

# Yield Enhancement of Soybean (*Glycine max* L. Merrill) in Genotypes 'Polije-4' and 'Polije- 5' through Backcross with Large Seed Donor Parent

*by* Nurul Sjamsiah

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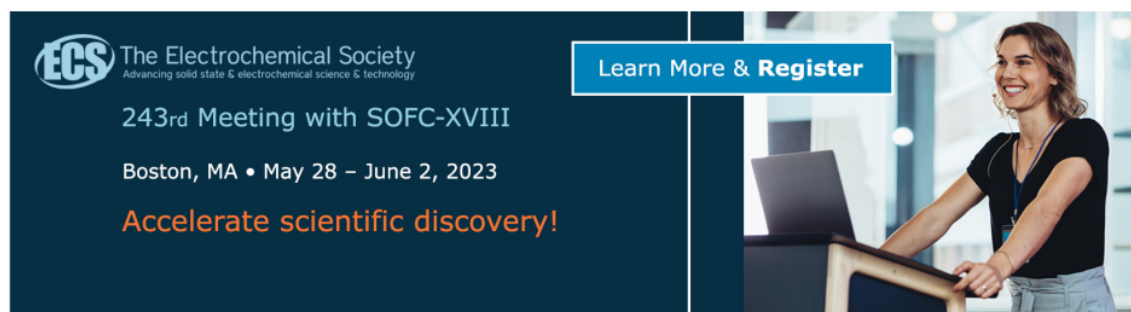
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## Yield Enhancement of Soybean (*Glycine max* L. Merrill) in Genotypes 'Polije-4' and 'Polije-5' through Backcross with Large Seed Donor Parent

N Sjamsijah<sup>1</sup>, S Rahayu<sup>1</sup>, S Suharjono<sup>1</sup>, E Rosdiana<sup>1</sup> and P Santika<sup>1</sup>

<sup>1</sup> Department of Agricultural Production, PoliteknikNegeriJember, JlnMastrip Kotak Pos 164 Jember, Jember, Indonesia

E-mail: <sup>1</sup>nurul\_sjamsijah@polije.ac.id

**Abstract.** Soybean is one of important crops in Indonesia because of its role as a source of vegetable protein and it is used as an industrial raw material. However, national soybean production cannot keep up with the need. Hence, large amount of import is required to meet national needs. This study aims to assemble new high yielding soybean varieties, which have high yield ( $\geq 3$  ton/ha), early maturity (harvest age  $\leq 76$  days), large seed ( $> 15$  g) and have moderate resistance to major soybean disease, the leaf rust, caused by *Phakopsora pachyrhizi*. In the previous research, soybean genotypes which fit to the criteria above have been obtained, namely 'Polije-4' and 'Polije-5'. However, these genotypes have a major drawback which is the small size of the seed (around 13 g/100 seeds). This drawback can be repaired by using the recurrent backcross method with 'Ryokko' edamame as the donor parent, which has a distinctly large seed size around 35 g/100 seeds. In the current research, this backcross method between 'Polije-4' and 'Ryokko', as well as 'Polije-5' and 'Ryokko' was conducted and resulted in the increase of yield ( $> 20$  g/plant) and seed size ( $> 15$  g/100 seeds), but still maintaining the early harvest age ( $\leq 76$  days).

### Introduction

Soybean is an important crop because of its role as a source of vegetable protein and it is used as an industrial raw material. Nonetheless, national soybean production is low and cannot keep up with the need. This results in a very large amount of imports every year, which can reach up to 70% of our total need [1]. In 2018 alone, national soybean production was around 982 thousand tons [2], whereas the national need for soybeans is around 3 million tons/year. Moreover, national soybean productivity has only reached 1.4 tons per hectare [3].

Low soybean productivity and high production costs results in the low domestic production of soybean, which cannot keep up with the increasing needs. However, judging from the existing potential, domestic soybean production is still possible to be improved. One important step in increasing soybean production is the use of superior varieties. These varieties can be obtained through plant breeding activities, by conducting selection of available germplasm or by conducting selection from segregated populations.

