Assessment of agronomic performance and shattering resistance of F7 soybean lines

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Abstract. Soybean productivity can be increased through optimizing the agronomic performance and minimizing the yield losses due to pod shattering. The objectives of this study were to evaluate the agronomic performance and shattering resistance of F7 soybean lines. Twenty-one F7 lines including three check varieties (Dega 1, Detap 1, and Anjasmoro) were evaluated in two soybean production centers (Blitar and Mojokerto, East Java, Indonesia) from July to October 2018. The field experiment was arranged in a randomized block design with four replications. The screening for shattering resistance was done by the oven-dry method. The results showed that the plant height, number of filled pods, seed size, and seed yield were higher in Mojokerto than in Blitar, meanwhile, the average branches number in Blitar was higher than in Mojokerto. The yield of Detap 1 (2.89 t/ha) was highest than the two other check varieties. Three lines produce higher yield than Detap 1, namely Anjs/G100H-44 (3.33 t/ha), Anjs/Rajabasa-306 (3.22 t/ha), and Anjs/Rajabasa-311 (3.26 t/ha). The agronomic traits for determining high yields differ between locations. The assessment for shattering resistance resulted in seven highly resistant lines, twelve resistant lines, three moderately resistant lines, one susceptible line, and one highly susceptible line. Three selected lines with high yield and resistant to pod shattering were recommended to be tested in the various environments.

1. Introduction
Variety has a significant position in increasing soybean productivity per unit area. Among the food crop commodities, the first variety released in Indonesia was soybean in 1918. Currently, a total of 102 soybean varieties have been released, of which 58 varieties (56.9\%) were formed through the crossing derived from two or more parental [1]. The improvement of soybean varieties consists of the yield productivity as well as the agronomic performance.

Seed yield is a complex character that is influenced by various agronomic and environmental characteristics. Therefore, the evaluation of several soybean lines across was generally obtained an interaction between genotypes and the environment [2-4], which implies that each line has a specific adaptation in a particular environment. Research conducted in eight soybean production centers in Indonesia showed that the environmental contribute to the yield production reached 64.4\%, and followed by the genotype (10.8\%) and the interaction of genotype with the environment or GEI (24.8\%) [5]. A study in field pea (\textit{Pisum sativum} L.) at twelve environments showed that the contribution of the
environment was 79.68%, it was higher than the effect genotype as well as the GEI which were 4.53% and 5.70%, respectively [6].

The soybean yield is supported by various agronomic characters that interact with each other. Faot et al. [7] suggested that the characters of the fertile nodes and the 100 seed weight can be considered as selection criteria for high yield in soybean. Furthermore, a study in Sudan showed that the plant height and the days to maturity can be used as selection criteria for the improvement of soybean yield [8].

The yield security through the genetic approach is not only based on the selection of yield improvement but it also needs to be done on securing the yield losses due to pod shattering. Pod shattering is the opening of mature pod along the dorsal or ventral sutures and followed by seed dispersal when the crop reaches maturity and during harvesting [9]. A study reported that the yield losses due to shattering can occur in two periods, i.e. pre-harvest and during the harvest process [10]. In Indonesia, soybeans are harvested manually, hence much pod-shattering occurs because of delayed harvesting due to the labor shortages. This is different from other soybean production countries where yield losses occur at the harvesting time as the effect of harvester machines.

The yield losses due to pod shattering on susceptible varieties and delayed harvesting may range from 34-99% [11]. The yield losses caused by pod-shattering were also reported in sorghum [12], mungbean [13,14], rapeseed [15, 16], common bean [17], and lentil [18]. The identification of shattering resistance in soybean by Barate et al. [19] obtained 11 resistant genotypes of 50 tested genotypes. Some abiotic factors that may affect the shattering were the low-moisture availability, high-temperature stress in spring and high elevations, cold temperatures in winter [20].

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2. Methods

2.1. Research materials
The experimental material consisted of 21 F7 soybean populations derived from crossing between pod shatter-resistant varieties (Anjasmoro) with several high yielding genotypes. Three large-seeded varieties were used as checks, i.e. Dega 1 (early maturity), Detap 1 (early maturity), and Anjasmoro (medium maturity).

