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Research Article

# Effects of Seed Source and Storage Duration on Yield and Yield Related Traits of Soybean [*Glycine max* (L) Merrill] Varieties at Pawe, Northwestern Ethiopia

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## Abstract

Soybean [*Glycine max* (L) *Merril*] is among the important legume crops produced in northwestern Ethiopia. The production of seeds from improved varieties under favorable growing condition and stored for shortest possible duration period are among the requirements of quality seed production. This study was conducted to assess the effect of seed source and storage duration on growth, yield and its components of four soybean varieties. The treatments were four varieties (AFGAT, Cheri, Clark 63k and Davis) x seed source (rain-fed and irrigation) x two storage duration (one and two years stored under ambient temperatures) arranged in factorial combinations. Randomized complete block design with three replications were used to evaluate treatments at Pawe Agricultural Research Center during 2019/2020 cropping season. The results indicated that interactions of variety x seed source had significant effect on days to physiological maturity and number of pods per plant whereas; interaction of variety and storage period had significant influence on seed yield. Days to flowering and plant height were significantly influenced by varietal difference. The growing of Clark-63k and AFGAT varieties from seeds stored for one year produced higher seed yield of 1.191and 1.174 t/ha respectively, while growing of all varieties from seeds stored for two years produced significantly lower seed yield (0.562 to 6.42 t/ha). The results from the experiments showed that the influence of variety, storage duration, seed source and interaction of the two had significant effect on seed yield and yield related traits. In most cases, the seeds of improved varieties from seed source of irrigation and stored at room temperatures for one year produced high yield. Thus, it is suggested to consider varieties; seed source and seed storage duration to produce high yield to improve the productivity of soybean..

**Keywords:** Seed Source; Storage Period; Yield

## Introduction

Soybean [*Glycine max* (L.) Merrill] is an important global legume crop that grows in the tropical, subtropical and temperate climates. It was widely distributed in most parts of the world and has a lot of potential in Africa [1]. It is frost sensitive, thrives best on sandy or clay loam and alluvial soils of good fertility with optimum soil pH of 6.0-6.5 [10].

The most important nutritional problems in most developing countries, including Ethiopia, are protein, energy malnutrition and micronutrient deficiencies [13]. The high cost and inadequacy in production of protein rich foods have resulted in increased protein energy malnutrition among children and other vulnerable groups in the developing world [22]. The worldwide importance of soybean arises from its high nutritional value i.e., high protein, oil and fat content, and its market value as whole grain, and factory processed food products, such as oil, margarine, and concentrate infant feeds. It is also a crop of worldwide market importance [25].

Besides its role as an export commodity, soybean has high agricultural value in crop rotation and nitrogen fixation. Soybean, like all other legumes, also improves soil fertility by converting atmospheric nitrogen from the soil for its own use, which also benefits subsequent crop in rotation. It, therefore, cuts down the amount of

nitrogen fertilizer that farmers have to purchase to apply to their fields to improve productivity. This is a major benefit in Africa, where soils are poor in nutrients and fertilizers are expensive and not available for farmers [11].

Soybean yield was impacted by cultivars [20]. Water is an important controlling factor for soybean growth and development in semi-arid and semi-humid region. Inadequate soil water limits root exploration and supplemental water could increase crop yield [6]. Reasonable water entry could increase soybean photosynthetic rates of soybean. The seeds of soybean produced during dry period under irrigation might improve the quality due to the low disease pressure, higher photosynthesis efficiency and vigorous growth of plants [19]. An occurrence of drought stress during early reproductive growth may increase flower and pod abortion thus decrease seed number and increase seed weight [17].

In Ethiopia, during 2016/17 cropping season a total of 36,635.79 hectares of land covered by soybean with a total production of 81,234.66tonnes and in 2017/18, it was 38,072.70 hectares with 86,467.87tonnes in which land coverage and total production increased by 3.92 and 6.44%, respectively. The National average yield was 2.217 and 2.271 t/ha during 2016/17 and 2017/18 cropping seasons, respectively (CSA, 2018). The average yield is by far lower than the world's average yield of 3.72t/ha [9].

The storage duration also deteriorated the quality of seeds due to loss of germination which is much more acute under tropical condition that reduce the productivity in soybean. The cultivars of soybean have inherent difference for tolerance to seed deterioration due to extended storage and the response of cultivars for different seed source might vary in respect to seed production. Therefore, it is necessary to study the seed source and seeds storage duration to produce high seeds yield of soybean cultivars. However, such studies have not been conducted in Ethiopia. This research was initiated with the following specific objective, to assess effect of seed source and storage duration on seed yield and yield related traits of soybean varieties.

