Growth and production of seven soybean varieties (*Glycine max* (L.) Merrill) in a coastal area

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Abstract. An experiment was conducted in Barombong, Makassar City, to determine the growth and production of several soybean varieties on coastal land. The research was an experiment designed by a randomized block design with seven soybean varieties as treatments, namely Ijen, Wilis, Anjasmoro, Sinabung, Burangrang, Tanggamus, and Kaba. Each treatment was repeated four times, making a total of 28 experimental units. Results showed that all varieties could adapt to the coastal area. However, Anjasmoro provided the best growth and production based on variables of plant height (58.50 cm), the weight of 100 seeds (14.93 g), seeds weight per plot (447.65 g) and seed production per hectare (1.70 tons ha⁻¹). Ijen variety only gave the highest value on the number of leaves (20 strands) and the earliest 50% flowering age, (33.5 days). Kaba variety only gave the highest value on productive branches (2.75 branches) and the earliest 50% flowering age (33.5 days). Sinabung variety only gave the highest value on the number of pods per plant (30.9 pods) and the lowest percentage of empty pods (17.33%). Burangrang variety gave the earliest harvesting time at 85.5 days.

1. Introduction

Indonesian national demand for soybeans has now reached 2.8 million tons per year. Since the country could fulfill only 40% of them, importing is necessary to cover the shortfall. Forecasting model indicated the annual deficit in soybean production in 2013 were 0.98% per year. Average consumption projection of 2.8 million tons per year or an increase of around 2.1% or. Hence, domestic needs are met from imported soybeans by 57% [1].

Among the cause of low national soybean production is the unpopular use of superior varieties of seeds by most farmers and the limited available planting area. However, the government continues to increase soybean production through various programs of both intensification and extension of cultivation area [2].

The national average soybean production is 800,000 tons - 1 million tons per year [3], while at the research level, it reached 1.6 - 3.2 tons ha⁻¹, depending on conditions land and technology applied. These figures indicate soybean production at the farm level can still be improved through technological innovation, one of which is the use of location-specific superior varieties of seeds [4].

There is an opportunity for increasing domestic soybean production by the expansion of planting areas and increased productivity through the use of superior varieties. Secretary-General of the Directorate General of Food Crops, Ministry of Agriculture, stated the government targeted for increasing planting of soybeans covering an area of 500 thousand hectares [5].
However, some view skeptically emphasized that the target for production improvement for soybean sovereignty of Indonesia will remain as a faraway dream without significant actions that are practicable on the ground. Figure 1 showed the volume and value of imported soybean in Indonesia.

![Figure 1. Volume and value of Indonesian soybean import](Source: Comtrade NDY; tirto.id)

To overcome the excessive import of soybean and reach the sovereignty of soybean, the government need to emphasize the improvement in three aspects. These aspects are productivity increase; extension of cultivation area and increase profitability of the soybean [6]. Increase on productivity can be achieved through improvement in cultivation technique and utilization of quality seeds. Extension of cultivation area needs to consider fields which have limitation and less usable such as coastal areas with its salinity problem. The government themselves already have the intention to utilize this type of land [5].

Indonesia is an archipelago consisting of around 13,760 large and small islands with a coastline length of about 81,000 km [7,8]. There are 39.42 million hectares or approximately 25 percent of the land area of the Indonesian archipelago affected by the tides of the sea which then causes the land in the coastal area to become saline [9]. In the province of South Sulawesi, there are approximately one million hectares of coastal land that are considered not suitable for planting due to salinity problems [10].

Utilization of coastal land for the expansion of planting areas is one part of government policy to increase soybean production. However, considering that salinity is an inhibiting factor for plant growth, it is necessary to utilize superior varieties that adapt and produce optimum on such field. This paper presents results of a trial on seven soybean varieties to see their growth and production in coastal areas where salinity presumably becomes an inhibiting factor.
2. Methodology
An experiment was conducted in Barombong, Makassar City, at a location with an altitude of 1 m asl. The soil type is alluvial with a sandy texture. Soil salinity levels were fluctuating during the study, from 2.98 mmhos cm\(^{-1}\) to 4.36 mmhos cm\(^{-1}\).

The experiment was designed using a randomized block design with seven soybean varieties as the only treatment: v1= Ijen; v2= Wilis; v3= Anjasmoro; v4= Sinabung; v5= Burangrang; v6= Tanggamus; v7= Kaba

Each treatment unit consists of one experimental plot measuring 2.6 m × 2 m and repeated four times, making a total of 28 experimental plots.