One attempt in assembling high yielding soybean varieties is to increase the size of the seed. This can be done through the restoration of soybean seed size characteristics through crossing with large



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seed donor parent. In the previous study, 'Ryokko' Japanese edamame was used as the initial donor parent for its large seed size. Now in the continuous study, the descendants of crossings between 'Ryokko' and several other varieties were re-crossed with 'Ryokko' all over again to restore the seed size. This technique is called *backcross* and the selection is termed *recurrent parent selection*. The method of cross-breeding is a form of repeated crosses with the aim of transferring or adding genes of a superior trait to a cultivar or variety. Superior varieties are technological innovations that are easily adopted by farmers and provide a significant contribution in increasing production.

Nowadays, the development of soybean varieties is directed to productivity and quality improvement, as well as adaptation to certain growing environments [5]. Hence, in order to overcome the low soybean production, assembling new high yielding varieties follows these characteristics: 1) High productivity  $\geq 3$  tons / ha so that farmers are attracted to plant soybeans, 2) Early maturity that allows farmers to plant two or three times a year, 3) Moderately resistance to the main disease of soybeans, the leaf rust disease.

Plant material of the study was F1 population resulted from previous studies [4], namely genotypes of 'Polije 4' and 'Polije 5'. These genotypes are the improvements to local varieties that could be the farmers' hope in the future. The initial parents of both genotypes were local variety 'Wilis' (high number of pods but small seed size) and Japanese edamame 'Ryokko' (low number of pods but large seed size around 35 g/100 seeds). The crossing result between 'Wilis' and 'Ryokko', which is named 'Unej 2', produced moderately high number of pods with moderately large seed size. However, the age of harvest was not preferable. In order to shorten the age of harvest, 'Unej 2' was crossed with 'Malabar' which has an early harvest age. The crossings between these two resulted in the genotypes of 'Polije 4' and 'Polije 5', which have adapted well to eight soybean production centers in East Java. However, after crossed with 'Malabar', compared to the previous crossing results, there was a decrease of seed size in both 'Polije 4' and 'Polije 5', down to around 13 g/100 seeds.

Thus, in order to restore the seed size, backcross was conducted until the desired target characteristic was inserted into both 'Polije 4' and 'Polije 5'. By backcrossing both genotypes back with 'Ryokko', it is expected that the seed size should increase to be up to more than 15 g/100 seeds, and the early harvest age should be maintained. These two characteristics would become a special attraction for farmers to plant soybean.

## 2. Research Methods

The study was conducted in the State Polytechnic of Jember experimental garden, during the dry season (MK) 1 from April to October 2019. The land was located at 84 meters above sea level, with soil type of composition of brown latosol and gray regusol. The material used in this research was the genotype of Polije-4 and Polije-5 resulted from the previous studies, and 'Ryokko' edamame as the backcross parent donor. In general, the research was conducted in several stages, which were genotype selection with the desired character, cultivation, crossing (backcrossing), labeling and observing, as shown in Figure 1, 2, 3 and 4. The observation parameters included plant height, number of branches, age of flowering, age of harvest, seed weight per plant and 100-seed weight. The sample size used was 10 plants for each backcrossed genotypes.

### 2.1 Backcross Method

Recurrent parents used in this study were genotype 'Polije-4' (A) and genotype 'Polije-5 (B)', while the donor parent used was 'Ryokko' (C). After crossing was done successfully, BC 1 (Backcross I) seeds were collected for each cross. The BC1 seeds of each crossing were then planted and observation was carried out on several production parameters, such as, age of flowering, age of harvest, 100-seed weight, seed weight per plant, plant height, and number of branches.

