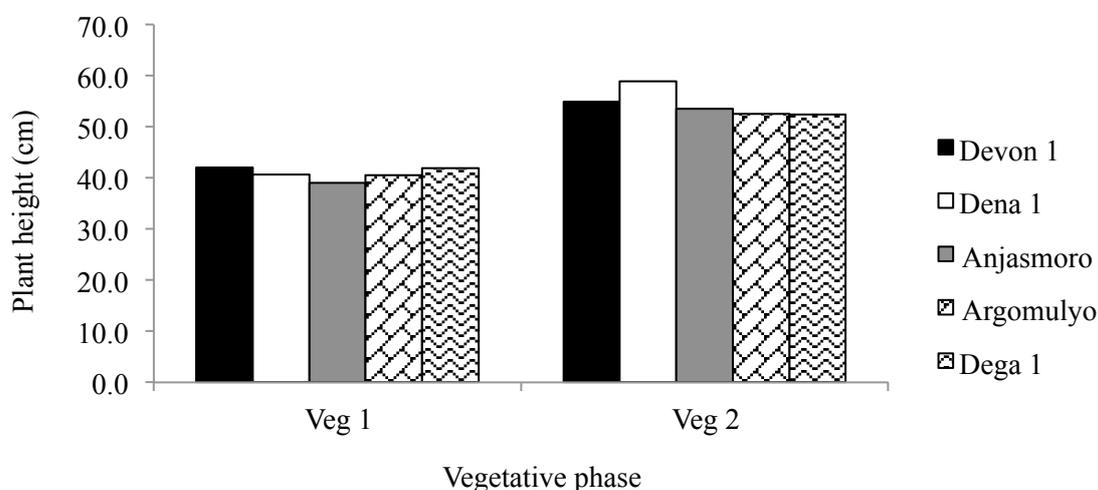
### 3.1. General condition of the experimental site

The experimental site was farmers' rice fields with paddy-rice cropping patterns, soil pH 6.86 with clay structure. The location is a soybean area for DS I in Central Lombok Regency, and includes in a category of rainfed lowland rice fields. The irrigation process comes from small dam and relies on rainwater. The soil condition at the sowing time was suitable for planting soybean, but at that there was heavy rain so that the land conditions were flooded. Then when the plants grow up to harvest there is no rain, therefore the plants experienced water stress.

### 3.2. Agronomic performances

3.2.1. *Plant height.* The highest of plant height in the vegetative phase 1 was produced by Devon 1 (42.1 cm) and the lowest was Anjasmoro (39.1 cm). Plants continue to grow, until the vegetative phase 2 has a high increase of about 33% from the previous phase. The highest value is owned by the variety

of Dena 1 (58.9 cm), while the lowest was Dega 1 (52.4 cm) (figure 1). The results of the variance analysis showed that during the phase of vegetative 1, soybean varieties did not have a significant effect on plant height. While during vegetative phase 2, soybean varieties have a significant influence on plant height. Based on Duncan's advanced test, Dena 1 variety is different from Argomulyo and Dega 1 varieties, while Devon 1 and Anjasmoro varieties were not significantly different from Dena 1, Argomulyo and Dega 1 (figure 1).



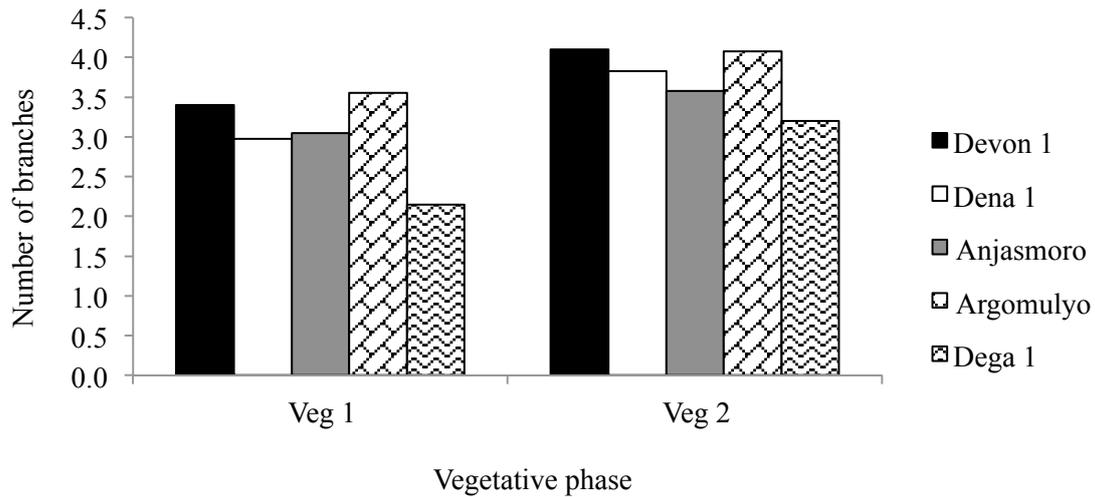
**Figure 1.** The plant height of five new superior varieties of Indonesian soybean during vegetative phase 1 and 2.

