

Comparative Assessment of Winter Sown Soybean Germplasm for Growth, and Yield Traits Under High pH Soil

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ABSTRACT

In spite of many success stories and multi benefits associated with soybean cultivation in the whole world, survival of this crop always creates problems in different regions of Pakistan due to unavailability of resilient genotypes and fixed cropping systems. There is a need to promote soybean cultivation in different agro-climatological belts of Pakistan by conducting adaptability trials of available genotypes. In Pakistan, extremes in soil pH and harsh climatic conditions, have a great influence on the growth, nodulations and yield of soybean. The careful selection of appropriate genotypes would be a feasible strategy to overcome the above-mentioned problems for increasing yield and overall income for soybean growers in Pakistan. Keeping in view the above-mentioned facts, a field experiment was undertaken at the Agronomic Research Area, the University of Agriculture Faisalabad, in the winter season of 2023-24. In this experiment, seven treatments i.e. soybean genotypes, G_1 = AARI soybean, G_2 = Faisal soybean, G_3 = Rawal-1, G_4 = NARC-21, G_5 = SL-196, G_6 = SL-171, and G_7 = UAF-soya-1 were used. A basic arrangement of a Randomized Complete Block Design (RCBD) was employed, with three replications and a gross

plot size of 3 m × 6 m. Fisher's analysis of variance techniques were used to statistically assess the data on growth and yield characteristics, and the Least Significance Difference (LSD) test was used to compare the treatment means at a 5% probability level. Data was compiled using standard procedures on growth, yield, and quality characteristics. Result indicated that UAF-soya-1 performed best among all the treatments. While minimum plant height (22.66 cm), number of pods per plant (13.96), and 1000 seed weight (140.10g) were recorded with Rawal-1, maximum plant height (54.00 cm), number of pods per plant (23.86), and 1000 seed weight (200.67 g) were seen with UAF-soya-1. Therefore, it is concluded that UAF-soya-1 soya would be the best choice among all the understudied genotypes.

Key words: Soybean, Genotypes, Winter sown, High pH, Punjab

INTRODUCTION

In recent decades, soybean (*Glycine max* L.) has become a highly productive, lucrative, and adaptable field crop. It has the highest commercial value and is a significant oil seed crop globally (Naamala et al., 2016). In Pakistan the main concerns with commercial soybean production include low seed viability, poor germination in the field, a lack of high-quality soybean seed, deterioration of seed viability, climate dangers, and a weak marketing infrastructure (Yari et al., 2010). Soybean genetic diversity is determined on the basis of agronomic traits, pedigree information and morphological variations showed by the new developed accession (Deforemental et al., 2004). Research on various genotypes is very important for a researcher mainly in a new emerging crop like soybean. Selection of new genotypes which show promising yield may prove beneficial as it may develop into new high yielding varieties to fulfill the food and oil demands (Dong et al., 2001). Its adaptability issues and overlapping of its season with major existing crops always demand some sustainable solutions for its survival.

Farmers in central Punjab's semi-arid region have little interest because of issues with reduced germination and seed viability (Abbasi et al., 2009). Uneven crop stands are caused by a lack of high quality seed. Gaining a decent crop production requires quick and even crop stand (Yari et al., 2010). Hence, using high-quality seed is essential if you want to grow the required number of plants and get a yield that is satisfactory. We can accomplish this goal by giving our farmer high-quality seed (Abbasi et al., 2009). It is essential to choose soybean cultivars that are appropriate for a certain region in order to increase yield levels to levels that are satisfactory. In dry and semi-arid areas, the climate is more erratic, which experience severe drought and low rainfall, these areas are more vulnerable to temperature extremes and disturbances of regular rainfall (Bhuiyan, 2008). The same thing is happening in Faisalabad's agricultural climate.

As soybeans have short days, blooming requires a lengthy period of darkness. Photoperiod controls the growth process and blooming mechanism in soybean (Zhang et al., 2001). A variety of developmental processes are influenced by the length of the day, or photoperiod, including seed germination, flowering, the growth of storage organs, the development of stems and leaves, and assimilate partitioning (Taiz and Zeiger, 2004).

