Effect of spacing on growth and yield of several black soybean varieties (*Glycine max* L Merril)

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Abstract. This research aims to determine the growth response and yield of several Black Soybean varieties in several variations of spacing. The experiment is a factorial experiment using a randomized block design (RBD) consisting of two treatment factors, the first factor is the variety consisting of 3 levels: V1 = Detam 1, V2 = Detam 3 Prida, V3 = Detam 4 Prida. The second factor is spacing which consists of 3 levels: J1 = 20 cm x 20 cm, J2 = 20 cm x 30 cm, J3 = 20 cm x 40 cm. The interaction of varieties with plant spacing has a very significant effect on crop dry weight and seed oven per planting hole. The significant effect the yield seeds of dried and oven per hectare. The weight of oven-dry seeds per planting hole and the highest yield of oven-dried seeds per hectare was obtained in the interaction of Detam 1 varieties with the spacing of 20 cm x 40 cm with was 33.79 g and 2.53 tons per hectare which increased 138.79% and 42.93% compared with the interaction of Detam 4 Prida varieties with a spacing of 20 cm x 20 cm with was 14.15 g and 1.77 tons per hectare.

1. Introduction

Soybean is a plant native to the Chinese plains. Soybeans began to be known in Indonesia since the 16th century. The beginning of the spread and cultivation of soybeans, namely in Java, then developed into Bali, Nusa Tenggara and other islands [1]. Soybeans can be seen from the color of the seeds, namely yellow soybeans and black soybeans. Soy sauce made from black soybeans in addition to having a delicious soy sauce aroma and taste also has better protein and nutrient content compared to soy sauce produced from yellow soybeans so that demand black soybeans increases [2]. Black soybean has a water content of 12.3 g/100g, 33.3g/100g protein, 15.0g/100g fat, 35.4g/100g carbohydrates, and 4.0g/100g minerals [3]. Black soybean can be used as a raw material for making quality soy milk and other food products. Black soybeans contain anthocyanins such as 1,1-diphenyl-2-picrylhydrazyl (DPPH) and O₂ with high antioxidant content [4].

Efforts to increase the production of black soybean plants require the provision of high yielding varieties of high yields both in quantity and quality and be able to adapt to unfavorable environmental conditions [5]. The use of high yielding varieties will make a difference in growth and yields. The potential yields of several black soybean varieties include Detam 1 (2.86 tons/ha), Detam 2 (2.96 tons/ha), Detam 3 Prida (3.15 tons per hectare), Detam 4 Prida (2.54 tons per hectare), Malika (2.34 tons per hectare) [6]. In the process of growth and development of black soybean plants, different varieties will contribute to different results depending on the environment in which one of them grows. Plant spacing plays an important role associated with competition in getting sunlight, absorption of nutrients...
in the soil. A wide distance increases the evaporation of water from the soil, thereby disrupting plant growth, while a narrow distance results in competition for plants to get nutrients, sunlight, and water [7]. Plant population can be done by adjusting the distance between rows and the distance in rows [8]. The recommended spacing for middle-aged black soybean varieties is 40 cm x 15 cm, short-lived varieties 40 cm x 10 cm or 30 cm x 15 cm [9]. From the results of the study Andrade et al., obtained a spacing of 40 cm x 20 cm was able to increase the yield of yellow soybean varieties, namely 2.94 tons per hectare which increased 116.17% compared to the spacing of 40 cm x 25 cm. is 1.36 tons per hectare [10]. This research was conducted to determine the response of growth and yield of several varieties of Black Soybean in some distance variations.

2. Materials and methods
The materials used in this study were black soybean seeds Detam 1 variety, Detam 3 Prida variety, Detam 4 Prida variety, urea fertilizer, SP36, KCL, insecticide brands FATAK, Furadan, Cocopyte, and soil. This research was a factorial randomized block design with 2 factors tried and carried out in Sumerta Village, East Denpasar District, that lasts from February to May 2019. The first factor is the variety consisting of 3 levels: V1 = Detam 1, V2 = Detam 3 Prida, V3 = Detam 4 Prida. The second factor is the spacing which consists of 3 levels, namely: S1 = 20 cm x 20 cm, S2 = 20 cm x 30 cm, S3 = 20 cm x 40 cm. Thus 9 combination treatments were obtained. Each experiment was repeated 3 times so that 27 trial plots were needed. The variables observed in this study were: maximum plant height, the maximum number of leaves, number of filled pods, number of seeds per planting hole, harvest dry weight and oven-dry weight per planting hole, dry seed yield per hectare, dry weight of harvest 100 seeds, oven-dry stover weight.