2.2. Field experiment
The field experiment was conducted at two locations of soybean production centers, namely Blitar and Mojokerto, during the dry season from July – October 2018. On each location, the experiment was laid out in a randomized block design with four replications. Sowing was done on 1.6 m × 4.5 m plot size, with the 40 cm × 15 cm planting distance, two seeds per hill. The experiment was carried out in lowland (after rice planting) without soil tillage. The weed control was using herbicide, and the drainage channel was made before planting. Fertilizer dose of 50 kg Urea, 100 kg SP36 and 75 kg KCl/ha was applied at the time of sowing. Pest and disease control were carried out regularly.

Data collection of field experiment was done on days to flowering, days to maturity, plant height, number of branches, number of nodes, number of filled pods, number of empty pods, 100 seed weight, and seed yield.

2.3. Screening for pod shattering resistance
Pod shattering screening was done as per oven dry method reported by Krisnawati & Adie [21]. When plants at R8 stage, three sample plants were randomly taken. The selected sample plants drying at room temperature for three days. Thirty pods from the sample plants of each genotype were randomly
detached and were kept in brown paper bags. Then the bags were kept in a hot air oven at 30 °C for three days, and then elevated into 40 °C (for one day), 50 °C (for one day), 60 °C (for one day). Pod shattering was observed for the sample which put in the oven at a temperature of 60 °C. Percentage of shattering was recorded based on the scale by AVRDC [22]: highly resistant (0% shattering), resistant (1-10% shattering), moderately resistant (11-25% shattering), moderately susceptible (26-50%), and highly susceptible (>50% shattering).

2.4 Data analysis
The data collected were subjected to descriptive statistical analysis of mean, minimum value, maximal value, and standard deviation. The relationship between agronomic characters and seed yield was investigated using correlation analysis and path analysis [23].

3. Result and Discussion

3.1 Agronomic characters

The agronomic characters (days to flowering, days to maturity, number of branches, number of nodes, number of a filled pod, number of empty pods, 100 seed weight, and seed yield) in the locations of Blitar and Mojokerto were presented in Figure 1 to Figure 8. The days to flowering in Blitar as well as in Mojokerto were similar, i.e. 37 days, meanwhile the days to maturity in Blitar (78 days) were two days faster than in Mojokerto (80 days). The field in Mojokerto had adequate water irrigation, whereas the location of Blitar has been reported to have experienced water shortages. Thus, the environment in Blitar tends to be drier caused faster maturity when compared to the environment with sufficient water as in Mojokerto. A similar result also reported by Nadeem et al. [24] that the water-deficit condition (or drought stress) in soybean often results in earlier maturity. The average of days to maturity from two locations ranged from 75 – 86 days, and there were seven lines that have maturity under 80 days (Table 1).

The optimal water condition as Mojokerto also affects the performance of plant height (56.70 cm), which higher than those of in Blitar (48.77 cm). The average number of branches were similar among two locations, i.e. 2.11 branches per plant. However, the average number of nodes was higher in the Blitar location (16.04 nodes per plant) than those in Mojokerto (14.86 nodes per plant). The average number of filled pods per plant in Mojokerto (42.45 pods) was higher than those of in Blitar (39.72 pods), meanwhile the number of empty pods were relatively comparable between the two locations. The seed size which measured by the 100 seed weight, the average seed size in Mojokerto (15.52 g/100 seeds) was higher than those of in Blitar (14.59 g/100 seeds). The range of seed size of 21 lines from two locations was 14.06 – 17.09 g, meanwhile the seed size of the check varieties of Dega 1, Detap 1, and Anjasmoro were 18.83 g, 15.44 g, and 14.89 g, respectively. The seed size traits in soybean play were reported to play an important role in determining seed yield, quality and appearance [25].

The seed yield is an important character in soybean (Table 1). The range of seed yield in Blitar was 1.83 – 3.10 t/ha (an average of 2.65 t/ha), whereas in Mojokerto was 2.11 – 3.77 t/ha (an average of 3.09 t/ha). The check variety of Detap 1 consistently showed a higher yield than other check varieties in two locations (Table 2). The average yield of Detap 1 in two locations was 2.89 t/ha, slightly higher than the general mean (2.87 t/ha). If the selection limit for F7 soybean lines uses 10% higher seed yield of the best check varieties (Detap 1), then there were three lines which produce yield over 3.17 t/ha, namely Anjs/G100H-44 (3.33 t/ha), Anjs/Rajabasa-306 (3.22 t/ha), and Anjs/Rajabasa-311 (3.26 t/ha).