## Materials and Methods

The field experiment was aimed to evaluate the productivity of the varieties obtained from different seed sources and storage duration of the same varieties.

### Description of experimental site

The experiment was conducted at Pawe Agricultural Research Center (PARC) during 2019 main cropping season. The area is located in Metekel Zone of Benishangul Gumuz Regional State, Southwestern Ethiopia. The center is 575 km far from Addis Ababa, the capital city of the country, and lies 11°19'N latitude 36°24' E longitude, and at an altitude of 1120 meters above sea level (m.a.s.l.). The area has an annual average rainfall of 1587 mm and the rainy season covers June to December and maximum rain was received in the months of July and August. The Mean minimum and mean maximum air temperature are 16.5 $^0$C and 32.6 and respectively [23].

### Experimental materials

The experimental material includes a total of four medium maturity types of soybean varieties, which were released in different years and stored under room temperature in polypropylene bag. The varieties used in the experiment were *AFGAT* (TGX-1892-10F), *Cheri* (IPB-81-EP7), *Clark 63k, Davis* (Table 1). The recommended NPS fertilizer at the rate of 100 kg/ha were applied [10].

| Variety | Year of release | Yield t ha$^{-1}$ | | Altitude (m.a.s.) | Maintainer Center |
|---|---|---|---|---|---|
| | | Research | Farmer | | |
| *AFGAT* (TGX-1892-10F)) | 2007 | 14.8 | 13 | 750-1800 | AwARC/ SARI |
| *Cheri* (IPB-81-EP7) | 2003 | 22 | 15 | 1300-1800 | BARC/OARI |
| *Clark 63k* | 1981/2 | 25-30 | 15-20 | 100-1700 | AwARC/ SARI |
| *Davis* | 1981/82 | 25-30 | 15-20 | 1000-1700 | AwARC/ SRARI |

**Table 1:** Description of soybean varieties.

**Source:** MoANR (2016).

### Treatments and experimental design

The treatments consisted of two level of seed source (from rain-fed, irrigation), two storage periods (one and two year) and four soybean varieties (*AFGAT, Cheri, Clark 63k* and *Davis*). Thus, there were 2 × 2 × 4 (16) treatment combinations. The treatments were laid out in Randomized Complete Block Design in a factorial arrangement with three replications. The total number of plots was 16 × 3 = 48. The size of individual plots was 2.4 x 3 m and intra-row and inter-row spacing of 0.05 m and 0.60 m, respectively. There were four rows per plots and 60 plants per rows. The spacing between blocks and plot was 1.5m and 0.75 m, respectively. Only plants in the central rows were harvested for data collection.

### Crop Phenology and growth

- **Days to 50% flowering (DF):** The time from sowing to days required to 50% plants in a plot produce flower.
- **Days to maturity (DM):** This refers to duration from sowing to the time 90% of plants in a plot reach physiological maturity.
- **Plant height (PH):** plant height from ground level to the tip of main stem at harvest, it was measured using a ruler on ten plants randomly taken from the middle rows.
- **Number of branches per plant (BPP):** This refers to the number of primary branches on the main stem per plant was counted from ten randomly taken plants from middle rows at maturity.

### Seed Yield and yield components.

- **Number of pods per plant (NPPP):** This refers to total number of pods per plant at full maturity and was obtained from ten randomly taken plants from central rows of each plot.
- **Number of seeds per pod (NSPP):** This refers to the total number of seeds per pod and was obtained from ten randomly taken plants from central rows of each plot those seeds of all the pods was trashed, seeds counted and divided by the number of pods threshed.
- **Seed yield per hectare (SY):** This refers to the seed yield and was determined by harvesting the plants from the entire net plot area (including that use for determination of yield attributes). The harvested plants were sun dried for one week, threshed and weighed. The moisture content of seed yield from each plot was determined over drying method and seed yield of each plot was adjusted to 10% moisture content. The seed yield per plot was converted to per hectare.

### Data Analysis

The data recorded in this study were subjected to statistical analysis. The analysis of variance was carried out using SAS software (SAS, 2000). Significance differences between treatment means were delineated by Least Significance Difference (LSD) test at 5% level of significance.