3. Results
The results of analysis of variance obtained significance from the effect of various tests (V) and plant spacing (S) and their interactions (VxS) on the growth and yield of black soybean plants as presented in Table 1.

| Variable | Treatment | (V) | (S) | (VxS) |
|----------|-----------|-----|-----|-------|
| 1 Maximum plant height (cm) | * | ns | ns |
| 2 Maximum number of leaves (strands) | ns | ns | ns |
| 3 Number of filled pods per planting hole (fruit) | ns ** | ns |
| 4 Number of seeds per planting hole (fruit) | ns ** | ns |
| 5 The dry weight of seed harvest per planting hole (g) | * ** | ** |
| 6 Seed oven-dry weight per planting hole (g) | ns ** | ** |
| 7 Yields of dried seeds harvested per hectare (tons) | ns ns | * |
| 8 Crop dry weight of 100 seeds (g) | ** ** | ns |
| 9 Oven dry weight stover per planting hole (g) | * | ns | ns |

Note: ns = not significant (P≥0.05), * = significant (P<0.05), ** = very significant (P<0.01).

Based on Table 1, the interaction between varieties and plant spacing has a very significant effect (P ≤ 0.01) on the dry weight of the harvest and oven seeds per planting hole, which has a significant effect (P≤0.05) on the yield of dried seeds harvested per hectare. Variety treatment had a very significant effect (P≤ 0.01) on the dry weight of 100 seed harvests, had a significant effect (P≤0.05) on maximum plant height, dry weight of seed harvest per planting hole and oven-dry weight of stover per planting hole. The treatment of spacing has a very significant effect (P ≤ 0.01) on the number of filled pods per planting
hole, the number of seeds per planting hole, dry weight of seeds harvested per planting hole, the oven-
dry weight of seeds per planting hole, dry weight of 100 seeds harvested.

The effect of variety test and planting distance on the growth and yield of soybean plants can be seen
in Table 2. From Table 2, Detam 3 Prida (V2) and Detam 4 Prida (V3) Varieties give the best results on
plant height, number of leaves, and oven dry weight per plant hole. However, the Detam 1 (V1) variety
gave the best value on the dry weight variable of 100 seeds. Whereas the 20 cm x 30 cm (S2) and 20 cm
x 40 cm (S3) planting spacing treatments gave the best results on the number of filled pods per planting
hole, number of seeds per planting hole, and dry weight of 100 seeds.

Table 2. Effect of variety treatment and planting distance on the growth and yield of soybean plants.

| Treatment          | Maximum plant height (cm) | Maximum number of leaves (strands) | Number of filled pods per planting hole (fruit) | Number of seeds per planting hole (fruit) | Crop dry weight of 100 seeds (g) | Oven dry weight stover per planting hole (g) |
|--------------------|---------------------------|-----------------------------------|-----------------------------------------------|-----------------------------------------|----------------------------------|-----------------------------------------|
| Varieties          |                           |                                   |                                               |                                         |                                  |                                         |
| Detam 1 (V1)       | 72.22 b                   | 50.89 b                           | 126.22 a                                      | 189.61 a                               | 18.36 a                          | 33.02 b                                 |
| Detam 3 Prida (V2) | 73.89 a                   | 52.33 a                           | 119.33 a                                      | 236.36 a                               | 13.30 c                          | 39.90 a                                 |
| Detam 4 Prida (V3) | 74.11 a                   | 52.22 ab                          | 132.67 a                                      | 192.46 a                               | 15.33 b                          | 40.24 a                                 |
| LSD 5%             | 1.27                      | 1.42                              | -                                             | -                                       | 1.57                             | 6.10                                    |
| Planting distance  |                           |                                   |                                               |                                         |                                  |                                         |
| 20 cm x 20 cm (S1) | 72.67 a                   | 51.11 a                           | 90.67 b                                       | 146.22 b                               | 14.05 b                          | 38.12 a                                 |
| 20 cm x 30 cm (S2) | 73.89 a                   | 52.22 a                           | 135.22 a                                      | 246.44 a                               | 15.80 a                          | 39.54 a                                 |
| 20 cm x 40 cm (S3) | 73.67 a                   | 92.75 a                           | 152.33 a                                      | 225.77 a                               | 17.14 a                          | 35.50 a                                 |
| LSD 5%             | -                         | -                                 | 21.33                                         | 60.40                                  | 1.57                             | 6.1                                     |

Note: The average value is followed by the same letter in the same column, not significantly different in the 5% LSD test.