3.2 The seed yield determinant

The relationship between the agronomic traits and seed yield differed between locations (Table 3). At the Blitar location, seed yield has a strong correlation with the plant height character ($r = 0.536^{*}$) and the number of branches ($r = 0.41^{*}$), but the correlation between the plant height and number of branches was not significant. Plant height was significantly correlated with the flowering days, while the number of branches was more determined by the maturity days. The highest correlation value is obtained from
the character of the number of nodes with the number of filled pods ($r = 0.592^{**}$). At Mojokerto location, there was no correlation found between some agronomic traits and seed yield (Table 3). However, there were three characters with high correlation coefficients, i.e. number of branches, number of nodes, and number of filled pods. At the Mojokerto location, plant height characters did not play a role compared to the Blitar location. The significant correlation between the number of nodes and the number of branches was $r = 0.540^{**}$, the between a number of branches and the filled pods was $r = 0.554^{**}$, and between the number of nodes and the filled pods was $r = 0.518^{**}$. Another study also reported the number of pod plays a role in determining yield [26].

Table 1. Descriptive data of F7 soybean lines for agronomic characters in two locations.

| No. | Character                  | Symbol | Blitar    | Mojokerto |
|-----|----------------------------|--------|-----------|-----------|
|     |                            | Mean   | Min<sup>a</sup> | Max<sup>b</sup> | STD<sup>c</sup> | Mean   | Min<sup>a</sup> | Max<sup>b</sup> | STD<sup>c</sup> |
| 1   | Days to flowering          | FD     | 37.20     | 35.00     | 39.00     | 1.10   | 37.20     | 35.00     | 39.00     | 1.10   |
| 2   | Days to maturity           | MD     | 78.16     | 75.00     | 85.00     | 1.99   | 80.41     | 78.00     | 86.00     | 1.88   |
| 3   | Plant height (cm)          | PH     | 48.77     | 29.67     | 57.67     | 5.85   | 56.70     | 36.83     | 65.33     | 5.80   |
| 4   | Number of branches         | NB     | 2.11      | 0.33      | 5.00      | 1.05   | 2.11      | 1.33      | 3.67      | 0.54   |
| 5   | Number of nodes            | NN     | 16.04     | 8.67      | 22.67     | 3.83   | 14.86     | 10.50     | 19.50     | 2.23   |
| 6   | Number of filled pod       | FP     | 39.72     | 29.33     | 53.53     | 7.10   | 42.45     | 34.70     | 55.53     | 4.94   |
| 7   | Number of empty pod        | EP     | 1.19      | 0.00      | 2.33      | 0.73   | 1.32      | 0.17      | 2.50      | 0.59   |
| 8   | 100 seed weight (g)        | SW     | 14.59     | 12.71     | 16.99     | 1.10   | 15.52     | 13.89     | 18.83     | 1.08   |
| 9   | Seed yield (t/ha)          | SY     | 2.64      | 1.83      | 3.10      | 0.31   | 2.86      | 2.25      | 3.33      | 0.28   |

<sup>a</sup> Min = minimal value  
<sup>b</sup> Max = maximal value  
<sup>c</sup> STD = standard deviation

The path analysis was used to describe the relationship between yield and yield components in Blitar (Table 4) and Mojokerto (Table 5). At the Blitar location, the highest direct effect on yield was plant height (0.515), followed by the number of nodes (0.390) and the 100 seed weight (0.381). A similar finding was reported by Enideg et al. [27]. The plant height was a necessary character at Blitar because there were no other characters that weakened the plant height character. Furthermore, the plant height character has an equal direct effect value with its correlation of coefficient. This was different from the number of nodes which was weakened by the 100 seed weight, and the same pattern also showed by the 100 seed weight which was weakened by the number of nodes. Thus, in relatively dry areas, the soybean yield can be increased by optimizing the plant height to support the formation of the number of nodes and the number of filled pods.