## Results and Discussion

### Phenology and Growth of soybean varieties

Days to 50% flowering, 90% physiological maturity and plant height were significantly influenced by variety. In addition, days to 90% physiological maturity was significantly influenced by seed source and interaction of variety x seed source. Number of primary branches was significantly influenced by seed source and storage duration (Appendix Table 1). This indicated that phenology, plant

| Parameter | Replication (2) | Variety (3) | Seed source (1) | Storage (1) | V*Ss (3) | V*Sd (3) | Ss*Sd (1) | V*Ss*Sd (3) | Error (32) | CV (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| DF | $0.06^{ns}$ | 383.18** | $0.18^{ns}$ | $0.18^{ns}$ | $0.02^{ns}$ | $0.02^{ns}$ | $0.18^{ns}$ | $0.02^{ns}$ | 0.06 | 0.55 |
| DPM | 3.25* | 345.13** | 10.08** | $2.08^{ns}$ | 3.69* | $0.80^{ns}$ | $0.08^{ns}$ | $2.25^{ns}$ | 0.82 | 0.93 |
| PH (cm) | $10.80^{ns}$ | 3681.25** | $7.13^{ns}$ | $1.23^{ns}$ | $6.24^{ns}$ | $8.26^{ns}$ | $9.45^{ns}$ | $7.75^{ns}$ | 3.3 | 3.18 |
| NPB | $0.08^{ns}$ | $0.05^{ns}$ | 1.11* | 1.96** | $0.18^{ns}$ | $0.30^{ns}$ | $0.42^{ns}$ | $0.05^{ns}$ | 0.16 | 13.07 |
| NPP | $10.05^{ns}$ | 59.65** | 171.76** | 397.90** | 24.01** | $1.34^{ns}$ | 39.24** | $10.11^{ns}$ | 4.92 | 12.09 |
| NSP | $0.05^{ns}$ | 0.43** | $0.08^{ns}$ | 0.34** | $0.03^{ns}$ | $0.01^{ns}$ | 0.11* | $0.06^{ns}$ | 0.02 | 7.73 |
| GY (kg $ha^{-1}$) | $13106.46^{ns}$ | 111929.74** | 191170.28** | 2397019.66** | $18440.04^{ns}$ | $69241.72^{**}$ | $58163.33^{ns}$ | $16084.77^{ns}$ | 9970.17 | 12.13 |

**Appendix 1:** Mean squares from analysis of variance for phenology, growth, yield components and seed yield of soybean varieties at Pawe in 2019/20 production season. ns, * and **: non-significant significant, significant at $P < 0.05$ and $P < 0.001$ probability level, respectively. V: Variety, Ss: Seed source, Sd: Storage duration and CV (%): Coefficient of variation; Number in parenthesis represents degree of freedom for the respective source of variation. DF: Days to 50% flowering; DPM: Days physiological maturity; PH (cm): Plant height (cm); NPB: Number of Primary Branches; NPP: Number of Pods Per Plant; NSP: Number of Seed Per Pod; HSW(g): Hundred Seed Weight (g) and GY (kg $ha^{-1}$): Grain Yield kg Per Hectare

height and number of primary branches of soybean varieties were significantly influenced by the genetic factor; storage period and seed source by the effects of the two factors. Soybean development is influenced by several environmental factors, such as temperature, precipitation, relative humidity and soil moisture. No other individual cropping factor influences soybean development and production so much as the sowing season interaction to soybean genotypes. Since these factors are operative regardless of the storage phase or period, anyone concerned with storage of soybean seed-or other kinds of seed-must understand their effects and interactions as they relate to maintenance of quality [8].

Significant difference observed between the varieties might be attributed to the fact that days to flowering in soybean are considered to be varietal characteristics, which is genetically controlled and individual varieties have different growing habit, flowering and maturity days [24]. Longest duration (50 day) to 50% flowering took for both *AFGAT* and *Cheri* variety while shortest duration (39 day) to 50% flowering took for *Davis* variety (Table 2).

| Variety | Days to 50% flowering (%) | Plant height (cm) |
|---|---|---|
| *AFGAT* | 50.08[a] | 76.22[a] |
| *Cheri* | 50.08[a] | 66.80[b] |
| *Clarck-63* | 42.08[b] | 46.70[c] |
| *Davis* | 39.00[c] | 38.32[d] |
| LSD (0.05) | 0.20 | 1.54 |

**Table 2:** Variation of soybean varieties for days to 50% flowering and Plant height of soybean at Pawe in 2019.

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P < 0.05 and CV (%) = percentage of coefficient of variation.