During their entire life cycle, from emergence to maturity, soybeans are sensitive to temperature. According to Câmara et al. (1997), the average daily temperature throughout the growing season shouldn't drop below 15 °C because this will hinder the growth of the plants and impede the development of new leaves, shoots, and pods. A temperature decrease of less than 10°C might potentially stop the soybean from blossoming. Soybean morphological and physiological features vary widely and are influenced by environmental factors. This species is sensitive to the transition from blooming to flowering, however genotypes of soybeans differ significantly in their reaction to temperature (Lin et al., 2005), (Board et al., 1996) revealed differences in 3 °C cold tolerance amongst 10 genotypes of soybeans.

MATERIALS AND METHODS

Experimental site

An experiment was conducted to examine the comparative assessment of winter sown soybean germplasm for growth, seed yield, and nodulation improvement under high pH soil at Agronomy farm, University of Agriculture, Faisalabad during the winter season. Faisalabad is a city of central Punjab that lies between 31.25° North latitude and 73.09° East longitudes at 184 m height from the sea level.

Soil analysis

Preceding the experiment, a region of choice was subjected to chemical and physical investigation. Soil samples were taken from a depth of 0 to 30 cm using an auger. In the laboratory of the Ayub Agricultural Research Institute (AARI) in Faisalabad, samples were examined.

Table.1 Chemical analysis of experimental soil

Characteristics	Unit	Values level
Ec	mScm ⁻¹	0.76
pH		8.01
Organic matter	%	1.01
Available phosphours	mg kg ⁻¹	23.2
Availabe Potassium	mg kg ⁻¹	203
Saturation	%	36
Texture		Loam

Agro-meteorological data

Agro-meteorology cell, Department of Agronomy, UAF, provided the meteorological data for the cropping season (From November to March 2023 -2024).

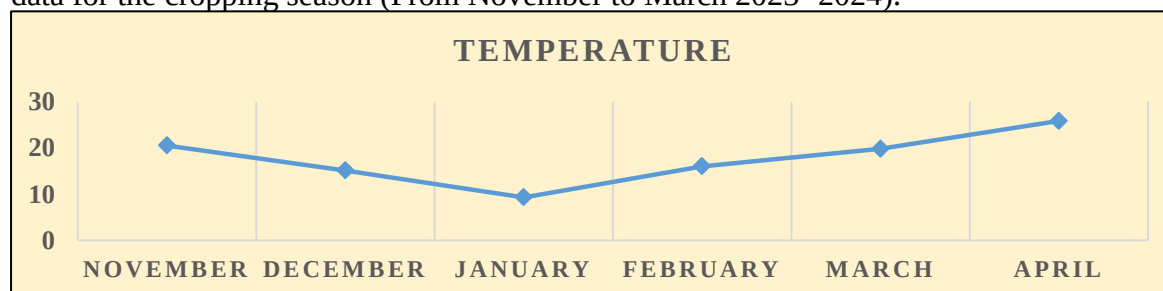


Figure 1. Weather data Average Temperature during crop growing season of soybean.

Treatments

The following treatments were included in the experiment.

G₁ = AARI soybean

G₂ = Faisal soybean

G₃ = Rawal-1

G₄ = NARC-21

G₅ = SL-196

G₆ = SL-171

G₇ = UAF-soya-1

Gross Plot size = 3 m x 6 m = 18 sq.m

Net Plot Size = 3 m x 5 m = 15 sq.m

Crop Husbandry

Three replications of a randomized complete block design (RCBD) experiment were run. For every treatment, a gross plot size of 3 m × 6 m was utilized.

Seed collection

Seeds of a newly developed variety of soybean called AARI soybean and Faisal soybean (*Glycine max* (L.) Merrill) were procured from the Ayub Agriculture Research Institute (AARI), Faisalabad while NAR C-21 and Rawal-1 were taken from the National Agriculture Research Centre, Islamabad. SL-196, SL171, and UAF-soya genotypes were brought from the University of Agriculture, Faisalabad.

