CORRELATION AND PATH COEFFICIENT ANALYSIS FOR YIELD COMPONENTS OF VEGETABLE SOYBEAN IN NORTHEAST CHINA

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ABSTRACT

Correlation coefficients and path coefficients of fresh pod yield and yield components of vegetable soybean were investigated in 2010. Thirty vegetable soybean genotypes were grown at the rate of 28 plants m⁻² in a randomized complete block design with three replications in field condition in Northeast China. The results showed that fresh pod yield was positively correlated with 3-seed pod per plant (0.81**), 2-seed pod per plant (0.76**), 2-seed pod width (0.59**) and 100-fresh seed weight (0.47**), and negatively correlated with plant height (-0.75**) and 2-seed pod length (-0.64**). Path coefficient analysis also revealed that 3-seed pod per plant (0.58) had the greatest direct positive effect on fresh pod yield, followed by 2-seed pod per plant (0.56), 2-seed pod width (0.31), and 100 fresh seed weight (0.23), whereas plant height (-0.36) and 2-seed pod length (-0.35) had negative direct effect on fresh pod yield. It was concluded that more considerations should be given to the number of seed pod per plant, 2-seed pod width, 100-fresh seed weight, plant height, and 2-seed pod length when selecting higher fresh pod yield of vegetable soybean.

Key words: Cultivars, Edamame, Fresh pod, Pod number, Soybean.

INTRODUCTION

Vegetable soybean (edamame) is a special type of soybean with larger seed size, and pleasant flavor harvested at R6-R7 stage when seeds are immature and pods are not turning yellow (Zhang et al., 2010). As a nutritional and healthy food, edamame has high level of protein and lower oil content compared with grain soybean. Vegetable soybean is more popular among people who seek healthy lifestyle mostly in developed countries and thus its consumption is highly demanded all over the world (Brar and Carter, 1993). Ernst and Woods (2001) reported the return per acre of land from vegetable soybean was $124 more than sweet corn. In Taiwan the sown area of vegetable soybean had a steady escalation since farmers became conscious of its high economic return (Lin, 2001). Northeast China is considered as alternative option to cultivate vegetable soybean, because of its longer duration of sunshine and greater diurnal temperature difference in the summer, which is beneficial to soybean seed carbohydrate accumulation that influences the eating quality.

Improving seed yield is still the priority to vegetable soybean breeders. However, seed yield is a function of several yield components including number of pods per plant, seeds per pod, plant height, node position and number per plant and seed size (Rao et al., 2002). The relationship between yield and yield components has been extensively studied in grain soybean and is used as a tool in cultivar...
selection by many researchers (Board et al., 1999; Arshad et al., 2006). For example, more pods per plant and seeds per pod of soybean frequently have shown highest positive correlation with seed yield and thus are the most used criteria to improve seed yield in selection program (Showkat and Tyagi, 2010). Machikowa and Laosuwan (2011) stated that correlation of particular trait with other traits contributing to seed yield is important in indirect selection of genotypes for higher yield. However, consideration of simple correlation between yield and yield components in breeding program sometimes is misleading because of mutual effects among yield components. Path analysis helps partitioning the effects into direct and indirect to identify yield components most responsible for increasing yield (Kobraee et al., 2010). Gan et al. (2003) reported seeds per pod had negative effect on chickpea yield, however, they found the negative effect was counterbalanced by positive effect of seed weight on yield using path coefficient analysis. Salahuddin et al. (2010) affirmed that path analysis permitted a critical examination of specific factors that produce a given correlation, which can be successfully employed in formulating an effective selection program. Mebrahtu and Devine (2008) found 100-pod weight, number of pods per plant, and main stem height were more effective in selecting high green pod yield in vegetable soybean and these yield components were highly associated with their general combining ability effects. However, the authors are not aware of any documented investigation where path analysis was used on yield components relationship of vegetable soybean cultivars. Therefore, the main objective of this study was to evaluate the relationship between fresh pod yield and yield components and to determine direct and indirect contributions of certain agronomic traits for obtaining higher yield in vegetable soybean breeding program of Northeast China.

