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# Performance Evaluation and Estimates of Genetic Components for Yield and Yield Related Traits of Early Soybean (*Glycine Max* (L.) Varieties at Tepi, Ethiopia

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## Abstract

The field experiment was conducted at Tepi Agricultural Research Center at experimental station during 2012/13 cropping season. The purpose of this study was to evaluate soybean genotypes for yield as well as other parameters at Tepi, South Western. The field experiment was set up in a Randomized Complete Block Design (RCBD) with three replications over a one-year period in four rows per plot, with 4m long and a spacing of 40 cm between rows and 5 cm between plants. Nova, wello, awassa-95, crowford, and Ags-7-1 were the varieties tested. Plant height, days to flowering, days to maturity, number of branches per plant, hundred seed weight, number of pods per plant, number of seeds per pod, and grain yield were among the agronomic characteristics collected. The results showed significant differences at ($P<0.05$) among the varieties for some parameters that were evaluated. Wello variety had the highest days to flowering (47.67 days), days to maturity (108.66 days), pods per plant (41.67) and plant height (93.9 cm), respectively. Furthermore, this variety outperformed Ags-7-1 in terms of dry weight of seeds per hectare (31.37 qt/ha) and dry weight of grain seeds per hectare (28.33 qt/ha). As a result, we advised that the two varieties with better yields be grown in the South West area, particularly at Tepi. Moreover, for all examined traits, the phenotypic coefficient of variation is greater than the genotypic coefficient of variation, indicating that the environment has an impact on each trait. Plant height, hundred seed weight, days to maturity, and number of pods per plant had the highest heritability, demonstrating a large component of heritable variance. Furthermore, genotypic path coefficients analysis results showed that days to flowering (1.745) and days to maturity (1.828) had high positive direct effect on grain yield in conclusion, so far, no soybean variety has been released or recommended for South West Ethiopia, particularly for Tepi area. As a result, if the above-mentioned varieties are demonstrated and disseminated among small-scale farmers, it will improve the poor farmer's food security and livelihood income.

**Keywords:** Adaptation; Early varieties; *Glycine max*; Genetic components; Soybean; Heritability

## Introduction

Soybean is a legume that grows in tropical, subtropical and temperate climates. The crop is grown on roughly 6% of the world's arable land, covering an estimated total area of about 925 million hectares and yielding 217.6 million tonnes each year. Soybean has the highest protein (42%), 20% oil. Soybean used for a variety of purposes including preparation of different kinds of soybean foods, animal feed, soy milk, raw material for the processing industry, and it counter effects depletion of plant nutrients in the soil resulting from continuous mono-cropping of cereals, especially maize and sorghum, thereby contributing to increasing soil .Moreover, because of its various uses as a food, feed, and in industry, soybean could become an important crop in Africa. It also has a significant advantage over cereal crops in terms of symbiotic nitrogen fixation [1].

The key production constraints in Ethiopia were local farmers' lack of knowledge about the crop's utilization, the lack of an attractive market for the products, and a lack of a systematic approach to popularizing the crop, which stressed training farmers on soybean production, utilization, and market potential. As a result, the amount of land available for producing soybeans in the country was restricted for several years. Moreover, its production and productivity are constrained by rust, red leaf blotch, frog-eye leaf spot, bacterial pustule, bacterial blight, and soybean mosaic virus. Pests include pod (stink bugs) and foliage feeders, bean flies and nematodes in Africa [2].

Soybean is a non-native and non-staple crop with commercial promise in Sub-Saharan Africa (SSA) due to its wide range of uses as food, feed, and industrial raw material. It was initially introduced to SSA in the 19th century by Chinese traders, and it was planted as an economic crop in South Africa as early as 1903. Because of its high protein concentration, soybean meal has been the dominant protein feed source for livestock and poultry production operations for decades. Chinese traders brought soybean to SSA in the 19th century, and it was farmed as a commercial crop. Soybean was first introduced to Ethiopia in 1953, and the country's current soybean production is estimated to be 11, 261 hectares, with a total yield of 1,582 tons per hectare (CSA, 2012). In South Western Ethiopia, there are favorable weather and soil conditions for soybean production, which is important for both commercial and subsistence farming. Although yield is a complex polygenically inherited character impacted by its component traits, direct selection based on crop yields is often a paradox in breeding programs. As a result, character associations of various component traits with yield and among themselves should be considered in breeding programs Therefore, this study was designed to evaluate soybean genotypes for yield as well as other parameters at Tepi, South Western [3].