Soil preparation and sowing methods

Pre-sowing irrigation (Rouni) was applied in this field experiment. When the moisture is at field capacity (Wattar), then ridges were prepared. Sowing was done manually on 06 November 2023. Seeds @ 75 kg ha⁻¹ were sown by manual dibbling (Choppa method) on 75 cm apart ridges. Seed was sown on both sides of the ridges by keeping a plant-to-plant 10cm distance and row-to-row distance of 30cm.

Fertilizer

The recommended dose of NPK (25 kg ha⁻¹, 50 kg ha⁻¹, and 50 kg ha⁻¹ respectively) was applied by Urea, and DAP fertilizers respectively. Before planting, calculated dosages of DAP, SOP, and urea were administered; urea was applied after sowing. Whereas urea was applied in three splits (4-5 leaf stage, knee height, and blooming), the whole amount of DAP and SOP were applied at planting.

Plant protection measures

a) Weeding

All precautionary measures were adopted to control weeds. Dual Gold (S-metolachlor) was used as pre-emergence weedicide. Weeding will be done 3 times.

b) Pests management

A shoot fly attack was observed after 10-20 days of sowing. For controlling shoot fly, an insecticide named Advantage (FMC) @ 400 ml in 120 liter of water per acre was used. 20-25 days after sowing was critical period for army worm and fall army worm attack. Amma Lu (Emamectin + Leufenuron) @ 400 ml per acre in 120-liter water were applied to control army worm and fall army worms. Borer attack was observed after one month. Virtako @ 4 kg per acre was used for borers. Fortunately, no serious diseases were found in the field.

Irrigation

Irrigations was applied from early vegetative stage till maturity, according to the climatic conditions.

Data collection

Using standard procedures, data on the desired parameters of component crops were collected for each treatment.

OBSERVATIONS TO BE RECORDED

During the research, the following parameters were studied using the standard procedures

Growth parameters

Plant height at maturity (cm)

Number of branches per plant

Yield parameters

Number of pods per plant

1000-seed weight (g)

Biological yield (t ha⁻¹)

Grain yield (t ha⁻¹)

Harvest Index (%)

Statistical analysis

Fishers' analysis of variance approach was used to statistically examine data that was captured at various stages. The means of the treatments were compared using the 5% probability level LSD (Least Significance Difference) test. (Steel *et al.*, 1997).

Procedure for recording observations

Following procedure was adopted to record the readings of above parameters.

Plant height (cm)

Using a measuring tape, the height of five randomly chosen plants from each experimental unit (treatment) was determined. The plant's height was measured from the ground to its summit. After then, the values were averaged.

Number of branches per plant

The number of branches per plant was counted at physiological maturity, when all plants had ceased growing, and at various sampling intervals. Three selected plants from each pot were counted on their branches before the plants were dried, and an average was determined.

Number of pods per plant

Each plot included five randomly selected plants whose pods were counted before an average was calculated.

1000- Seed weight (g)

By taking three typical samples from each plot and weighing them with the aid of an electrical balance, the weight of one thousand seeds was calculated and averaged.

Biological yield (t ha⁻¹)

After the crop reached full maturity, it was left in the sun for a week to ascertain the yield per plot.

Grain yield (t ha⁻¹)

At crop maturity, seeds were collected from pods of each plot. After sun drying, seed yield was determined in kg per plot and then it was changed to tons per hectare (t ha⁻¹).

Harvest Index (%)

Harvest index is defined as the ratio of dry biological yield to economical yield. The following was used to get the final reading:

$$HI = \frac{\text{Grain Yield}}{\text{Biological Yield}} \times 100$$

RESULTS

Plant height at maturity (cm)

Results shows that the maximum plant height (54.00 cm) was reported with treatment G₇ where a soybean genotype, UAF-Soya-1 was grown in winter. However, the minimum plant height (22.66 cm) was reported in G₃ where a soybean genotype, Rawal-1 was grown in winter.

Number of branches per plant

Comparison of treatments' means shows that the maximum number of branches (8.86) was reported with treatment G₇ where a soybean genotype, UAF-Soya-1 was grown in winter. In comparison, the minimum number of branches (4.37) was reported in G₃ where a soybean genotype, Rawal-1 was grown in winter.

