Correlation, path analysis and heritability estimation for agronomic traits contribute to yield on soybean

To cite this article: A Sulistyo et al 2018 IOP Conf. Ser.: Earth Environ. Sci. 102 012034
Correlation, path analysis and heritability estimation for agronomic traits contribute to yield on soybean

A Sulistyö1, Purwantorö1 and K P Sari1
1Indonesian Legumes and Tuber Crops Research Institute, Jl. Raya Kendalpayak Km 8, Po Box 66, Malang 65101, East Java, Indonesia

E-mail : apri.sulistyö@gmail.com

Abstract. Selection is a routine activity in plant breeding programs that must be done by plant breeders in obtaining superior plant genotypes. The use of appropriate selection criteria will determine the effectiveness of selection activities. The purpose of this study was to analysis the inheritable agronomic traits that contribute to soybean yield. A total of 91 soybean lines were planted in Muneng Experimental Station, Probolinggo District, East Java Province, Indonesia in 2016. All soybean lines were arranged in randomized complete block design with two replicates. Correlation analysis, path analysis and heritability estimation were performed on days to flowering, days to maturing, plant height, number of branches, number of fertile nodes, number of filled pods, weight of 100 seeds, and yield to determine selection criteria on soybean breeding program. The results showed that the heritability value of almost all agronomic traits observed is high except for the number of fertile nodes with low heritability. The result of correlation analysis shows that days to flowering, plant height and number of fertile nodes have positive correlation with seed yield per plot (0.056, 0.444, and 0.100, respectively). In addition, path analysis showed that plant height and number of fertile nodes have highest positive direct effect on soybean yield. Based on this result, plant height can be selected as one of selection criteria in soybean breeding program to obtain high yielding soybean variety.

Keywords : Correlation, path analysis, heritability estimation, soybean

1. Introduction
Processed food from soybean such as tempe and tofu, are still main source of vegetable protein for most of the population in Indonesia. This is evident from the growing demand for soybeans from year to year. According to Sudaryanto and Swastika [1], the average annual growth of demand for soybean consumption in Indonesia reached 2.44%. Most of the domestic demand is met through imports as national soybean production is still low [2]. Therefore, domestic production should be increased to reduce imports [3].

One attempt to improve yields is by genetic improvement of plants through plant breeding program. Germplasm collection, forming the basic population through hybridization and selection are the steps to achieve superior genotypes. Among a series of routine activities in the breeding program, selection is the most important step for obtaining high yielding varieties. The effectiveness of selection is determined by the selection criteria used.

Determining selection criteria can be done in various ways. Information on genetic parameters such as heritability can be used as a consideration to determine selection criteria. In addition, knowledge of
correlation is needed as a basis for planning a more efficient selection program [4]. Furthermore, the direct and indirect effects of agronomic traits with seed yield also need to be known in determining selection criteria. The relationship between these properties can be known through path analysis [5]. The aim of this study was to analyze the inheritable agronomic traits and contributes to yield in soybean.

2. Material and method
The study was conducted at Muneng Experimental Station, Probolinggo District, East Java, Indonesia, from August to October in 2016. A total of 91 soybean lines were planted and arranged in a randomized complete block design with two replicates in a plot measuring 1.0 m x 2.5 m for each lines (100 plants each lines per plot). Spacing used was 40 cm between rows, 10 cm in rows, and 20 cm between plots. Fertilizer was given at the planting time with a dose of 50 kg/ha Urea, 100 kg/ha SP36 and 100 kg/ha KCl. Irrigation was done four times, i.e. at planting time, on 3 weeks after planting, during flowering and pods filling. Pest control was done intensively by spraying an insecticide in accordance with the attacking pest.

Agronomic traits observed include days to flowering, days to maturing, plant height, number of branches, number of fertile nodes, number of filled pods, weight of 100 seeds, and yield. The data obtained were analyzed using PKBT software. The estimation of variance components using the tables of analysis of variance follows the methods given by Burton and Devane [6]. Correlation analysis follows the correlation model of Singh and Choudhury [7]. Path analysis were calculated using the Dewey and Lu methods [5].

3. Result and discussion
Table 1 shows the results of the analysis of variance of eight agronomic traits in soybean. Based on the analysis of variance, it can be seen that there are significant differences in almost all agronomic traits observed. Among the eight observed agronomic traits, there is only one character that showing an insignificant difference, namely the number of fertile nodes.