## Materials and Methods

### Analysis of variance

For various variables tested, the analysis of variance revealed significant differences ($p<0.01$) among the evaluated early soybean genotypes. At the ($p<0.05$) level, there was a significant difference in the number of pods per plant, days to physiological maturity, and grain yield. The number of seeds per pod and days to 50% flowering, on the other hand, were not significant. Similar highly significant different in genetic variability study of soybean was reported by [3].

### Phenological traits

Table 1 shows that varieties differed significantly for days to maturity and non-significantly for days to flowering based on analysis of variance. Days to flowering ranged from 38.00 to 47.67, and days to maturity ranged from 92.00 to 108.66. Genotype Nova flowered and matured earlier than the other cultivars studied. Genotype Wello, on the other hand, had the longest time to flower (47.67 days) and mature (108.66). Moreover, the maximum days to 50% flowering was observed for the Wello genotype (47.67days) followed by Ags-7-1 (43.67 days), whereas the minimum days to 50% flowering was observed in the Nova genotype with 38.00 days. Genotypes Awassa 95, Crowford and Ags-7-1 took relatively shorter days to flowering and physiological maturity. A difference of 9.67 and 16.66 days was observed between the longest and shortest days to flowering and maturity, respectively. Regarding the mean value of the cropping season, significantly higher days to 95% maturity were found at 108.67, 107.667 and 102.33 for Wello, Ags-7-1 and Crowford varieties, respectively [4].

### Growth yield traits

The analysis of variance revealed that the evaluated varieties had significant differences in terms of growth parameters. The plant heights of the genotypes ranged from the shortest (21.90 cm) to the tallest (93.90 cm) for Wello (Table 1). The Wello genotype had the highest plant height (93.9 cm), followed by Ags-7-1 and Awassa-95 genotypes with 63.9 cm and 46.9 cm plant heights, respectively. For the Nova genotype, a minimum plant height of 21.9 cm was found. The number of branches per plant was one of the growth traits evaluated, and it ranged from 0.67 to 4.00, with Wello having the most and Ags-7-1 having the least [5].

### Yield components and yield

The results revealed a significantly significant difference in grain yield between genotypes (0.05). Differences in grain yield ranged from 31.37 to 14.00 (qt/ha), with a grand mean of 10.89 (Table 1). The Wello genotype produced the maximum grain yield (31.37 qt/ha), followed by Ags-7-1 (28.33 qt/ha) and Awassa-95 (24.16 qt/ha) with a mean of 17.36 qt/ha, respectively. Pods per plant ranged from 19.00 to 41.67, with genotype Wello having the highest number and genotype Nova having the lowest. Seeds per pod were reported with genotype Ags-7-1 having the lowest number and genotype Wello having the highest. The hundred seed weight varied between genotypes, ranging from 14.66 to 20.00 g, with genotype Ags-7-1 having the greatest HSW (20.00 g) and genotype Wello having the lowest hundred seed weight (14.66 g) [6].

| Varieties | DF | DM | PH | POP | BPP | HSW | SPP | GY qt/ha |
|---|---|---|---|---|---|---|---|---|
| Nova | 38 | 92 | 21.9 | 19 | 0.67 | 17.42 | 3.41 | 14 |
| Wello | 47.67 | 108.66 | 93.9 | 41.67 | 4 | 14.66 | 3.86 | 31.37 |
| Awassa-95 | 42 | 97 | 46.9 | 21.66 | 3.66 | 17.16 | 3.52 | 24.16 |
| Crowford | 42 | 102.33 | 45.5 | 29.67 | 3.66 | 16 | 3.43 | 17.89 |
| Ags-7-1 | 43.67 | 107.67 | 63.9 | 28.33 | 4 | 20 | 3.21 | 28.33 |
| Mean | 42.67 | 101.53 | 54.4 | 28.07 | 3.2 | 17.05 | 3.48 | 23.14 |
| CV | 13.87 | 3.75 | 11.9 | 23.52 | 13.98 | 5 | 7.93 | 24.99 |
| LSD (0.05) | $11.13^{ns}$ | 7.16 | 12.19 | 12.42 | 0.842 | 1.61 | $0.52^{ns}$ | 10.89 |