Number of pods per plant

Comparison of treatments' means shows that the maximum number of pods (23.86) was reported with treatment G₇ where a soybean genotype, UAF-Soya-1 was grown in winter. In comparison, the minimum number of pods (13.96) was reported in G₃

where a soybean genotype, Rawal-1 was grown in winter.

1000- seed weight (g)

Comparison of treatments' means shows that the maximum 1000-seed weight (200.67 g) was reported with treatment G₇ where a soybean genotype, UAF-Soya-1 was grown in winter. In comparison, the minimum 1000-seed yield (140.00 g) was reported in G₃ where a soybean genotype, Rawal-1 was grown in winter.

Biological yield (t ha⁻¹)

Result shows that the maximum biological yield (5.29 t ha⁻¹) was reported with treatment G₇ where a soybean genotype, UAF-Soya-1 was grown in winter. In comparison, the minimum biological yield (0.95 t ha⁻¹) was reported in G₃ where a soybean genotype, Rawal-1 was grown in winter.

Grain Yield (t ha⁻¹)

Results shows that the maximum seed yield (1.98 t ha⁻¹) was reported with treatment G₇ where a soybean genotype, UAF-Soya-1 was grown in winter. In comparison, the minimum seed yield (0.57 t ha⁻¹) was reported in G₃ where a soybean genotype, Rawal-1 was grown in winter.

Harvesting Index%

The harvest index (HI) is a critical parameter that reflects the efficiency of a plant in allocating biomass to seed production. In this study, the harvest index did not show a significant variation among the different soybean germplasm. This outcome suggests that the genetic potential for biomass partitioning to seeds is relatively similar across the tested genotypes under high pH soil and cold conditions Singh *et al.*,2020.

Table 2 Evaluating the performance of winter sown soybean genotypes for their plant height at maturity, No. of branches per plant, No. of pods per plant, Biological yield, Grain yield, Harvest index.

Treatment	Plant Height (cm)	No. of Branches/plant	No. of Pods/plant	1000-seed wt.	Biological Yield (t ha ⁻¹)	Grain Yield (t ha ⁻¹)	Harvest Index
G ₁ : AARI soybean	44.66 b	5.93 b	21.06 b	183.00 b	3.96 b	1.3600 b	44.33
G ₂ : Faisal soybean	41.00 c	6.76 c	19.40 c	195.33 a	3.53 c	0.913 c	25.33
G ₃ : Rawal-1	22.66 g	4.37 g	13.96 g	140.00 c	0.95 g	0.570 g	22.33
G ₄ : NARC-21	25.33 f	5.46 f	17.40 d	150.00 c	1.23 f	0.630 f	51.33
G ₅ : SL-196	32.00 e	4.80 e	16.13 e	194.00 a	2.23e	0.733 e	32.33

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G ₆ : SL-171	37.00 d	5.06 d	15.13 f	141.33 c	3.22 d	0.830 d	25.33
G ₇ : UAF-Soya-1	54.00 a	8.86 a	23.86 a	200.67 a	5.29 a	1.980 a	53.33
LSD Value	2.138	2.0486	0.679	10.921	0.497	0.413	