Table 1. Analysis of variance of eight agronomic traits in soybean

| Agronomic traits       | Mean square | P-value | Significance |
|------------------------|-------------|---------|--------------|
| Days to flowering      | 12.66       | 0.000   | **           |
| Days to maturing       | 19.93       | 0.000   | **           |
| Plant height           | 112.26      | 0.000   | **           |
| Number of branches     | 0.90        | 0.000   | **           |
| Number of fertile nodes| 88.80       | 0.115   | ns           |
| Number of pods         | 5.36        | 0.000   | **           |
| Weight of 100 seeds    | 92,437.74   | 0.000   | **           |
| Yield                  | 23,675.88   | 0.000   | **           |

** = significant difference, ns = not significant

3.1. Heritability
The estimation value of environmental variance, genotypic variance, phenotypic variance, and broad sense heritability of eight agronomic traits in soybean based on the method of Burton and Devane [6] are showed in Table 2. Based on the results of heritability calculations, it is seen that the days to flowering has the highest heritability (0.88), while the number of fertile nodes has the lowest heritability (0.12). However, except for the character of the number of fertile nodes, all of the observed agronomic traits are classified as characters with high heritability based on heritability groupings proposed by MacWhirter [8]. According to MacWhirter [8], heritability values can divided into three criteria, namely low heritability ($h^2 < 0.2$), medium heritability ($0.2 < h^2 < 0.5$), and high heritability ($h^2 > 0.5$).

Plant breeders usually use heritability values to find out whether the expression of a plant character is genetically inherited or more influenced by the environment. This is understandable because the
heritability value is the proportion of the genetic variance ($\sigma^2_g$) to phenotypic variance ($\sigma^2_p$) [9]. The value of heritability will be close to 0 if the variation of phenotype is more influenced by environmental factors than genetic factors, and will be close to 1 if the expression of phenotype is more controlling by genetic factors than environmental factors.

Table 2. Components of variance and broad sense heritability of eight agronomic traits in soybean

| Agronomic traits               | $\sigma^2_e$ | $\sigma^2_g$ | $\sigma^2_p$ | $h^2_b$  | Category |
|--------------------------------|--------------|--------------|--------------|----------|----------|
| Days to flowering             | 0.83         | 5.92         | 6.75         | 0.88     | High     |
| Days to maturing              | 3.22         | 8.36         | 11.58        | 0.72     | High     |
| Plant height                  | 15.25        | 48.51        | 63.74        | 0.76     | High     |
| Number of branches            | 0.26         | 0.32         | 0.58         | 0.55     | High     |
| Number of fertile nodes       | 0.72         | 0.10         | 0.82         | 0.12     | Low      |
| Number of pods                | 22.68        | 33.06        | 55.74        | 0.59     | High     |
| Weight of 100 seeds           | 1.09         | 2.14         | 3.23         | 0.66     | High     |
| Yield                         | 23,675.88    | 34,380.93    | 58,056.81    | 0.59     | High     |

$\sigma^2_e =$ environmental variance, $\sigma^2_g =$ genotypic variance, $\sigma^2_p =$ phenotypic variance, $h^2_b =$ broad sense heritability

In this study, the heritability value of days to flowering, days to maturing, plant height, number of branches, number of pods, weight of 100 seeds, and yield were categorized high (Table 2). These findings reinforce the results of previous studies that find high heritability value in these agronomic traits [10-14]. When compared with the heritability value of other agronomic traits, three traits including days to flowering, days to maturing and plant height, have a heritability value close to 1 (0.88, 0.72 and 0.76, respectively), meaning that the three characters are inherited from the elders to their offspring. This indicates a possible improvement of these three agronomic traits.

In addition, the yield component characteristics (such as number of branches, number of pods, and weight of 100 seeds) and yields have high heritability (0.55, 0.59, 0.66 and 0.59, respectively). In relation to improvement of yield on soybean, there is an opportunity to improve yield and yield components in soybean, because based on the heritability value of each character then number of branches, number of pods, weight of 100 seeds and yields are inherited from parents to offspring.

3.2. Correlation analysis

Table 3 shows the results of correlation analysis among eight agronomic traits on soybean. Based on the results of the correlation analysis, it is seen that only three traits are positively correlated with seed yield, while the others are negatively correlated with seed yield. The three characters are days to flowering, plant height and number of fertile nodes with correlation coefficient values of 0.015, 0.042 and 0.101, respectively. However, of these three characters only plant height is significantly positive correlated with seed yield.