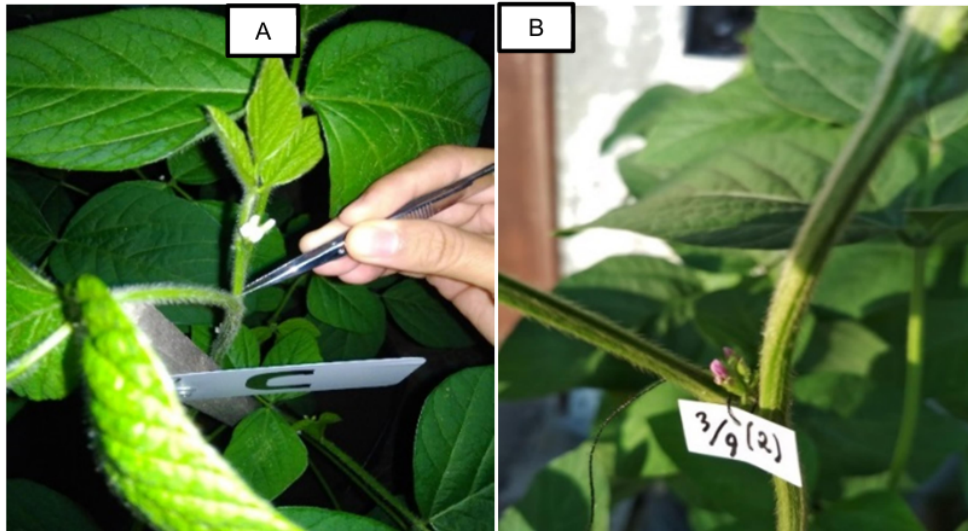


Figure 1. a) Castration b) Hibridization

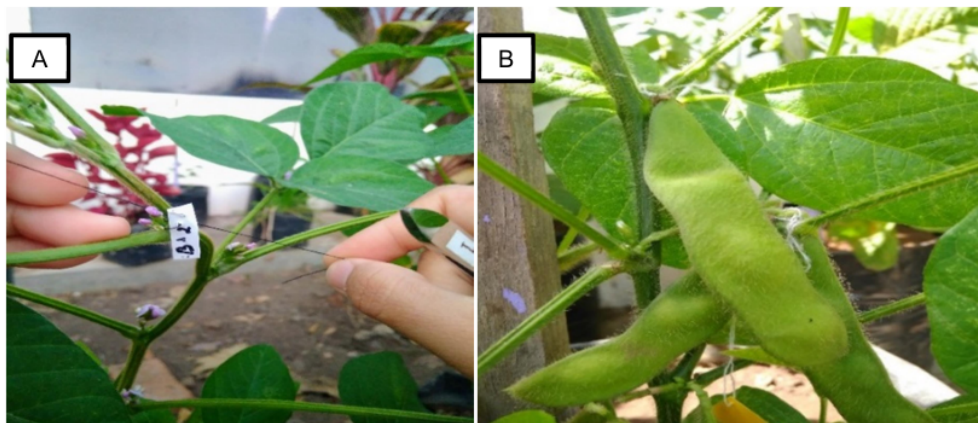


Figure 2. (A) Labelling, (B) Backcross result

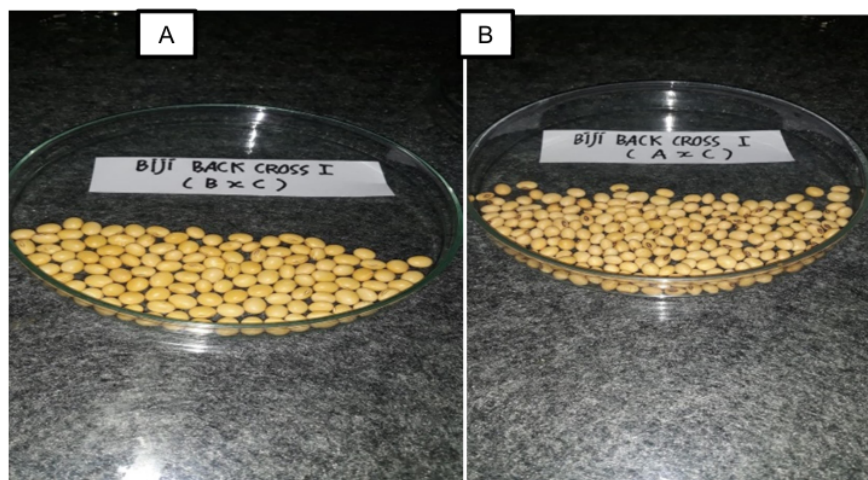


Figure 3. A) Seeds from crossing between 'Polije 5' x 'Ryokko'  
 B) Seeds from crossing between 'Polije 4' x 'Ryokko'

### 3. Results and Discussion

The result of observation of Backcross I and the parents in average is shown in the table 1 below.