The plant height at the beginning of the observations was relatively same, but in the next observation there were significant differences in several varieties, such as Dena 1 with Argomulyo and Dega 1. The Devon 1 variety had the highest plant height, but this value was lower if compared with the description of ILETRI [6]. Research by [7] showed that Devon 1 variety soybeans treated with 3 dS/m water salinity had plant height of 60.15 cm. This shows that different environmental conditions can produce different plant responses.

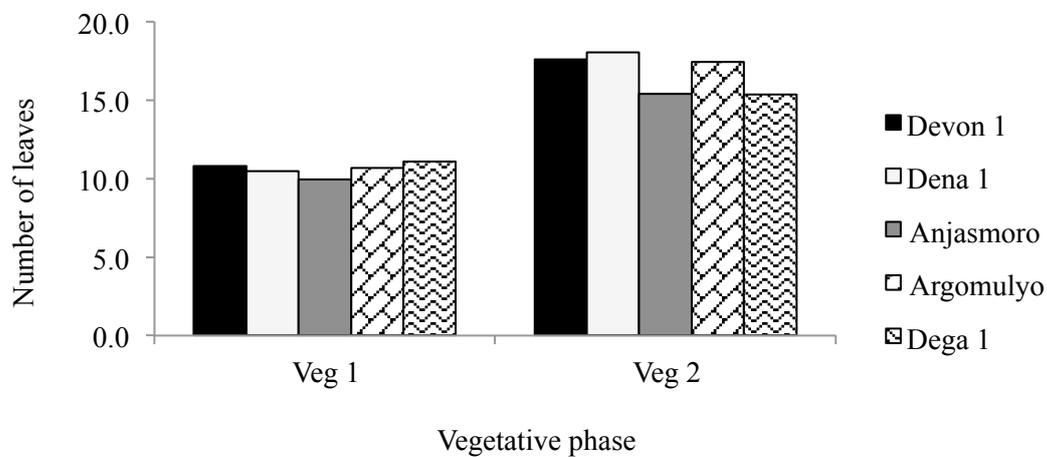
**3.2.2. Number of branches.** The number of branches of soybean plants in the vegetative phase 1 is around 2,2 - 3,6, then increases in vegetative phase 2 to 3.2 – 4.1 (figure 2). The number of branches of Devon 1 and Argomulyo varieties tends to have more branches compared to the other three varieties.

The analysis of variance showed that the varieties had a significant influence on the number of branches, both in vegetative phase 1 and 2. Based on Duncan's further test it can be seen that Devon 1 and Argomulyo varieties differ from Dega 1, both at vegetative phase 1 and 2. While Dena 1 and Anjasmoro were not significantly different compared to other varieties (Figure 2). The number of branches of soybeans was significantly different during vegetative phase 1. The value of the number of branches increases most frequently in Dega 1. However, Dega 1 still has the lowest number of branches compared to other varieties. When compared with [8], the results of this study indicated a lower number of branches for Argomulyo variety, and higher for Anjasmoro variety. It was known that plant height and number of branches were positively correlated with soybean yield [9]. While a large number of branches allow for the formation of many pods [10].

**3.2.3. Number of leaves.** The number of leaves of soybean plants in the vegetative phase 1 is generally similar as values ranging from 10-11 (figure 3). Furthermore, in the vegetative phase 2, there was an increase in the number of leaves around 58% of the vegetative phase 1, which was with a value of 15-18. The results of variance analysis indicated that soybean varieties do not have a significant effect on the number of leaves, both during vegetative phase 1 and 2.