Table 3. Correlation coefficient among eight agronomic traits in soybean

|     | DF  | DM  | PH  | NB  | NF  | NP  | WO  |
|-----|-----|-----|-----|-----|-----|-----|-----|
| DF  | 0.468** |     |     |     |     |     |     |
| DM  | 0.378** | 0.008 |     |     |     |     |     |
| PH  | 0.546** | 0.542** | -0.023 |     |     |     |     |
| NB  | 0.279** | 0.199 | 0.466** | 0.274** |     |     |     |
| NF  | 0.431** | 0.653** | 0.076 | 0.757** | 0.452** |     |     |
| NP  | -0.066 | 0.255* | -0.242* | 0.229* | -0.110 | 0.212* |     |
| WO  | 0.015 | -0.101 | 0.442** | -0.348** | 0.101 | -0.373** | -0.322** |

DF = days to flowering, DM = days to maturing, PH = plant height, NB = number of branches, NF = number of fertile nodes, NP = number of pods, WO = weight of 100 seeds, YD = yield, * = significant at P < 0.05, ** significant at P < 0.01
A significant positive correlation between plant height and seed yield has been widely reported [15-17]. In addition, those researchers also found a significant positive correlation between other agronomic traits with seed yield, among others on the total number of nodes and number of filled pods [18], days to flowering and total number of pods [15]; weight of seed per plant [16]; and days to maturing [17]. Plant height was also reported to be positively correlated with yields on soybean vegetables [19].

A positive correlation between plant height and seed yield means the increase in the plant height will increase the resulting soybean seed. This is understandable because soybean flowers appear along the stem of plant, so the higher the appearance of a plant the more likely it is to produce flowers and pods. Besides the plant height, actually the number of fertile nodes can better describe the resulting soybean seeds. But in this study, the correlation coefficient between the number of fertile nodes and yield is small and positively correlated not significantly. This is probably due to the calculation of the number of fertile nodes involved unfilled pods, so that the addition of the number of fertile nodes can not increase the seed yield. Several previous study reports have also found similar results [16][18][20].

3.3. Path analysis

Path analysis is performed to partition the correlation coefficient between the yields and yield components into direct and indirect effects that are responsible for the increase of yield [21]. The path coefficient analysis of direct and indirect effects of seven agronomic traits on soybean yields are presented in Table 4. Based on the results of path analysis, it is seen that days to flowering, plant height and number of fertile nodes give a positive direct effect on soybean yield. These results are in line with previous research reports [15-17].

Table 4. Path coefficients analysis of agronomic traits on the direct and indirect effects of yield components and yield of soybean

| Character | DF  | DM  | PH  | NB  | NF  | NP  | WO  | YD  |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|
| DF        | -0.049 | 0.191 | 0.151 | -0.025 | 0.035 | -0.263 | 0.017 | 0.057 |
| DM        | -0.025 | 0.374 | 0.019 | -0.025 | 0.028 | -0.393 | -0.041 | -0.063 |
| PH        | -0.019 | 0.018 | 0.392 | 0.000 | 0.056 | -0.050 | 0.047 | 0.444 |
| NB        | -0.028 | 0.212 | -0.001 | -0.044 | 0.037 | -0.457 | -0.037 | -0.318 |
| NF        | -0.014 | 0.088 | 0.184 | -0.014 | 0.119 | -0.281 | 0.019 | 0.101 |
| NP        | -0.022 | 0.245 | 0.033 | -0.033 | 0.056 | -0.600 | -0.042 | -0.363 |
| WO        | 0.004 | 0.080 | -0.097 | -0.009 | -0.012 | -0.131 | -0.192 | -0.356 |

Note: DF = days to flowering, DM = days to maturing, PH = plant height, NB = number of branches, NF = number of fertile nodes, NP = number of pods, WO = weight of 100 seeds, YD = yield

The results of the path analysis confirmed the correlation analysis results. Days to flowering, plant height and number of fertile nodes act as the most important of seed yield component determination. According to Hakim [16], this information can be utilized in determining selection criteria in soybean breeding program. However, among these three agronomic traits, plant height has a positive direct effect on soybean yield (Tabel 4). Similar results are also reported by Asadi [15]. The implication is that plant height can be used for selection of soybean seed yields.

4. Conclusion

Based on the results of this study, it can be concluded that almost all agronomic traits in soybean are inherited, indicated by the high heritability value. In relation to the soybean breeding program to obtain high yield soybean varieties, the plant height can be used as the selection criteria. The reason, plant height is not only inherited but also has a positive direct effect on the yield of soybean.

