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*Original Article*

# Correlation and path coefficient analysis for yield and its components in vegetable soybean

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**Abstract**

The associations of yield and its components offer important information in breeding plants. A study was conducted at the experimental field of the Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok on 22 genotypes of the vegetable soybean to determine the association of yield and its components. The association was analyzed by correlation coefficient, and further subjected by path coefficient analysis to estimate direct and indirect effects of each character on pod yield. Positive and significant correlation were found between the plant height and number of marketable pods/plant (0.821**), plant height and marketable pod yield (0.520*), and number of marketable pods/plant and marketable pod yield (0.822**). Negative and significance was determined between the plant height and green pod weight (-0.620**), and number of marketable pods/plant and green pod weight (-0.588**). Direct effects of the number of marketable pods/plant and green pod weight on marketable pod yield were positive and significant with path coefficients of 1.310** and 0.707**, respectively. Indirect effect of the plant height on marketable pod yield through its association with number of marketable pods/plant was positive and significant (1.075**). The results of this study suggested that the number of marketable pods/plant, green pod weight and plant height were important characters that should be taken into account as selection criteria in improving marketable pod yield of the vegetable soybean.

**Keyword:** vegetable soybean, relationship between characters, correlation coefficient, path coeffcient analysis

## 1. Introduction

Vegetable soybeans are the same species as field or grain soybeans (Glycine max (L.) Merrill). They differ from field soybeans is having large seeds, sweeter-flavor, creamier-texture, and easier digestibility (Sciarappa, 2011). Green vegetable beans contain 12.4% protein (Department of Health, 1992), four fold higher than cow's milk, which has 3.1% (Panizzi and Mandarino, 1982). They are rich sources of vitamin A, iron (Anonym, 2011), vitamin C, vitamin E and dietary fiber (Johnson *et al.*, 2000). They also contain a lower percentage of gas-producing starches (Born, 2011). Under Thai condition, vegetable soybeans are ready for harvest about 65-70 days after planting when a majority of the pods are well filled but still green, and generally sold in the pod as fresh or frozen beans. Brix of a green bean is 8.5-12.0 (Johnson *et al.*, 2011). The consumption of vegetable soybeans is rapidly increasing in Japan, Korea, China and Taiwan, and now gaining popularity as a fresh vegetable throughout the United States (Sciarappa, 2011). The annual fresh pod production in Thailand is 20,000-22,000 tons (Mongkolsilp, 2009). Half of the products are exported, mostly to Japan and some to United States. As with all cultivated plants, the main objective of vegetable soybean culture is to obtain a high yield and high quality products. Selection for yield and quality, which are polygenic characters, often leads to changes in other characters. Therefore, knowledge of the relationship of bean yield and quality with other characters is desirable

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in order to adopt the most appropriate selection criteria in breeding.

Correlation coefficients generally show the degree of relationships among characters. It is not sufficient to describe this relationship when the causal relationship of the characters among them are unknown. Path analysis is used when we want to know causal effects. In other words, path analysis is used when we want to determine the amount of direct and indirect effects of the causal components on the effect components. For this reason, Serivichayaswadi *et al.* (1997), Koauychai *et al.* (2001), Arshad *et al.* (2004), Musaana and Nahdy (1998), and Ayciker and Yildirim (2006), had determined the direct and indirect effects of various plant characters on yield using path analysis in sugarcane, baby corn, chick pea, pigeon pea, and bread wheat cultivars, respectively. As in previous studies, plant breeders could find certain characters which have importance direct and indirect effects on plant yield from path analysis, and used this information as selection criteria in breeding. Path coefficient analysis has also been used in determining the relationships among yield and its components in Turkish tobacco (Kara and Esendal, 1996), rice (Surek and Beser, 2003), and field soybean (Khan *et al.*,2000; Ariyo,1995, 2001; Ball *et al.*, 2001; Shivastava *et al.*, 2001; Iqbal *et al.*, 2003; Arshad *et al.*, 2006; Faisal *et al.*, 2007). However, to date this has not been done in vegetable soybean. In this study, the correlation coefficients among yield and its components were examined, and the level of the direct and indirect effects of the independent characters on the marketable pod yield were estimated in the vegetable soybean.