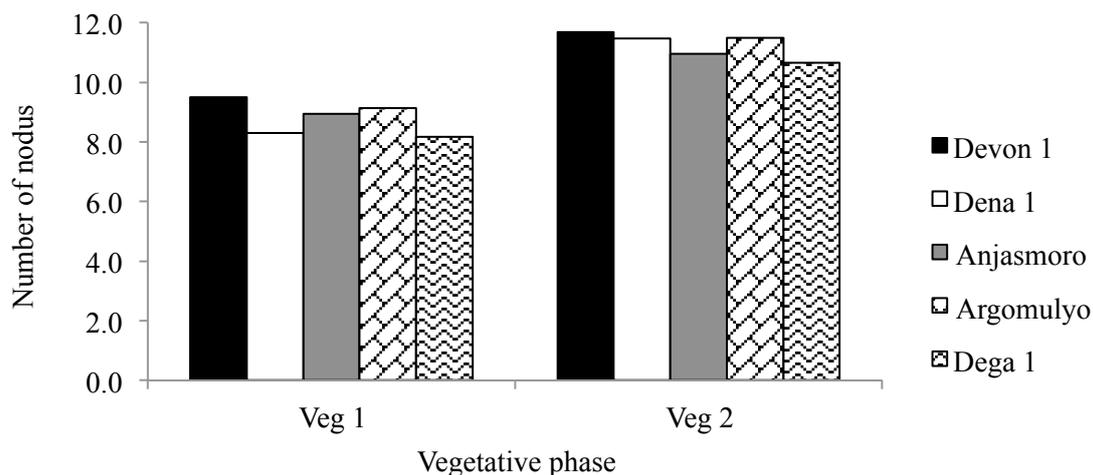
**Figure 2.** Number of branches of five new superior varieties of Indonesian soybean during vegetative phase 1 and 2.



**Figure 3.** Number of leaves of five new superior varieties of Indonesian soybean during vegetative phase 1 and 2.

Leaves are one of the important organs in plant metabolic processes, namely photosynthesis. The components needed for photosynthesis include water. It was argued that water is an important component in plant growth and development [11]. Conditions in the field indicated that plants experienced water shortages because there is no rain during the growing period and the nearest water source has dried up. It also argued that the vegetative phase, flowering, and the formation phase of soybean pods are phases that are sensitive to drought stress [12]. The lowest number of leaves was produced by Anjasmoro and Dega 1 varieties. Those numbers were lower than the lowest number of leaves in other study which was received irrigation treatment every 30 days [13].

**3.2.4. Number of nodus.** The number of nodus of soybean plants ranged from 8 to 9, with the highest value possessed by Devon 1 variety and the lowest was owned by Dega 1 variety (figure 4). Furthermore, in the vegetative phase 2 there was an increasing the number of nodus around 27% it is almost the same value, ranging from 10-11.

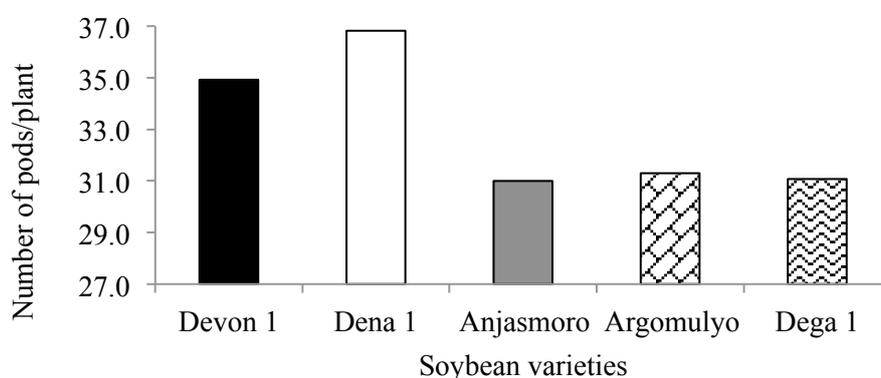


**Figure 4.** Number of nodus of five new superior varieties of Indonesian soybean during the vegetative phase 1 and 2.

The results of the variance analysis showed that soybean varieties only had a significant effect on the number of nodus in the vegetative phase 1. Based on Duncan's test, Devon 1 variety was not significantly different from Anjasmoro and Argomulyo, while Dena 1 and Dega 1 varieties were significantly different from Anjasmoro (figure 4). The number of nodus on the stem is influenced by the type of stem growth and the period of irradiation. It was known that soybean plant height affects the number of nodus on Seulawah and Baluran varieties [14]. Meanwhile, the number of reproductive nodus affects the number of pods [15].

### 3.3. Yield Parameters

**3.3.1. Number of pods per plant.** The number of pods was produced by the variety of Dena 1 (36.8), then followed by Devon 1 (34.9), Argomulyo (31.3), Dega 1 (31.1), and Anjasmoro (31.0) (figure 5).