**Table 1:** Mean performance of five early varieties at 2012/13 cropping season.

Grain Yield quintal per hectare (GY qt/ha), Days to 50% Flowering (DF), Days to 95% Physiological Maturity (DM), Branch Per Plant (BPP), Pod Per Plant (POP), Plant Height (PH), Hundred Seed Weight (HSW) and Seeds Per Pod (SPP) [7].

### Variance components

**Phenotypic and genotypic variations:** Phenotypic variance varied from 0.22 for the number of branches per plant and seeds per pod to 2161.27 for plant height (Table 2). Higher phenotypic variance (≥ 100%) was observed for days to maturity, plant height and number of pods per plant. Days to flowering and grain yield had relatively high phenotypic variance (50%-100%), whereas the number of branches per plant, number of seeds per pod, and hundred seed weight had comparatively low phenotypic variance. On the other hand, genotypic variance ranged from 0.02 for the number of seeds per pod to 2119.32 for plant height. Days to maturity, plant height, and number of pods per plant all had the highest genotypic variance (>100%). Days to maturity and grain yield showed moderate genotypic (g2) variance.

Days to flowering, hundred seed weight, and grain yield all had decreased genotypic variance (g2).

The Phenotypic Coefficient of Variation (PCV) for days to maturity ranged from 12.46 to 85.42 for plant height (Table 2). PCV is classified as high if it is greater than 20%, moderate if it is between 10% and 20%, and low if it is less than 10%, according to Sivasubramanian and Madhavamenon (1973). Plant height, number of pods per plant, grain yield, and hundred seed weight had greater PCV based on this delineation. Days to flowering and maturity, number of seeds per plant, and number of branches per plant, on the other hand, showed moderate PCV. The magnitude of Phenotypic Coefficient of Variation (PCV) estimates was found to be a bit higher than their corresponding Genotypic Coefficient of Variation (GCV) for all the studied traits, which might be the result of environmental influence on the expression of traits. According to Johanson (1955), GCV estimates were classified as low (0-10 percent), moderate (10-20 percent), and high (>20 percent) (1955). Based on this classification, plant height, number of pods per plant, and grain yield had higher GCV. However, moderate GCV values were observed for the number of seeds per pod (10.81%), 50% days to flowering (11.68%), 95 % days to maturity (12.46%), number of seeds per pod (13.41%), number of branches per plant (14.66%) and 95% days to maturity (11.88%). However, the lowest PCV estimates were obtained from the number of branches per plant (4.42%). Furthermore, high GCV and PCV estimates for plant height, number of pods per plant, and grain yield were recorded in this study, indicating that these characters can be manipulated for breeding high-yielding varieties through hybridization and selection in subsequent generations in the soybean improvement program. Getnet (2018) observed similar high PCV and GCV estimations for soybean plant height and grain yield [8].

## Heritability and genetic advance

The estimates of heritability in the broad sense ranged from 9.0 percent to 98.0 percent (Table 2). In the present study, the highest heritability was recorded by plant height (98.0%), hundred seed weight (94.0%), days to 95% maturity (91.0%) and the number of pods per plant, which showed high heritability. High heritability suggests a high component of the heritable portion of variation that will be exploited by a breeder in the selection of superior genotypes on the basis of phenotypic performance of the varieties. Furthermore, grain yield, number of seeds per pod, and days to 50% flowering indicated modest heritability, indicating the possibility of a soybean improvement program could be successful. On the other hand, the trait of the number of branches per plant had low heritability and was strongly affected by the environment. Therefore, direct selection for this trait is infective for soybean improvement. Low heritability value was estimated for the number of branches (0.09) and days to flowering (0.42). In contrast, Sulistyo (2018) was reported the highest heritability for days to flowering. High genetic advance was found for plant height and the number of pods per plant. However, the genetic advance was moderate for hundred seed weight, and grain yield. Similarly, Mahbub (2015) reported hundred seed weight and grain yield. High heritability coupled with high genetic advance was observed for plant height and number of pods per plant, which is due to additive gene effects and expressed in these traits.