## 2. Materials and Methods

This research was carried out at the experimental field of the Department of Plant Production Technology, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. Twenty two pre-commercial/commercial lines/varieties of vegetable soybean were planted in a randomized complete block design with four replications in the early rainy season (May-July) of 2009. Plot size of the experiment was 2.25 $m^2$, each plot was planted in 3 rows 2.5 m long with 30x10 cm row and plant spacing. Measurements of examined characters were done on 10 plants which had been randomly chosen in the mid row of each plot. The following measurements were made: plant height, number of primary branches per plant, number of marketable pod per plant, pod weight, 100 green-beans weight and marketable green-pod yield. In order to determine the relationships between examined characters and marketable green-pod yield, correlation coefficients were firstly calculated from the mean values of characters. Correlation coefficients were further analyzed by path coefficient to understand the direct and indirect effects of examined characters on marketable green-pod yield. Path coefficient was analyzed by the methods used by Dewey and Lu (1959) as described by Uppraditsakul (1983).

## 3. Results and Discussion

### 3.1 Marketable yield and yield components

The marketable green-pod yield and five independent characters; plant height, number of first branch/plant, number of marketable pod/plant, pod weight, and 100 beans weight of the 22 vegetable soybean genotypes were highly significant differences. AGS334 had the highest marketable green-pod yield (71.86 g/plant) while AGS330 had lowest of 33.38 g/plant. Kamphangseang 292 and Chiang Mai 1, government authority recommended varieties, had marketable green-pod yield of 48.06 and 56.41 g/plant, respectively. AGS331 had the largest green-bean, with a weight of 98.47 g/100 beans while, Nakornsawan 1, the variety that is more popular for growing as field soybean, had the smallest green-bean and lowest pod weight of 46.94 g/100 beans and 2.12 g/pod (Table 1). AGS334, GC88005-3-3-1, AGS335, GC88005-3-1-B, and GC84130-12-3-2-P7 were 5 lines that had significant higher marketable green-pod yield than Kamphangseang 292 (48.06 g/plant) and Chiang Mai 1(56.41 g/plant), with yields of 71.86, 68.17, 68.10, 66.78, and 63.12 g/plant, respectively.

### 3.2 Correlation coefficient between yield and its components

Simple correlation coefficients calculated among examined characters are shown in Table 2. Positive and statistically significant relationships were found for the plant height with the number of marketable pods/plant (0.821, $p < 0.01$) and with the marketable pod yield/plant (0.520, $p < 0.05$), and for the number of marketable pods/plant with the marketable pod yield/plant (0.822, $p<0.01$). The coefficient of determination ($R^2$) between the plant height with the marketable pod yield/plant was 0.270, meaning that 27.0% of the variance in the marketable pod yield/plant can be explained by the plant height. The $R^2$ between the number of marketable pods/plant with the marketable pod yield/plant was 0.676, meaning that 67.6% of the variance in the marketable pod yield/plant can be explained by the number of marketable pods/plant. Negative and significant relationships were found between the plant height with the green-pod weight (-0.620, $p<0.01$), and between the number of marketable pods/plant with the green-pod weight (-0.588, $p<0.01$). Arshad *et al.* (2004) reported similar results, that is: the grain yield of chick pea (*Cicer arietinum* L.) was positively and significantly correlated with the plant height, pods/plant, 100 seeds weight and biological yield. Iqbal *et al.* (2003) studied the relationships between characters of 10 soybean varieties and reported that the plant height, pods/plant and seeds/pod had a positive and significant correlation with grain yield. Faisal *et al.* (2007) assessed the correlation coefficient and undertook path analysis among 27 genotypes of soybean, and reported that the correlation coefficient for the bean yield was positive and significant with leaf area, first pod height, days to flowering, days to maturity, plant height and number of branches per plant. Musaana and Nahdy (1998) studied