The relationship pattern between agronomic characters in Mojokerto areas with adequate irrigation water differs from the relatively dry location of Blitar. The high direct effects on yield were the characters of the number of nodes (0.577), 100 seed weight (0.379), and plant height (0.373). The high direct effect of the number of nodes was weakened by its indirect effect through 100 seed weight (-0.190), the days to maturity (-0.135), and the number of filled pods (-0.135). This means that the higher number of nodes will increase the chance of obtaining the smaller seed size (100 seed size), decreasing the number of filled pods, and the longer plant maturity. This pattern was also shown by the direct effect
of 100 seed weight which was weakened by its indirect effect through the number of nodes. There was
also an indication that higher plants will closely relate to the decrease in the number of empty pods in
soybean. Hence, in an optimal location such as Mojokerto, the important contributors to the soybean
yield productivity were a high number of nodes and combined with relatively large seed size. Seed size
as an important contributor to the seed yield was also reported by Sundari and Herdina [28].

| Table 2. Seed yield of F7 soybean lines in two locations. |
|-----------------------------------------------|
| No. | Soybean line | Blitar | Mojokerto | Mean |
|-----|--------------|--------|-----------|------|
| 1   | Anjs/G100H-6 | 2.73   | 2.93      | 2.83 |
| 2   | Anjs/G100H-12| 2.83   | 2.96      | 2.89 |
| 3   | Anjs/G100H-14| 2.88   | 3.07      | 2.98 |
| 4   | Anjs/G100H-16| 2.78   | 3.01      | 2.90 |
| 5   | Anjs/G100H-21| 2.74   | 3.11      | 2.92 |
| 6   | Anjs/G100H-24| 2.94   | 3.11      | 3.02 |
| 7   | Anjs/G100H-28| 2.83   | 2.92      | 2.88 |
| 8   | Anjs/G100H-43| 2.89   | 3.11      | 3.00 |
| 9   | Anjs/G100H-44| 2.95   | 3.70      | 3.33 |
| 10  | Anjs/IAC 100-19| 2.42 | 3.41      | 2.91 |
| 11  | Anjs/IAC 100-22| 2.63 | 3.24      | 2.93 |
| 12  | Anjs/IAC 100-28| 2.73 | 2.26      | 2.50 |
| 13  | Anjs/Rajabasa-19| 2.09 | 3.09      | 2.59 |
| 14  | Anjs/Rajabasa-204| 1.83 | 2.66      | 2.25 |
| 15  | Anjs/Rajabasa-258| 2.73 | 2.11      | 2.42 |
| 16  | Anjs/Rajabasa-304| 2.73 | 3.17      | 2.95 |
| 17  | Anjs/Rajabasa-305| 3.10 | 3.16      | 3.13 |
| 18  | Anjs/Rajabasa-306| 2.99 | 3.44      | 3.22 |
| 19  | Anjs/Rajabasa-309| 2.52 | 3.45      | 2.99 |
| 20  | Anjs/Rajabasa-311| 2.83 | 3.68      | 3.26 |
| 21  | Grobogan/Anjs-2| 2.46 | 3.77      | 3.12 |
| 22  | Dega 1         | 2.21   | 2.69      | 2.45 |
| 23  | Detap 1        | 2.46   | 3.31      | 2.89 |
| 24  | Anjas/moro     | 2.26   | 2.68      | 2.47 |

Mean 2.65 3.09 2.87

| Character | SY | FD | MD | PH | NB | NN | FP | EP | SW |
|-----------|----|----|----|----|----|----|----|----|----|
| SY        | 1  | 0.266 | 0.220 | 0.536** | 0.413* | 0.378 | 0.273 | -0.080 | 0.183 |
| FD        | 0.166 | 1 | 0.399* | 0.489** | 0.303 | 0.117 | 0.037 | -0.123 | -0.051 |
| MD        | -0.273 | 0.332 | 1 | 0.297 | 0.515** | 0.296 | 0.219 | -0.122 | -0.112 |
| PH        | 0.277 | 0.522** | 0.174 | 1 | 0.381 | 0.154 | 0.033 | -0.326 | -0.109 |
| NB        | -0.041 | 0.311 | 0.394* | 0.242 | 1 | 0.562** | 0.491* | -0.208 | -0.223 |
| NN        | 0.095 | 0.156 | 0.459* | 0.223 | 0.540** | 1 | 0.592** | -0.194 | -0.355 |
| FP        | -0.222 | 0.029 | 0.326 | 0.085 | 0.554** | 0.518** | 1 | -0.062 | -0.064 |
| EP        | 0.066 | -0.229 | -0.35 | -0.507** | 0.019 | -0.282 | -0.021 | 1 | 0.318 |
| SW        | 0.283 | -0.186 | -0.362 | -0.158 | -0.395* | -0.501** | -0.389* | 0.131 | 1 |