3. Results and discussion

3.1. Vegetative variables.
The results showed that the varieties have significant effects on plant height (table 1), yet, but have no significant impact on the number of leaves (figure 1) and the number of productive branches (figure 3).

| Variety   | Average | DMRT |
|-----------|---------|------|
| v1 (Ijen) | 46.35\(^b\) | 9.54 |
| v2 (Wilis)| 44.45\(^b\) | 10.02|
| v3 (Anjasmoro) | 58.50\(^a\) | 10.31|
| v4 (Sinabung) | 52.10\(^ab\) | 10.50|
| v5 (Burangrang) | 53.93\(^ab\) | 10.60|
| v6 (Tanggamus) | 53.58\(^ab\) | 10.76|
| v7 (Kaba) | 44.41\(^b\) |      |

Notes: Numbers followed by different letters in the column were significantly different at the level of 95% (DMRT \(\alpha=0.05\)); DMRT= Duncan Multiple Range Test

Figure 2. Average number of leaves six weeks after planting

Ijen variety gave the highest average number of leaves while Burangrang gave the lowest (figure 2). The stressed plant showed the ability to maintain their continued growth by minimizing the physiological and morphological damage. The small number of leaves in Burangrang variety plants is thought to be a form of plant adaptation to saline conditions which affects plant metabolism. Plants balance the potential of water for maintaining turgor and other biochemical processes. It could result
in a relatively smaller number and size of leaves. Mechanism of plant tolerance to salinity could be seen in morphological and physiological adaptation [11]. The most obvious one is morphological adaptation with several common expressions in leaves. These expressions for example are changes in leaf structure both in terms of quantity and size; relatively small stomata per unit leaf area; increase in succulence; root lignification and thickening of the cuticles and wax layers on the leaves.

**Figure 3.** Average of number of productive branches

The highest number of fruitful branches was obtained by Kaba variety (figure 3). Although the difference was not significant, it could be an indication that the genetic nature of the variety was able to interact with the growing environment.

Differences in growth between plants of the same species relate to genetic and environmental factors. Different genotypes will show different appearances after interacting with the environment. Marliah et al. [12] stated each plant variety has distinct characteristics that are determined by the interaction between genetic traits and the growing environment.

Anjasmoro had the highest average plant height (table 1). According to the above explanation, it is possible to assume the environment and genetic properties to be supporting each other. The environment where plants grow supports the expression of plant height characters in the variety. Some soybean varieties show significant differences in plant height. It indicates the genes that regulate the characters are different; thus, within the same environment, the expressed plant phenotype is also distinct. Welsh [13] emphasized a genotype will give different responses to different environment condition as well as different genotypes that will give different responses when growing in the same environment. There are differences between two individuals on the same environmental factors and can be measured; then this difference comes from variations in the genotypes of the two plants [14].

### 3.2. Generative variables: pods

Observable generative parameters related to pods formation are yielding age, the number of pods per plant unit and percentage of empty pods. Table 2 showed the number of pods produced by all varieties.
Table 2. The average number of pods of all soybean varieties

| Variety   | Average | DMRT |
|-----------|---------|------|
| v1 (Ijen) | 26,8<sup>ab</sup> | 6,41 |
| v2 (Wilis)| 21,7<sup>b</sup>   | 6,72 |
| v3 (Anjasmoro) | 23,4<sup>b</sup>   | 6,90 |
| v4 (Sinabung) | 30,9<sup>a</sup>   | 7,02 |
| v5 (Burangrang) | 22,7<sup>b</sup>   | 7,13 |
| v6 (Tanggamus) | 22,8<sup>b</sup>   | 7,23 |
| v7 (Kaba)  | 25,8<sup>ab</sup> |      |

Notes: Numbers followed by different letters in the column were significantly different at the level of 95% (DMRT <span style='color: #0000ff;'>α</span>=0,05); DMRT= Duncan Multiple Range Test

Table 3. The average number of empty pods of all soybean varieties

| Variety   | Average | DMRT |
|-----------|---------|------|
| v1 (Ijen) | 27,21<sup>c</sup> | 5,50 |
| v2 (Wilis)| 24,28<sup>bc</sup> | 5,77 |
| v3 (Anjasmoro) | 20,96<sup>ab</sup> | 5,92 |
| v4 (Sinabung) | 17,33<sup>a</sup> | 6,03 |
| v5 (Burangrang) | 19,90<sup>ab</sup> | 6,13 |
| v6 (Tanggamus) | 29,23<sup>c</sup> | 6,21 |
| v7 (Kaba)  | 18,29<sup>a</sup> |      |

Notes: Numbers followed by different letters in the column were significantly different at the level of 95% (DMRT <span style='color: #0000ff;'>α</span>=0,05); DMRT= Duncan Multiple Range Test

Soybean variety of Sinabung had the highest number of pods per plant and gave the lowest percentage of empty pods (tables 2 and 3). It indicated that this variety is tolerant of salinity, which had not significantly affected the growth and development process. According to Sipayung [11], tolerance to salinity is diverse with a broad spectrum between species and plant varieties ranging from sensitive to tolerant.