| Variable | σ2p | σ2g | GCV | PCV | GA | H2b |
|---|---|---|---|---|---|---|
| DF | 59.83 | 24.83 | 11.68 | 18.13 | 10 | 0.42 |
| DM | 160.09 | 145.61 | 11.88 | 12.46 | 22.27 | 0.91 |
| PH | 2161.27 | 2119.32 | 84.58 | 85.42 | 170.86 | 0.98 |
| POP | 262.11 | 218.54 | 52.67 | 57.68 | 90.47 | 0.83 |
| BPP | 0.22 | 0.02 | 4.42 | 14.66 | 0.83 | 0.09 |
| HSW | 12.21 | 11.48 | 19.87 | 20.49 | 38.5 | 0.94 |
| SPP | 0.22 | 0.14 | 10.81 | 13.41 | 14.46 | 0.65 |
| AGY | 89.2 | 59.47 | 23.29 | 28.52 | 31.99 | 0.67 |

**Table 2:** Genotypic and phenotypic coefficient variation, heritability in broad sense and genetic advance of five early soybean released soybean varieties during 2012/13 grown at Tepi.

Genotypic variance and phenotypic variance, GCV, PCV: Genotypic and phenotypic coefficient of variation, Hb: broad sense heritability, GA: Genetic advance.

## Correlation analysis

Yield is a complicated attribute that is influenced by a number of interconnected quantitative variables. Understanding the relationships between yield and its components is critical since it can aid in the development of appropriate yield selection criteria. In order to determine the relationships between yield and the other examined traits, correlation coefficients were calculated. Simple correlation coefficients are calculated among the examined traits. The strongest significant positive correlation coefficient with yield (r=0.92) was found in plant height. Yield and days to flowering (r=0.91), days to maturity (r=0.82), number of branches per plant (r=0.77), and number of pods per plant (r=0.71) all had highly significant and positive associations. The results suggest that any positive increase in these traits will accelerate the yield potential of soybeans. So, these traits should be paid attention to in the soybean breeding program.

In the present study, days to maturity (0.72) showed the highest significant and positive genotypic correlation followed by days to flowering (0.55), plant height (0.54) and number of branches per plant (0.48). Days to flowering showed a strong positive correlation with days to maturity (0.91), number of pods per plant (0.92), plant height (0.87), and number of branches per plant (0.87). Days to maturity showed a significant positive association with plant height (0.86), followed by the number of pods per plant (0.82), and the number of branches per plant (0.81). Plant height exhibited a significant and positive correlation with the number of pods per plant (0.88), and the number of branches per plant (0.83). On the other hand, the number of pods per plant had a significant positive correlation with the number of branches per plant (0.87). Moreover, hundred seed weight had a significant negative correlation with days to flowering (-0.59), followed by plant height (-0.54), number of pods per plant (-0.60) and number of branches per plant (-0.51).

| Variable | DF | DM | PH | POP | BPP | HSW | SPP | AGY |
|---|---|---|---|---|---|---|---|---|
| DF | 1 | 0.89 | 0.99 | 0.92 | 0.80 | -0.36 | 0.58 | 0.91 |
| DM | 0.48 | 1 | 0.89 | 0.86 | 0.81 | -0.06 | 0.2 | 0.82 |
| PH | 0.49 | 0.83 | 1 | 0.92 | 0.74 | -0.39 | 0.57 | 0.92 |
| POP | 0.05 | 0.57 | 0.71 | 1 | 0.63 | -0.53 | 0.63 | 0.71 |
| BPP | 0.41 | 0.68 | 0.71 | 0.47 | 1 | -0.08 | 0.17 | 0.77 |
| HSW | -0.09 | -0.08 | -0.24 | -0.28 | -0.01 | 1 | -0.88 | -0.03 |
| SPP | 0.28 | 0.12 | 0.28 | -0.02 | 0.12 | 0.04 | 1 | 0.38 |
| AGY | 0.24 | 0.56 | 0.73 | 0.56 | 0.64 | -0.02 | 0.31 | 1 |

**Table 3:** Estimates of genotypic (rg) above diagonal and phenotypic (rp) correlation coefficients below diagonal for 8 traits of 5 soybean genotypes at Tepi.