*SY = seed yield, **FD = days to flowering, MD = days to maturity, PH = plant height, NB = number of branches per plant, NN = number of nodes per plant, FP = number of filled pods, EP = number of empty pods per plant, SW = seed weight. Diagonal top for Blitar location and diagonal bottom for Mojokerto location, * = significant at P ≤ 0.05, ** = significant at P ≤ 0.01
Table 4. The direct effect (bold) and the indirect effect of agronomic characters with the F7 soybean seed yield in Blitar.

| Character | FD | MD | PH | NB | NN | FP | EP | SW | r² |
|-----------|----|----|----|----|----|----|----|----|----|
| FD        | -0.021 | 0.008 | -0.010 | -0.006 | -0.002 | -0.001 | 0.001 | 0.001 | 0.266 |
| MD        | -0.023 | 0.153 | 0.049 | 0.196 | 0.079 | 0.017 | 0.006 | 0.007 | 0.220 |
| PH        | 0.252 | 0.066 | 0.060 | 0.219 | 0.072 | 0.063 | 0.001 | 0.001 | 0.536 |
| NB        | 0.039 | 0.115 | 0.000 | 0.219 | 0.001 | 0.001 | -0.012 | -0.007 | 0.413 |
| NN        | 0.046 | 0.000 | -0.020 | 0.219 | 0.001 | -0.012 | -0.012 | -0.085 | 0.378 |
| FP        | -0.007 | 0.000 | -0.024 | 0.000 | 0.001 | -0.004 | -0.007 | -0.043 | 0.273 |
| EP        | 0.266 | 0.115 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.381 |

¹FD = days to flowering, ²MD = days to maturity, ³PH = plant height, ⁴NB= number of branches per plant, ⁵NN = number of nodes per plant, ⁶FP = number of filled pods, ⁷EP = number of empty pods per plant, ⁸SW = seed weight, ⁹r = coefficient of correlation.

Table 5. The direct effect (bold) and the indirect effect of agronomic characters with the F7 soybean seed yield in Mojokerto.

| Character | FD | MD | PH | NB | NN | FP | EP | SW | r² |
|-----------|----|----|----|----|----|----|----|----|----|
| FD        | 0.150 | 0.050 | 0.078 | 0.047 | 0.023 | 0.004 | 0.003 | 0.001 | 0.166 |
| MD        | -0.098 | 0.065 | -0.051 | -0.116 | -0.135 | -0.096 | -0.012 | 0.006 | 0.277 |
| PH        | 0.195 | 0.065 | 0.017 | 0.090 | 0.083 | 0.032 | 0.103 | 0.006 | 0.413 |
| NB        | -0.026 | -0.033 | -0.021 | -0.085 | -0.046 | -0.047 | -0.189 | 0.005 | 0.277 |
| NN        | 0.090 | 0.265 | 0.129 | 0.312 | 0.299 | 0.299 | 0.103 | -0.163 | 0.666 |
| FP        | 0.000 | 0.085 | 0.000 | 0.006 | 0.000 | -0.006 | 0.000 | 0.000 | 0.379 |
| EP        | -0.068 | -0.104 | -0.150 | -0.150 | -0.083 | -0.124 | -0.173 | 0.006 | 0.283 |
| SW        | -0.070 | -0.137 | -0.060 | -0.041 | -0.190 | -0.147 | 0.000 | -0.070 | 0.000 |

¹FD = days to flowering, ²MD = days to maturity, ³PH = plant height, ⁴NB= number of branches per plant, ⁵NN = number of nodes per plant, ⁶FP = number of filled pods, ⁷EP = number of empty pods per plant, ⁸SW = seed weight, ⁹r = coefficient of correlation.

3.3. The pod shattering resistance

The pod shattering resistance in soybean can be improved by hybridization using the resistant cultivar as one of the parental [29]. In the earlier study of the 591 F5 segregating populations using Anjasmoro resistant-cultivar as one of the parental in the hybridization, a total of 104 very resistant lines were selected [30]. Further research in the 147 F6 populations, the degree of shattering resistant lines were consists of 52 highly resistant, 49 resistant, two moderately resistant, ten susceptible, and 34 highly susceptible lines [31]. In this study, the evaluation for pod shattering resistance in the F7 soybean lines using the oven-dry method also resulted in the varying degree of resistance (Table 6). The lines were not significantly shattered at oven temperatures of 30 °C and 40 °C, respectively. A similar result was obtained by Krisnawati and Adie [32]. At 50 °C, most of the lines were very resistant and resistant, except Dega 1 which has shattered 23% (moderately resistant). At 60 °C, from a total of 24 tested lines (100%), seven lines (29%) were very resistant, 12 lines (50%) were resistant, three lines (13%) were moderately resistant, one line (4%) was susceptible, and one line (4%) was very susceptible. The evaluation for pod shattering in soybean has been conducted in several countries. Three shattering resistant genotypes (Bragg, PK 416, and NRC) were obtained in India [33], three very resistant genotypes (TGx 1448-2E, Duiker, and Nam 2) were obtained in Nigeria [34], and a resistant genotype TGX 1448-2E was obtained in Ghana [35].