3.3. Generative variables: seeds

Variables of soybean seeds production are presented in table 4 and 5.

Anjasmoro (v3) gave the highest average weight of 100 seeds, yet not significantly different from Burangrang (v5) but was significantly different from other varieties.
Table 4. The average weight of 100 seeds (g)

| Variety     | Average | DMRT |
|-------------|---------|------|
| v1 (Ijen)   | 10,96<sup>b</sup> | 1,97 |
| v2 (Wilis)  | 10,08<sup>b</sup> | 2,06 |
| v3 (Anjasmoro) | 14,93<sup>a</sup> | 2,07 |
| v4 (Sinabung)| 10,57<sup>b</sup> | 2,15 |
| v5 (Burangrang) | 14,84<sup>a</sup> | 2,19 |
| v6 (Tanggamus) | 10,27<sup>b</sup> | 2,22 |
| v7 (Kaba)   | 10,33<sup>b</sup> |      |

Notes: Numbers followed by different letters in the column were significantly different at the level of 95% (DMRT <sup>α</sup>=0,05); DMRT= Duncan Multiple Range Test

Anjasmoro variety gave the highest average value of 100 seeds while the lowest average weight of 100 seeds was obtained in the Kaba variety. Descriptively, the seeds of the Anjasmoro variety are large while Kaba's are medium-sized seeds. Maximum size and weight of seeds are genetically determined, but the environment determines the actual size of seeds during seed filling [15]. Oemar & Soemartono [16] stated that salinity or salt stress during generative phase could result in the formation of stunted flowers, the fall of buds and young pods, besides causing incomplete filling of pods so that seed weight decreases. Salisbury and Ross [17], added a reduction in seed weight due to reduced photosyntheate translocated for the formation of pods and seeds as a result of an unbalanced increase in respiration rate with that of photosynthesis. Hence, a lot of starch and other organic materials are metabolized to balance the osmotic potential inside and outside the tissue. These are all the effect of salinity.

Table 5. Average seeds yield per hectare (tons per hectare)

| Variety     | Average | DMRT |
|-------------|---------|------|
| v1 (Ijen)   | 1,23<sup>c</sup> | 0,28 |
| v2 (Wilis)  | 1,13<sup>c</sup> | 0,29 |
| v3 (Anjasmoro) | 1,70<sup>a</sup> | 0,29 |
| v4 (Sinabung)| 1,30<sup>bc</sup> | 0,30 |
| v5 (Burangrang) | 1,53<sup>ab</sup> | 0,31 |
| v6 (Tanggamus) | 1,07<sup>c</sup> | 0,31 |
| v7 (Kaba)   | 1,34<sup>bc</sup> |      |

Notes: Numbers followed by different letters in the column were significantly different at the level of 95% (DMRT <sup>α</sup>=0,05); DMRT= Duncan Multiple Range Test

Dry seed production per hectare showed Anjasmoro to lead as a variety with the highest production. It is again presumably because the variety is tolerant to salinity compared to other varieties. Salinity-tolerant plants can withstand the effects of high salt in the root and surface area without a real adverse effect [18].

Anjasmoro variety is thought to be capable of adapting to growing environments in such a way that the metabolic process runs normally. The size and weight of seeds is determined by the results of photosynthesis translocated for the formation of pods and seeds, in this case, Gardner et al., [19] stated that in plant growth and development, materials are moved from the source, synthesized and then
translocated to where they are used or stored (sink). Tolerant varieties of salinity stress will provide optimal results.

4. Conclusion
Variety of Anjasmoro performed the best in terms of growth and production variables on coastal land compared to other varieties. It indicates Anjasmoro to be a potential saline tolerant variety. Therefore this variety is recommended to support government program for soybean development on sub-optimal land such as coastal area. Based on the soil analysis of the study location, this variety could be cultivated in a field with salinity levels between 2.90 - 4.36 mmhos cm⁻¹.

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