Grain Yield quintal per hectare (GY qt/ha), Days to 50% Flowering (DF), Days to Maturity (DM), number of Branch Per Plant (BPP), number of Pods Per Plant (POP), Plant Height (PH), Hundred Seed Weight (HSW) and Seeds Per Pod (SPP).

## Path coefficients analysis

In this study, genotypic correlation coefficients were classified as indirect effects on grain yield, with direct effects contributing to grain yield and indirect effects contributing to grain yield. The genotypic path coefficient analysis showed that days to flowering (1.745) and days to maturity (1.828) had a strong positive direct effect on grain yield and Balla and Ibrahim (2017) both observed similar findings. Days to flowering and days to maturity, on the other hand, were found to have a negative impact on grain yield, as Machikowa and Laosuwan (2011) noted. However, the highest negative direct effect was overserved for hundred seed weight (-0.163) and the number of branches per plant (-0.163). Through days to maturity, days to flowering, plant height, number of pods per plant, and number of branches per plant all had a favorable indirect effect on grain yield.

The indirect effects of days to maturity via other agronomic parameters suggest that direct selection of high yielding genotypes based on maturity period will be effective. Plant height (0.929), days to flowering (0.915), days to maturity (0.829), number of branches per plant (0.778), and number of pod per plant (0.715) had the strongest positive direct influence on grain yield, according to the genotypic correlation coefficient. Because of the substantial genetic correlation, the characteristic had a large positive direct effect on grain yield. Days to maturity had the highest positive direct effect on grain yield, according to Balla and Ibrahim (2017).

| Traits | DF | DM | PH | POP | BPP | HSW | SPP | AGY |
|---|---|---|---|---|---|---|---|---|
| DF | 1.745 | 1.627 | -0.37 | -2.053 | -0.163 | 0.059 | 0.33 | 0.915 |
| DM | 1.553 | 1.828 | -0.333 | -1.92 | -0.163 | 0.01 | 0.114 | 0.829 |
| PH | 1.727 | 1.627 | -0.374 | -2.053 | -0.163 | 0.064 | 0.324 | 0.929 |
| POP | 1.605 | 1.572 | -0.344 | -2.232 | -0.163 | 0.086 | 0.359 | 0.715 |
| BPP | 1.396 | 1.481 | -0.277 | -1.406 | -0.163 | 0.013 | 0.097 | 0.778 |
| HSW | -0.628 | -0.11 | 0.146 | 1.183 | -0.163 | -0.163 | -0.501 | -0.035 |
| SPP | 1.012 | 0.366 | -0.213 | -1.406 | -0.163 | 0.143 | 0.569 | 0.382 |

**Table 4:** Estimates of direct (bold diagonal and underlined) and indirect effect (off diagonal) at genotypic.

Grain Yield quintal per hectare (GY qt/ha), Days to 50% Flowering (DF), Days to Maturity (DM), number of Branch Per Plant (BPP), number of Pods Per Plant (POP), Plant Height (PH), Hundred Seed Weight (HSW) and Seeds Per Pod (SPP)

# Conclusions

Based on the study, there were significant differences among the genotypes for most of the traits studied. However, the highest grain yield was obtained from Wello and Ags-7-1 followed by Awassa-95 genotypes, whereas the lowest grain yield was obtained from the Nova genotype. As a result, it is recommended to repeat the experiment at least once more season by integrating new materials and places in order to examine seasonal variation of the genotypes while analyzing the protein and oil content of the genotypes in order to make sound recommendations for the areas. The area has high rainfall, which reaches around 10 months. Therefore, the late maturity variety is very important for producing a large amount of soybeans.

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