Evaluation for pod shattering resistance combined with the seed yield selection (Table 6) showed that three F7 lines classified as high yield (Anjs/G100H-44, Anjs/Rajabasa-306, and Anjs/Rajabasa-311. Those lines were also found to be resistant to pod shattering. Moreover, the very resistant criteria of shattering shown by Anjs/Rajabasa-306. Based on this study, it was suggested that the development of
soybean variety resistant to pod shattering using parental with carrying shatter-resistant gene is able to produce pod-shattering lines as well as high yielding lines.

Table 6. The pod shattering resistance and seed yield of F7 soybean lines.

| No | Genotype         | Pod shattering (%) | Criteria of resistance | Seed yield (t/ha) |
|----|------------------|--------------------|------------------------|------------------|
| 1  | Anjs/G100H-6     | 0 0 0 1            | Resistant              | 2.83             |
| 2  | Anjs/G100H-12    | 0 0 0 4            | Resistant              | 2.89             |
| 3  | Anjs/G100H-14    | 0 0 0 0            | Very resistant         | 2.98             |
| 4  | Anjs/G100H-16    | 0 0 0 3            | Resistant              | 2.90             |
| 5  | Anjs/G100H-21    | 0 0 0 0            | Very resistant         | 2.92             |
| 6  | Anjs/G100H-24    | 0 0 0 2            | Resistant              | 3.02             |
| 7  | Anjs/G100H-28    | 0 0 0 6            | Resistant              | 2.88             |
| 8  | Anjs/G100H-43    | 0 0 0 0            | Very resistant         | 3.00             |
| 9  | Anjs/G100H-44    | 0 0 0 2            | Resistant              | **3.33**         |
| 10 | Anjs/IAC 100-19  | 0 1 1 11           | Moderately Resistant   | 2.91             |
| 11 | Anjs/IAC 100-22  | 0 0 0 0            | Very resistant         | 2.93             |
| 12 | Anjs/IAC 100-28  | 0 0 0 3            | Resistant              | 2.50             |
| 13 | Anjs/Rajabasa-19 | 0 0 0 22           | Moderately Resistant   | 2.59             |
| 14 | Anjs/Rajabasa-204| 0 0 0 4            | Resistant              | 2.25             |
| 15 | Anjs/Rajabasa-258| 0 0 0 20           | Moderately Resistant   | 2.42             |
| 16 | Anjs/Rajabasa-304| 0 0 0 2            | Resistant              | 2.95             |
| 17 | Anjs/Rajabasa-305| 0 0 0 0            | Very resistant         | 3.13             |
| 18 | Anjs/Rajabasa-306| 0 0 0 0            | Very resistant         | **3.22**         |
| 19 | Anjs/Rajabasa-309| 0 0 1 4            | Resistant              | 2.99             |
| 20 | Anjs/Rajabasa-311| 0 0 1 10           | Resistant              | **3.26**         |
| 21 | Grobogan/Anjs-2  | 0 0 1 33           | Susceptible            | 3.12             |
| 22 | Dega 1           | 0 0 23 100         | Very Susceptible       | 2.45             |
| 23 | Detap 1          | 0 0 0 1            | Resistant              | 2.89             |
| 24 | Anjasmoro        | 0 0 0 0            | Very resistant         | 2.47             |

Mean 0 0 1 10 2.87

4. Conclusion
Each line has its adaptation to a certain environment. The determinant of high yield in Blitar was a higher plant to supports the development of the number of nodes and the number of filled pods. In Mojokerto, a high yield line was determined by the number of nodes and seed size. Selection for yield and shattering resistance resulted in three F7 lines considered as very resistant to resistant with seed yield ranging from 3.22 – 3.33 t/ha. Those lines were recommended to be tested in various environments.
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