The results showed that the interaction treatment between Detam 1 varieties with a spacing of 20 cm x
40 cm (V1S3) gave the highest yield of dry weight of crop seeds per planting hole, oven dry weight of
seeds per planting hole, and yield of seeds harvested per hectare (Table 3, 4, and 5).

Table 3. The average dry weight of seeds harvested per planting hole (g) in the interaction between
varieties and spacing.

| Treatment          | Max Plant Spacing          |
|--------------------|---------------------------|
|                    | 20 cm x 20 cm (S1) | 20 cm x 30 cm (S2) | 20 cm x 40 cm (S3) |
| Varieties          |                         |                     |                     |
| Detam 1 (V1)       | 22.87 a                 | 35.75 a             | 53.11 a             |
|                    | C                       | B                   | A                   |
| Detam 3 Prida (V2) | 23.90 a                 | 36.89 a             | 35.80 c             |
|                    | B                       | A                   | A                   |
| Detam 4 Prida (V3) | 22.57 a                 | 33.83 a             | 46.60 b             |
|                    | C                       | B                   | A                   |
| LSD 0.05           | 6.00                     |

Note: The numbers followed by the same lowercase letters in the same column and the same uppercase letters in the same row,
did not differ significantly in the 5% LSD test.
Table 4. The average weight of oven dry seeds per planting hole (g) in the interaction between varieties and plant spacing.

| Treatment          | Plant Spacing          |
|--------------------|------------------------|
|                    | 20 cm x 20 cm (S1)     | 20 cm x 30 cm (S2) | 20 cm x 40 cm (S3) |
| Varieties          |                        |                    |                    |
| Detam 1 (V1)       | 14.15 a                | 23.61 a            | 33.79 a            |
|                    | C                      | B                  | A                  |
| Detam 3 Prida (V2)| 17.49 a                | 26.76 a            | 25.86 b            |
|                    | B                      | A                  | A                  |
| Detam 4 Prida (V3)| 14.70 a                | 23.53 a            | 29.77 ab           |
|                    | C                      | B                  | A                  |
| LSD 0.05           |                        | 4.23               |                    |

Note: The numbers followed by the same lowercase letters in the same column and the same uppercase letters in the same row, did not differ significantly in the 5% LSD test.

Table 5. The average yield of dried seeds is harvested per hectare (tons) on the interaction between varieties and spacing.

| Treatment          | Plant Spacing          |
|--------------------|------------------------|
|                    | 20 cm x 20 cm (S1)     | 20 cm x 30 cm (S2) | 20 cm x 40 cm (S3) |
| Varieties          |                        |                    |                    |
| Detam 1 (V1)       | 2.83 a                 | 2.98 a             | 3.31 a             |
|                    | A                      | A                  | A                  |
| Detam 3 Prida (V2)| 2.98 a                 | 3.07 a             | 2.23 b             |
|                    | A                      | A                  | B                  |
| Detam 4 Prida (V3)| 2.82 a                 | 2.86 a             | 2.91 a             |
|                    | A                      | A                  | A                  |
| LSD 0.05           |                        | 0.57               |                    |

Note: The numbers followed by the same lowercase letters in the same column and the same uppercase letters in the same row, did not differ significantly in the 5% LSD test.