MATERIALS AND METHODS

Field experiment was conducted at the Agronomy Farm of Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Harbin (45°732 N, 126°612 E, and altitude 128 m). Thirty vegetable soybean genotypes were planted on 4th May 2010 in a randomized complete block design with three replications on a typical Mollisol (Black soil). Each plot consisted of five rows 5.0 m long and 0.65 m wide. The seeding rate was 280,000 seeds·ha⁻¹ and sowing depth was 3 cm. Plots were planted with a grain drill. A total of 50 kg·ha⁻¹ carbamide (46% N), and 50 kg·ha⁻¹ diammonium phosphate (18% N, 20% P), and 150 kg·ha⁻¹ of composite fertilizer (18% N, 8% P, 13% K) were applied before seeding. Weeds were controlled by hand. Plants from the middle two rows of each plot were sampled when the plants were at R6 stage. The plants were cut just at the cotyledon scar and taken to the laboratory where the pods were removed carefully by hand. Seventeen agronomic traits, including plant height, node number, branch per plant, 1-seed pod per plant, 2-seed pod per plant, 3-seed pod per plant, 1-seed pod per plant, 1-seed pod weight, 1-seed pod length, 1-seed pod thickness, 2-seed pod width, 2-seed pod length, 2-seed pod thickness, 3-seed pod width, 3-seed pod length, 3-seed pod thickness, 100-fresh seed weight and fresh pod weight were evaluated. For path coefficient analysis, fresh pod weight of vegetable soybean was selected as dependent variable and the other traits as independent variables. Data obtained were subjected to correlation and path coefficient analysis using SPSS 16.0 software. The means were compared by Least Significant Difference test (LSD) at the 5% level. Path coefficient was taken as the standardized coefficient of regression (direct effect) while the indirect effect was computed by multiplying the path coefficient of individual traits with their corresponding correlation coefficients (Cramer and Wehner, 2000).

RESULTS AND DISCUSSION

We first established models of fresh pod yield and yield components and related traits in vegetable soybean through stepwise regression. We found that g model was the optimal one that had the highest multiple correlation coefficient (0.961) and the lowest standard error of the estimates (10.462) (Table 1). As shown in the model, seven foremost characters i.e. 1-seed pod per plant (X1), 2-seed pod per plant (X4), 3-seed pod per plant (X3), plant height (X2), 2-seed pod width (X5), 2-seed pod length (X6), and 100-fresh seed weight (X7) were the key traits in predicting fresh pod yield, where their corresponding coefficients were 1.504, 1.200**, 2.386**, -0.999**, 103.490**, -20.183**, and 0.779**, respectively. Thus, besides the common traits considered in grain
soybean, pod width and length were also important traits in vegetable soybean breeding. Pod dimension has been suggested as a direct selection criteria for high quality cultivar and indirect selection criteria in identifying genotypes with high 100 fresh pod yield in vegetable soybean (Mebrahtu and Devine, 2008). Table 2 indicates that fresh pod yield of vegetable soybean was positively correlated with 3-seed pod per plant (0.81**), 2-seed pod per plant (0.76**) and 2-seed pod width (0.59 **). The results were in agreement with earlier reports that 2-seed pod per plant, 3-seed pod per plant and the pod width determined the fresh pod yield and apparent quality of vegetable soybean (Rao et al., 2002). In grain soybean, significant correlations between grain yield with pod number per plant (r = 0.458; P<0.01), seed number per pod (r= 0.458; P<0.01), and seed number per plant (r = 0.329; P<0.01) have been reported (Karasu et al., 2009, Oz et al., 2009, Machikowa and Laosuwan 2011). Bizeti et al. (2004) concluded that seed size was not important for improving yield but was essential in maintaining soybean seed yield when seed number per plant was changed. Other reports also confirmed a lack of significant relationship between seed size and grain soybean yield (Board et al., 1999; Liu et al., 2010). However, in present study 100-fresh seed weight was positively correlated with fresh pod yield (0.47*). This result indicated that larger seed size should be considered as the primary index in selecting vegetable soybean cultivar.