**Table 1.** Observation results of Backcross I and the parents on several parameters (average)

| Genotypes       | Observation Parameters |                    |                         |                       |                           |                     |
|-----------------|------------------------|--------------------|-------------------------|-----------------------|---------------------------|---------------------|
|                 | Plant height (cm)      | Number of branches | Age of flowering (days) | Age of harvest (days) | Seed weight per plant (g) | 100-seed weight (g) |
| Polije-4        | 70.2                   | 2.5                | 33.0                    | 74.00                 | 18.5                      | 12.85               |
| Polije-5        | 65.0                   | 3.1                | 35.0                    | 76.00                 | 20.8                      | 13.76               |
| Ryokko          | 47.0                   | 3.0                | 30.0                    | 74.00                 | 22.8                      | 35.00               |
| Polije-4xRyokko | 58.3                   | 2.8                | 31.0                    | 76.00                 | 21.8                      | 15.30               |
| Polije-5xRyokko | 65.5                   | 3.0                | 31.3                    | 76.67                 | 23.2                      | 15.47               |

Observed from the plant height average, it is showed that one backcrossed genotype ('Polije 4' x 'Ryokko') have shorter plant heights than the recurrent parent, 'Polije 4' and 'Polije 5'. [6] It is stated that plant height characters showed a real positive phenotypic and genotypic correlation with the number of filled pods. In this result, however, although the plant height got shorter, the weight of seeds per plant and 100-seed weight increased.

The flowering age of a plant species often varies greatly from one variety to another depending on the geographical conditions in which each cultivar is cultivated [7]. The age of flowering shows an average of 31 to 35 days. In Indonesia, soybeans that flower at under 35 days after planting grow under normal environment conditions, considered as early mature [8]. This shows that the plant belongs to the group of early maturing soybean. The harvest age of 'Polije-4'x'Ryokko' and 'Polije-5' x'Ryokko'(76 and 76.67 days respectively) were not much of a different from their recurrent parents (polije 4 and Polije 5) and categorized as early mature.

As expected, there was increase in seed size as well as the yield of the backcrossed genotype compared to the recurrent parents. This can be seen from 100-seed weight value of both 'Polije-4' x 'Ryokko' and 'Polije-5' x Ryokko' (>15 g/100 seeds) which are higher than their recurrent parents (12-13 g/100 seeds). In Indonesia, soybeans are classified as large if they weigh more than 14 g/100

seeds [9]. The increase of the yield is indicated for the value of seed weight per plant for both backcrossed genotypes (21.8 and 23.2 g respectively) which are higher than their recurrent parents (18.5 and 20.8 g respectively). The increase seed yield was due to the increase of the seed size.

The overall result average indicated that both backcross I plants have a higher yield potential and larger seed size compared to their recurrent parents, and they could also maintain their early mature characteristic. The assembly of superior varieties can be done through the restoration of soybean seed size characteristics through backcrossing with Japanese edamame 'Ryokko'. Thus this backcross method by using large seed donor parent Ryokko has succeeded in increasing the size of the seeds in the Backcross I plants.

#### 4. Conclusion

Backcrossed genotype 'Polije-4' x 'Ryokko' has higher potential yield (21.8 g/plant) and seed size (15.30 g/100) compared to the recurrent parent 'Polije-4' which has potential yield and seed size 18.5 g/plant and 12.85 g/100 seeds, respectively, but still could maintain the early maturity (76 days). The same goes with the Backcrossed genotype 'Polije-5' x 'Ryokko', in which early harvest age (76.67 days) could still be maintained, and there was an increase in the yield from 20.8 g/plant to 23.2 g/plant and seed size from 13.76 g/100 seeds to 15.47 g/100 seeds.

Further research needs to be carried out in F<sub>2</sub> generation until homozygote plants (in F<sub>7</sub> generation) is produced, in order to obtain new genotypes with large seed size and early harvest age.

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