4. Discussion

The highest dry weight of seeds harvested per planting hole was obtained in the interaction of Detam 1 varieties with the spacing of 20 cm x 40 cm (V1S3), which was 53.11 g, an increase of 135.31% compared to the interaction of Detam 4 Prida varieties with a spacing of 20 cm x 20 cm (V3S1) which is 22.57 g (Table 3). The highest dry weight of seed ovens per planting hole was obtained at the interaction of Detam 1 varieties with a spacing of 20 cm x 40 cm (V1S3) which was 33.79 g; increased 138.79% compared to the interaction of Detam 1 varieties with a spacing of 20 cm x 20 cm (V1S1) which is 14.15 g (Table 4). The highest yield of dry seeds per hectare was obtained at the interaction of Detam 1 varieties with a spacing of 20 cm x 40 cm (V1S3) which was 3.31 tons; increased by 48.43% compared to the interaction of the Detam 3 Prida variety with a spacing of 20 cm x 40 cm (V2S3) which is 2.23 tons (Table 5).

The high crop dry weight and oven-dry seeds per planting hole, yields of dry seeds harvested per hectare in the interaction of Detam 1 varieties with a spacing of 20 cm x 40 cm were allegedly due to the response of variety Detam 1 which was able to overcome the level of the competition despite occurring competition for sunlight and nutrients during growth. This is supported by the statement from Irvan varieties play an important role in the process of growing soybean plants because to achieve high productivity is largely determined by the potential yield of superior varieties planted [1]. The potential yield of seeds in the field is still influenced by the interaction between genetic factors of varieties and
the management of growing environmental conditions. If the management of the growing environment is not carried out properly, the potential for high yield yields of these superior varieties cannot be achieved. When the distance between plants decreases the percentage increase in production per land is significantly determined by the percentage increase in the light interception. Furthermore, it is mentioned that the use of plant density is basically to provide space and good plant growth without experiencing competition between fellow plants [10]. Plant spacing can affect the growing environment and crop yields, the closer the plant spacing, the plant population increases so that competition between plants to absorb nutrients from the soil will increase. The use of plant spacing can affect leaf shade due to leaf structure overhaul, increase in plant height, decrease in the number of branches [11].

5. Conclusions
Interaction between varieties and planting distance has a very significant effect on crop dry weight, oven-dry weight of seed per planting hole and has a significant effect on crop dry yield per hectare. The highest seed dry weight and oven-dry per planting hole was obtained in the interaction of Detam 1 varieties with the spacing of 20 cm x 40 cm with a weight of 53.11 g and 33.79 g which increased by 135.31% and 138.79% compared to the interaction Detam 4 Prida variety with the spacing of 20 cm x 20 cm with a weight of 22.57 g and 14.15 g. The highest yield of dry seeds per hectare was obtained in the interaction of Detam 1 varieties with a spacing of 20 cm x 40 cm which was 3.31 tons, an increase of 48.43% compared to the interactions of the Detam 3 Prida variety with a spacing of 20 cm x 40 cm namely 2.23 tons.

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References
[1] Irwan A W 2006 Budidaya Tanaman Kedelai (Glycine max L. Merril) [Online] Retrieved from http://pustaka.unpad.ac.id/wpcontent/uploads/2009/03/budidaya_tanaman_kedelai.pdf 26 Februari 2019
[2] Adie M M and Ayda K 2007 Biologi tanaman kedelai
[3] Sadikin M 2002 Biokimia enzim (Jakarta: Widya Medika)
[4] Futura D L and Mullen R E 2002 J. Plant Sci. 71 373-383
[5] Pangan E 2006 Karakteristik Kedelai Sebagai Bahan Pangan Fungsional [Online] Retrieved from http://tekpan. unimus. ac. id (7 Februari 2017)
[6] Badan Litbang Pertanian 2013 Produksi kedelai (Badan Penelitian dan Pengembangan Pertanian. Kementerian Pertanian)
[7] Viyanti E 1999 Pengaruh Media dan Jarak Tanam Kultivar Granola (Bogor: Departemen Budidaya Pertanian, Fakultas Pertanian-IPB)
[8] Purwati P 2006 Journal of Oceanology. Mar. Res. Indonesia 30 47-55
[9] Srihartanto E, Anshori A and Iswadi A 2015 Produktivitas Kedelai Dengan Berbagai Jarak Tanam Di Yogyakarta
[10] Andrade F H, Calvino P, Cirilo A and Barbieri P 2002 Agronomy Journal 94 5 975-980
[11] Ansori N and Haryadi S S 1993 Bulletin Agronomi 4 3 17-27