Longest duration (104 day) of physiological maturity took for seed of *AFGAT* variety from rain-fed. Physiological maturity of Cheri, *Clarck-63* variety from rain-fed and *Cheri, Clarck-63* varieties from irrigation seed source had non-significant. Shortest duration of physiological maturity took for both sample seed of *Davis* variety from irrigation and rain-fed (Table 3). This indicated that seed from irrigation source hasten days to physiological maturity. The present result was also in agreement with that excessive water delays the maturity [14].

| Variety | Seed source | Days to 90 % physiological maturity |
|---|---|---|
| *AFGAT* | Irrigation | 101.50[b] |
| *Cheri* | Irrigation | 97.83[c] |
| *Clark-63k* | Irrigation | 97.00[c] |
| *Davis* | Irrigation | 89.33[d] |
| *AFGAT* | rain-fed | 104.00[a] |
| *Cheri* | rain-fed | 97.83[c] |
| *Clark-63k* | rain-fed | 97.83[c] |
| *Davis* | rain-fed | 90.16[d] |
| LSD (0.05) | | 1.20 |

**Table 3:** Interaction effect of variety x seed source on physiological maturity of soybean varieties at Pawe in 2019.

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P < 0.05 and CV (%) = percentage of coefficient of variation.

The *AFGAT* and *Davis* varieties had tallest (76.22 cm) and shortest (38.32 cm) plants, respectively (Table 2). This might be influenced by the genetic improvement of soybean varieties for the height of the plants. The present study agreed with who had indicated that plant height is highly influenced by the varietal variation [16].

Higher number (3.29) of primary branches per plant was registered for plants grown from irrigation source while the lower number (2.99) of primary branches per plant was observed in plants from rain-fed source (Table 4). The higher number (3.34) of primary branches per plant was registered for plants from seed of soybean stored for one year while the lower number (2.94) of primary branches per plant was observed from seed stored for two-year soybean (Table 4). This indicated that prolonged storage duration

| Seed source | primary branches per plant (no) | Storage duration | primary branches per plant |
|---|---|---|---|
| Irrigation | 3.29[a] | One year | 3.34[a] |
| Rain-fed | 2.99[b] | Two years | 2.94[b] |
| LSD (0.05) | 0.24 | | 0.26 |

**Table 4:** Effects of seed source and storage duration on of primary branches per plant of soybean at Pawe in 2019.

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

decreases number of primary branches at both seed source.

## Seed yield and its components

The soybean varieties had showed significant differences for number of pods per plant, number of seeds per pod and seed yield. Number of seeds per pod was significantly influenced by seed source and interaction of seed source x storage duration. Seeds storage duration had significant effect on number of seeds per pod and seed yield while seed source and interaction of variety x seed source significantly influenced number of pods per plant and seed yield of varieties (Appendix table 1). This indicated that seed yield and yield of soybean varieties were significantly influenced by the genetic factor; storage period, seed source, interaction of seed source x storage duration and variety x seed source. Karkannavar also suggested that seed yield and components of yield were genetically heritable [15].

The higher number of pods per plant was recorded for both seeds of *AFGAT* and *Clarck-63k* varieties from irrigation source with statistical parity. The number of pods per plant from seeds of *AFGAT* and *Clarck-63k* varieties from rain-fed and *Cheri* variety from irrigation source had non-significant. Least number of pods per plant was estimated from sample seed of *Cheri and Davis* varieties from rain-fed and *Davis* variety from irrigation source with statistical parity (Table 5). This indicated that seed from irrigation source increases number of pods per plant.

| Variety | Seed source | Number of pods per plant |
|---|---|---|
| *AFGAT* | Irrigation | 24.18$^{a}$ |
| *Cheri* | Irrigation | 19.40$^{bc}$ |
| *Clark-63k* | Irrigation | 21.63$^{ab}$ |
| *Davis* | Irrigation | 15.75$^{c}$ |
| *AFGAT* | rain-fed | 17.46$^{bc}$ |
| *Cheri* | rain-fed | 15.26$^{c}$ |
| *Clark-63k* | rain-fed | 17.26$^{bc}$ |
| *Davis* | rain-fed | 15.83$^{c}$ |
| LSD (0.05) | | 4.66 |

**Table 5:** Interaction effect of variety x seed source on number of pods per plant of soybean varieties at Pawe in 2019.