Table 1. Marketable green-pod yield and yield components of 22 lines/varieties of vegetable soybeans

| Line/variety | Plant height (cm) | No. of 1st branches /plant | Marketable green-pod yield | | | 100 Beans weight (g) |
|---|---|---|---|---|---|---|
| | | | No. of pods /plant | Pod weight (g/pod) | Pod yield (g/plant) | |
| Nakornsawan1 | 35.1 | 3.22 | 31.62 | 2.12 | 67.04 | 46.94 |
| Chiang Mai1 | 25.0 | 4.42 | 21.55 | 2.81 | 56.41 | 89.73 |
| Kanphangseang292 | 25.2 | 2.52 | 18.00 | 2.67 | 48.06 | 68.42 |
| AGS334 | 53.7 | 2.40 | 31.82 | 2.26 | 71.86 | 81.10 |
| AGS335 | 40.4 | 4.15 | 30.18 | 2.26 | 68.10 | 66.31 |
| AGS333 | 25.0 | 4.00 | 16.00 | 2.62 | 45.00 | 78.81 |
| AGS332 | 40.9 | 3.55 | 24.02 | 2.60 | 62.35 | 91.67 |
| AGS331 | 28.4 | 4.42 | 19.20 | 2.86 | 54.92 | 98.47 |
| AGS330 | 26.5 | 2.78 | 14.00 | 2.59 | 33.38 | 88.32 |
| AGS328 | 23.1 | 2.70 | 15.40 | 2.34 | 36.10 | 79.29 |
| Shironomai | 28.1 | 3.38 | 17.00 | 2.51 | 42.70 | 76.51 |
| Karietia | 14.9 | 2.32 | 13.92 | 2.44 | 33.93 | 68.30 |
| GC83010-1-B-21 | 19.0 | 2.55 | 18.01 | 3.29 | 61.04 | 69.71 |
| GC84130-12-3-2-P7 | 22.2 | 2.61 | 16.10 | 3.62 | 63.12 | 65.23 |
| GC860110-80-1-1-P6 | 17.9 | 4.20 | 15.58 | 3.00 | 49.93 | 74.76 |
| GC860110-80-2-1-P5 | 20.7 | 3.00 | 10.80 | 3.04 | 34.96 | 80.24 |
| GC88005-3-1-B | 16.2 | 4.00 | 16.42 | 3.87 | 66.78 | 70.16 |
| GC88005-3-3-1 | 13.8 | 2.63 | 17.25 | 3.76 | 68.17 | 66.11 |
| GC89001-2-1 | 17.0 | 2.28 | 14.78 | 3.46 | 54.25 | 72.44 |
| GC89001-B-6-1 | 20.8 | 2.22 | 15.20 | 3.71 | 59.40 | 81.88 |
| GC89020-2-3-3 | 17.6 | 2.13 | 16.18 | 3.37 | 57.90 | 78.24 |
| GC89020-B-23-1 | 23.9 | 2.34 | 13.10 | 3.88 | 53.48 | 53.51 |
| F-test | ** | ** | ** | ** | ** | ** |
| $LSD_{.01}$ | 3.22 | 1.33 | 3.55 | 0.71 | 6.06 | 4.52 |
| C.V.(%) | 11.96 | 14.84 | 15.03 | 4.85 | 15.74 | 7.71 |

Note ** significant difference at 0.01 level

Table 2. Correlation coefficient between pairs of characters in 22 vegetable soybean lines/varieties

| Characters | No. of 1st branches/ plant | No. of marketable pods/plant | Green-pod weight (g/pod) | 100 Beans weight (g) | Marketable pod yield (g/plant) |
|---|---|---|---|---|---|
| Plant height (cm) | 0.200 | 0.821** | -0.620** | 0.280 | 0.520* |
| No. of 1st branches/plant | | 0.272 | -0.206 | 0.352 | 0.189 |
| No.of marketable pods/plant | | | -0.588** | -0.060 | 0.822** |
| Green-pod weight (g/plant) | | | | -0.043 | -0.001 |
| 100 Beans weight (g) | | | | | -0.203 |

Note * significant at $p < 0.05$
** significant at $p < 0.01$

8 pigeon pea (*Cajanus cajan* L.) lines and reported that the plant height, pods/plant, seeds/pod, seed weight and primary branch number were positive and significantly correlated with grain yield.