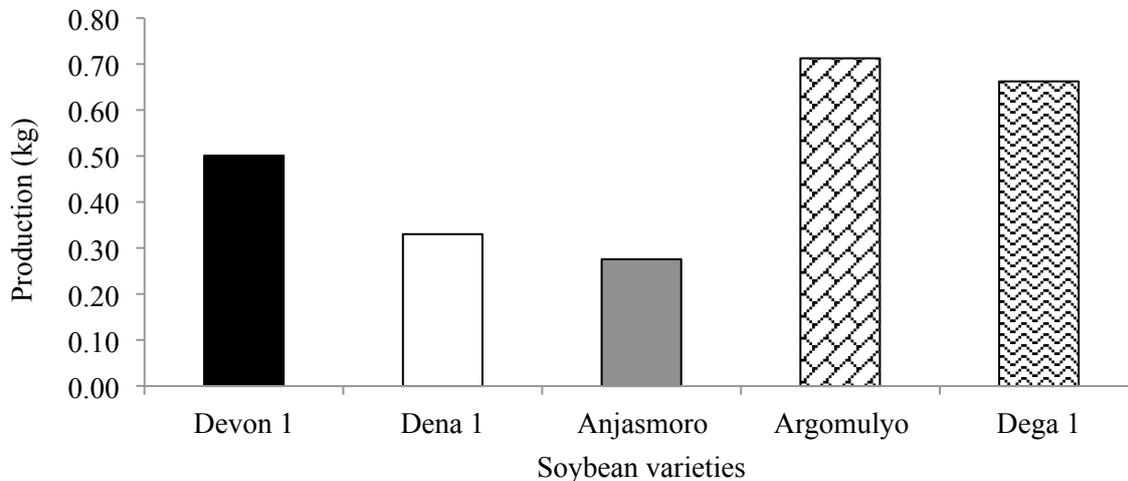


**Figure 5.** Number of pods among five new superior varieties of Indonesian soybean.

The results of the variance analysis showed that soybean varieties did not have a significant effect on the number of pods.

**3.3.2. Soybean production per sampling plot (2 m x 5 m).** The production of soybean from sampling plot shows that the variety of Argomulyo had the highest yield (0.71 kg), followed by Dega 1 (0.66

kg), Devon 1 (0.50 kg), Dena 1 (0.33 kg), and Anjasmoro (0.28 kg) (figure 6). Based on these results, the varieties gave a real influence on the production of soybean. Duncan's test showed that the Argomulyo variety was different from Devon 1, Dena 1, and Anjasmoro, but not different from Dega 1.



**Figure 6.** Plot sampling production among five new superior varieties of Indonesian soybean in dry climate rice fields.

Although the Anjasmoro and Dega 1 varieties have the lowest number of pods compared to Dena 1, the highest weight of the beans is actually produced by those varieties. This can be caused by the Dena 1 variety having more empty pods than Argomulyo and Dega 1. In addition, the size of the seeds could affect seed weight. Devon 1, Anjasmoro, Argomulyo, and Dega 1 varieties of soybeans are categorized to large seed soybeans [16]. However, because during the filling phase the plant pods did not get water, therefore the seed growth was not optimal. It was stated that the stress of water in the soil affects the volume of water needs of soybean plants [17]. In addition, the results of other research show that water stress has a significant influence on the number of pods, number of filled pods, and seed dry weight per plant. Based on the weights, Argomulyo variety has a productivity of 0.7 tons/ha. This is still much lower than the potential results in the description of [6]. The low yield obtained due to environmental factors in the form of water availability [18] shows that some soybean varieties grown in rainfed lowland areas have less than optimal results if compared with optimal conditions. However, soybean plants can still produce in rainfed lowland rice with clay texture, and experienced water stress during their growth period. Therefore, in general, soybean varieties could grow adaptively in rainfed lowland rice with clay structures if the environmental conditions are optimal.

#### 4. Conclusion and recommendation

Soybean varieties had a significant effect on plant height, number of branches, number of nodus and yield. Although in this experiment, the crop could not produce optimally in the field due to lack of water in the pod-filling phase, but in general, it could grow well and has ability to produce yield. New superior varieties of Indonesian soybean could grow and produce in rainfed lowland Central Lombok District in DS I. However, the yield obtained was lower than the potential yield due to water stress. It is recommended that similar treatments were tested in different year in order to compare the results from this research before gaining general conclusions.

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