Positive correlation between plant height and seed yield has been extensively reported for grain soybean and cowpea (Udensi et al., 2012; Malik et al., 2007). In current study, plant height was negatively correlated with fresh pod yield (-0.75**). Similar conclusion was made by Mebrahtu and Devine (2008) who indicated plant height was negatively associated with 100-pod weight. Therefore, we concluded that semi-dwarf vegetable soybean, pod width and length were also important traits in vegetable soybean breeding. Pod dimension has been suggested as a direct selection criteria for high quality cultivar and indirect selection criteria in identifying genotypes with high 100 fresh pod yield in vegetable soybean (Mebrahtu and Devine, 2008). Table 2 indicates that fresh pod yield of vegetable soybean was positively correlated with 3-seed pod per plant (0.81**), 2-seed pod per plant (0.76**) and 2-seed pod width (0.59 **). The results were in agreement with earlier reports that 2-seed pod per plant, 3-seed pod per plant and the pod width determined the fresh pod yield and apparent quality of vegetable soybean (Rao et al., 2002). In grain soybean, significant correlations between grain yield with pod number per plant (r = 0.458; P<0.01), seed number per pod (r= 0.458; P<0.01), and seed number per plant (r = 0.329; P<0.01) have been reported (Karasu et al., 2009, Oz et al., 2009, Machikowa and Laosuwan 2011). Bizeti et al. (2004) concluded that seed size was not important for improving yield but was essential in maintaining soybean seed yield when seed number per plant was changed. Other reports also confirmed a lack of significant relationship between seed size and grain soybean yield (Board et al., 1999; Liu et al., 2010). However, in present study 100-fresh seed weight was positively correlated with fresh pod yield (0.47*). This result indicated that larger seed size should be considered as the primary index in selecting vegetable soybean cultivar.

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soybean cultivar should be preferred in breeding program. The negative correlation of 2-seed pod length with fresh pod yield (-0.64**) also requires careful consideration.

Path analysis further indicated that 3-seed pod per plant and 2-seed pod per plant were the most crucial yield components due to their greatest and positive direct effect on fresh pod yield (Fig. 1, Table 3). Whereas in grain soybean pod number per plant has been reported to have the highest positive direct effect on seed yield (Machikowa and Laosuwan, 2011). In current study, we found 2-seed pod per plant and 3-seed pod per plant were more important than that of 1-seed pod per plant to fresh pod yield of vegetable soybean. This means that breeders already have successfully reduced the number of 1-seed pod per plant during breeding processes to satisfy the market demand for standard pod. We also found that though 100 fresh seed weight had direct effect on fresh pod yield (0.23), it was to some extent indirectly affected by 3-seed pod per plant (-0.07) and 2-seed pod per plant. Thus, the coordination between 100 fresh seed weight and seed pod number per plant in utilizing assimilate might be another approach in higher yield breeding in vegetable soybean. Plant height had negative and direct effect on fresh pod yield (-0.36), while this effect might be nullified in somewhat by its positive indirect effect on fresh pod yield through 2-seed pod per plant and 3-seed pod per plant. This reconfirms the importance of selecting semi-dwarf genotypes in improving fresh pod yield. Residual effect (27%) indicated that other factors influencing the yield were not considered in the model and requires further study.

In conclusion, characteristics correlated well with grain soybean yield were similarly important to vegetable soybean, however seed pod trait especially seed pod dimension should be given more consideration in breeding for higher vegetable soybean yield.

### ACKNOWLEDGMENT

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### TABLE 3: Path-coefficient analysis of vegetable soybean yield.

<table>
<thead>
<tr>
<th>Characters</th>
<th>Direct effect</th>
<th>1-SP</th>
<th>2-SP</th>
<th>3-SP</th>
<th>2-SL</th>
<th>2-SW</th>
<th>100-FSW</th>
<th>PH</th>
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<td>1-SP</td>
<td>0.18</td>
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<td>0.38</td>
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<td>-0.24</td>
<td>-</td>
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<td>0.00</td>
<td>-0.01</td>
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<tr>
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<td>-</td>
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<td>-0.13</td>
<td>-0.03</td>
<td>-0.03</td>
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<tr>
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<td>-0.03</td>
<td>-</td>
<td>0.18</td>
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<tr>
<td>2-SW</td>
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<td>0.00</td>
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<td>-</td>
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<tr>
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