### 3.3 Path coefficient analysis

The relationships determined by path analysis among characters are shown in Table 3. The direct effect of the

Table 3. Path analysis showing direct (diagonal) and indirect (off diagonal) effects of 5 characters on marketable pod yield in 22 vegetable soybeans lines/varieties, the last column shows correlation of 5 variables with marketable pod yield

| Characters | Plant height (cm.) | No. of 1st branches/ plant | No. of marketable pods/plant | Green-pod weight (g/pod) | 100 Beans weight (g.) | Correlation coefficient with market yield |
|---|---|---|---|---|---|---|
| Plant height (cm) | -0.102 | 0.005 | 1.075** | -0.437* | -0.021 | 0.520* |
| No. of 1st branches/plant | -0.020 | 0.025 | 0.356 | -0.045 | -0.027 | 0.189 |
| No. of marketable pods/plant | -0.083 | 0.006 | 1.310** | -0.415 | 0.004 | 0.822** |
| Green-pod weight (g/plant) | 0.063 | 0.005 | -0.770** | 0.707** | 0.004 | -0.001 |
| 100 Beans weight (g) | -0.028 | 0.008 | -0.077 | -0.029 | -0.077 | -0.203 |

Note * significant at $p < 0.05$
** significant at $p < 0.01$

number of marketable pods/plant and green-pod weight on marketable pod yield were positive and significant with path coefficient (p.c.) of 1.310 (p<0.01) and 0.707 (p<0.01), respectively. The number of marketable pods/plant had the highest value of the direct effects (1.310, p<0.01) on marketable pod yield. Plant height and 100 beans weight had non-significantly negative direct effects on marketable pod yield with p.c. value of -0.102 and -0.077, respectively. The indirect effect of plant height on marketable pod yield through its association with the number of marketable pods/plant was significantly positive (1.075, p<0.01), suggesting a positive relationship between the plant height and number of marketable pods/ plant. This relationship indicates that as the plant height increases, the number of marketable pods/plants increases significantly. Indirect effect of the plant height on marketable pod yield through its association with green-pod weight was significantly negative (-0.437, p<0.05), suggesting an inverse relationship between the plant height and green-pod weight. This relationship indicates a tendency for the green-pod weight to decrease significantly as plant height increases. The indirect effect of the number of marketable pods/plant on marketable pod yield through its association with green-pod weight was found to be large but non-significantly negative (-0.415). The indirect effect of green-pod weight on marketable pod yield through its association with the number of marketable pods/plant was significantly negative (-0.770, p<0.01). This negative relationship indicates that as the green-pod weight increases, the number of marketable pods/ plant decreases significantly. As in this research, Iqbal *et al.* (2003) reported the negative and non-significantly direct effect of plant height on grain yield of soybean (-0.097), while pods/plant was found to be positive and have a non-significant direct effect on grain yield (0.816). Faisal *et al.* (2007) stated that the days to flowering had the maximum direct contribution to soybean yield. This relationship indicates that a late genotype usually has higher grain yield than an early genotype. In contrast, Arshad *et al.* (2006) reported that the days to flowering had a negative direct effect on grain yield of soybean. They also reported that the total pods/plant was the character which had the highest direct effect on grain yield. Guler *et al.* (2001) stated that the direct effects of the number of pods/plant and number of seeds/ plant on seed yield/plant of chick pea were positive and significant. The results of this study showed that even though the correlations of some characters such as green-pod weight with marketable pod yield were negative and non-significant (-0.001) (Table 2), the path coefficient showed a significant positive direct effect of green-pod weight with marketable pod yield (p.c. 0.707, p<0.01, Table 3). According to this result, correlation coefficients (linear relations) among characters offer insufficient data in plant breeding programs. The path coefficient analysis provides more effective information and selection should be done according to these aggregate data.

## 4. Conclusion

The relationships of characters on economic yield are the primary important data in breeding programs. Selection for high yielding genotypes should focus on the strongly positively associated characters of crop plant on its yield. The results of this study revealed that the number of marketable pods/plant had the highest positive and significant correlation (0.822), and highest and significant direct effect (1.310) on marketable pod yield/plant in vegetable soybeans. The indirect effect of the plant height on marketable pod yield/plant through the number of marketable pods/plant was positive and significant (1.075), and the direct effect of green-pod weight on marketable pod yield/plant was positive and significant (0.707). Thus, selection for high marketable pod yield in vegetable soybeans should place maximum emphasis on these three characters; the number of marketable pods/ plant, plant height, and green-pod weight.

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