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

The highest (24.02) number of pods per plant was estimated from sample seed from irrigation source and stored for one year duration. Number of pods per plant from seeds of irrigation and stored two years had non-significant difference with number of pods per plant from seeds from rain-fed source and stored for one year. Lowest (14.48) number of pods per plant was estimated from sample seed of rain-fed source and stored for two years duration (Table 6). This indicated that prolonged storage period decreases number of pods per plant at both seed source. This is because of that the seed stored for a longer time the vigor of the seedling and the branch of the plant reduced and finally the number of seed per pod, number of pods per plant and total seed per plant reduced. This result was in agreement with the results reported that the minimum grains spike-1 in farmer's wheat seed category might be due to aging of the seed, which resulted from poor quality seedling and poor management practices during its development [2].

| Storage duration | Seed source | No. pods per plant | No. seed per pod |
|---|---|---|---|
| One year | Irrigation | 24.02$^{a}$ | 2.23$^{a}$ |
| | rain-fed | 18.43$^{b}$ | 2.05$^{ab}$ |
| Two year | Irrigation | 16.45$^{bc}$ | 1.97$^{b}$ |
| | rain-fed | 14.48$^{c}$ | 1.98$^{b}$ |
| LSD (0.05) | | 2.64 | 0.19 |

**Table 6:** Interaction effect of seed source x storage duration on number of pods per plant and number of seed per pod of soybean varieties at Pawe in 2019.

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P < 0.05 and CV (%) = percentage of coefficient of variation.

The highest number of seed per pod was estimated for sample seed from both seed source and stored for one year with statistical parity. Lowest seed pod per plant was estimated for sample seed from both seed source and stored for two years with statistical parity (Table 6). This indicated that prolonged storage period decreases number of seed per pod at both seed source. The suggestion may be supported by [5] who reported that Hashem variety was much more resilient to deterioration treatment than Arman variety with increasing age and less reduce yield and yield component of chickpea. Also finding indicated that significant differences in seeds per spike among different wheat varieties [21].

Highest seed yield was obtained from plants grown from both sample seed of *Clark-63k* variety and *AFGAT* variety and stored for one year with statistical parity. Least yield was obtained from plants grown from sample seed of *Davis*, *Clarck-63k*, *Cheri* and *AFGAT* varieties and stored for two years with statistical parity (Table 7). This indicated that prolonged storage period decreases seed yield and varietal variation influence grain yield. In agreement to the results reported that soybean yield was impacted by cultivars [20].

| Variety | Storage duration | Seed yield (Qt/ha) |
|---|---|---|
| *AFGAT* | One year | 11.74[a] |
| *Cheri* | One year | 8.30[c] |
| *Clark-63k* | One year | 11.91[a] |
| *Davis* | One year | 9.89[b] |
| *AFGAT* | Two years | 6.03[d] |
| *Cheri* | Two years | 5.90[d] |
| *Clark-63k* | Two years | 6.42[d] |
| *Davis* | Two years | 5.62[d] |
| LSD (0.05) | | 151.94 |

**Table 7:** Interaction effect of variety x storage duration seed yield of soybean varieties at Pawe in 2019.

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P < 0.05 and CV (%) = percentage of coefficient of variation.

## Conclusion

The effect of soybean seeds as influenced by three main factors (variety, seed source and storage period) and all possible two and three factors' interactions on phenology, growth, yield components and seed yield were evaluated at field condition. The results of field experiment indicated that days to flowering and plant height were significantly influenced by varietal difference. One or more main factors had significant influence on other phenology, growth, seed yield and its components. Besides, the interactions of variety x seed source had significant effect on days to physiological maturity and number of pods per plant whereas; interaction of variety and storage period had significant influence on seed yield. The growing of Clark-63k and AFGAT varieties from seeds stored for one year produced higher seed yield of 1.191 and 1.174 t/ha, respectively, with non-significant difference, while growing of all varieties from seeds stored for two years produced significantly lower seed yield (0.562 to 0.642 t/ha).

The results from the experiments showed that after growing the soybean seeds of different quality influenced by variety, storage duration, seed source and interaction of the two and/or three factors had significant effect on seed yield, yield related traits parameters. In most cases, the seeds of improved varieties from irrigation and stored at room temperatures for one year produced high yield. The use of seeds from rain-fed source and stored for two years not lead to produce high seed yield of soybean. Thus, it is suggested to consider varieties; seed source and seed storage duration to produce high yield to improve the productivity of soybean. However, to come to a conclusive recommendation, additional experiments should be conducted at different locations using a greater number of varieties, seed source and storage durations.

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