5. Acknowledgements

This work was funded by the Ministry of Research, Technology and Higher Education in 2016 through INSINAS scheme with grant number RD-2016-0185.
References
[1] Sudaryanto T and Swastika D K 2007 Soybean economy in Indonesia Soybean Production Techniques and Development eds Sumario et al (Jakarta: IAARD Press) pp 1-27 (In Bahasa Indonesia)
[2] Direktorat Akabi 2013 Soybean production only fulfilled 35%. http://tanamanpangan.pertanian.go.id/akabi/berita-142-produksi-kedelai-baru-terpenuhi-35-persen.html
[3] Adisarwanto T 2010 The strategy for improving soybean production as an effort to meet domestic demand and reduce imports Pengembangan Inovasi Pertanian 3(4) 319-33 (In Bahasa Indonesia)
[4] Arsyad M, Aslan M, and Irshad M 2009 Genetic variability and character association among morphological traits of mungbean, Vigna radiata L. Wilczek genotypes J of Agric Res 47(2) 121-126
[5] Dewey J R and Lu K H 1959 A correlation and path coefficient analysis of components of crested wheatgrass seed production Agron J 51(9) 515-518
[6] Burton G W and Devane E H 1953 Estimating heritability in Tall Fescue (Festuca arundinacea) from replicated clonal material Agron J 45(10) 481-487
[7] Singh R K and Choudhury 1979 Biometrical methods in quantitative genetic analysis (Kalyani Publishers, New Delhi)
[8] McWhirter K S 1979 Breeding of cross-pollinated crops: Selection methods for improving cross-pollinating plants species Plant Breeding ed Knight R (Academy Press Pty. Ptd, Brisbane)
[9] Roy D 2000 Plant Breeding, Analysis and Exploitation of Variation (Narosa Publishing House, New Delhi)
[10] Aditya J P, Bhartiya P and Bhartiya A 2011 Genetic variability, heritability and character association for yield and component characters in soybean (G. max (L.) Merrill) J of Central European Agric 12(1) 27-34
[11] Hakim L and Suyamto 2012 Heritability and expected genetic advances of quantitative traits in F4 progenies of soybean crosses Penelitian Pertanian Tanaman Pangan 13(1) 22-26 (In Bahasa Indonesia)
[12] Barmawi M, Yushardi A and Sa’diyah N 2013 Heritability and genetic advance estimate of agronomic traits in the F2 generation of soybean crosses between Yellow Bean and Taichung J Agrotek Tropika 1(1) 20-24 (In Bahasa Indonesia)
[13] Hakim L, Suyamto and Paturohman E 2014 Genetic variability, heritability and expected genetic advances of quantitative characters in F2 progenies of soybean crosses Indones J Agric Sci 15(1) 11-16
[14] Osekita O S and Olorunfemi O 2014 Quantitative genetic variation, heritability and genetic advance in the segregating F3 population in soybean (Glycine max (L.) Merrill) Int J Adv Research 2(7) 82-89
[15] Asadi 2012 Path analysis of agronomic characters and resistance to pod sucker bug on yield of soybean germplasm Bulletin Plasma Nutfah 18(1) 1-8 (In Bahasa Indonesia)
[16] Hakim L 2012 Yield components and morphological characters determining grain yield of soybean J Penelitian Pertanian Tanaman Pangan 31(3) 173-179 (In Bahasa Indonesia)
[17] Balla M Y and Ibrahim S E 2017 Genotypic correlation and path coefficient analysis of soybean [Glycine max (L.) Merrill.] for yield and its components Agric Res Tech 7(3) 1-5
[18] Wirnas D, Widodo I, Sobir, Trikoesoemaningtyas and Sopandie D 2006 Selection of agronomic characters to construct selection index on 11 soybean populations F6 generation Bulletin Agronomi 34(1) 19-24 (In Bahasa Indonesia)
[19] Li Y S, Du M, Zhang Q Y, Hashemi M, Liu X B and Hebert S J 2013 Correlation and path coefficient analysis for yield components of vegetable soybean in Northeast China Legume Res 36(4) 284-288
[20] Machikowa T and Laosuwan P 2011 Path coefficient analysis for yield of early maturing soybean Songkranakarin J Sci Technol 33(4) 365-368
[21] Kobraee S, Shami K and Rasekh B 2010 Investigation of correlation analysis and relationships between grain yield and other quantitative traits in chickpea (Cicer arietinum L.) Afr J Biotechnol 9(16) 2342-2348