DISCUSSION

Plant height is an important factor that describes the phenology and growth of crop because healthier, taller plants often enclose more pods and ultimately produce higher biological and grain output. UAF Soya-1 achieved superior plant height, indicating its robust growth performance and adaptability to high-pH soil. The climatic adaptability of UAF Soya-1 especially under lower temperatures conditions were observed during the winter sowing period might also played a pivotal role in its superior growth performance. Studies have shown that certain soybean varieties with enhanced climate resilience can maintain their physiological processes and growth even under cold conditions (Broun *et al.*, 2019). In contrast, Rawal-1' comparatively reduced plant height under similar conditions indicated a possible sensitivity to high pH soils and lower temperatures. This sensitivity could result in stunted growth and lower biomass accumulation, ultimately impacting the overall yield (Kumar & Singh, 2020). The number of branches-bearing pods has a major impact on seed production. It results from the combined effect of crops' genetic makeup and environmental conditions. These results were also in line with the findings of Khan *et al.* (2015), who concluded a significant difference in number of branches per plant among soybean genotypes. UAF-Soya-1 demonstrated the highest number of branches per plant, which suggests a robust branching capability that can contribute to a higher number of pods and consequently, higher seed yield. This can be attributed to the genetic makeup of UAF Soya-1 which is potentially more adaptable to high pH soil conditions, thus optimizing its growth and development. Studies have shown that certain soybean varieties with enhanced climate resilience can maintain their physiological processes and growth even under cold conditions (Broun *et al.*, 2019). One significant and noticeable factor that determines soybean production is the number of pods per plant. It determines the crop's potential yield as well as a contributing factor to yield. Leaves move quickly during bloom, which has a significant impact on pod placement. A higher contribution to soybean seed output is made by the filled pods per plant, as indicated by the close correlation between the two variables. The superior performance of UAF Soya 1 in terms of pod production could also be due to its genetic makeup, which might be more resilient to the stress factors associated with high pH soils. Studies have shown that certain soybean varieties have a better tolerance to soil alkalinity, which positively influences their reproductive growth stages. The results of this experiment were comparable to those of Khan *et al.*, 2015 who found a considerable variation in the number of pods per plant between genotypes of soybeans.

1000-seed weight is a key factor and primary goal of farming: Because seed yield is the primary objective for sowing the majority of crops, it is used to evaluate the

effectiveness of any treatment. The total amount of seeds produced per hectare depends on a variety of factors, including the crop's genetic potential, growth pace, number of grains per pod, seed weight, and availability of agronomic procedures, and environmental circumstances it must contend with during its whole growth cycle. Genetic variations in soybean genotypes may be the cause of variations in several yield-contributing characteristics (Ghadge and Kadu, 1993). These findings are comparable to those of Olewe (2014) and Saba *et al.* (2017), who found that there was a substantial variance in 1000 seed weights among genotypes of soybeans. Several factors could contribute to the superior performance of UAF Soya-1. Firstly, genetic makeup plays a pivotal role in determining seed size and weight. UAF Soya-1 might possess favorable alleles that enhance seed filling and weight. Secondly, environmental conditions, particularly soil pH, can significantly impact nutrient availability and uptake, influencing seed development (Kumar & Singh, 2020).

The biological yield of a crop is the entire amount of biomass it produces. It combines the yield of seeds and straw and depends on both the genetic makeup of the plant and the environment in which it is produced. It typically demonstrates plant performance as a whole and considerably raises crop seed output. It served as a measure of photosynthetic efficiency and demonstrated how well agricultural plants performed during vegetative development. These findings related to Olewe (2014) and Sava *et al.* (2017), who reported notable differences in biological yield amongst soybean genotypes. Higher biomass, or more pods and seeds per plant, is crucial for the future selection of high-yielding cultivars, according to Liu *et al.* (2005). UAF Soya-1 demonstrated the highest biological yield which suggests a robust branching capability that can contribute to a higher number of pods and consequently, higher seed yield. This can be attributed to the genetic makeup. UAF Soya-1's superior performance can be attributed to its enhanced climate resilience. Studies have demonstrated that this variety can thrive under low-temperature conditions, which are characteristic of winter sowing periods.

Seed yield is a key factor and primary goal of farming: Because seed yield is the primary objective for sowing the majority of crops, it is used to evaluate the effectiveness of any treatment. It is the function of combined effect of all the individual yield components and any change them may cause variation in yield. The total amount of seeds produced per hectare depends on a variety of factors, including the crop's genetic potential, growth pace, and number of grains per pod, seed weight, and availability of agronomic procedures, and environmental circumstances it must contend with during its whole growth cycle. All prevailing environmental circumstances during reproductive stages, especially strength and quality of solar radiations intercepted at canopy level are important factors which significantly affect all yield related attributes of soybean (Board and Harvill *et al.*, 1996). Moreover, notable variations in grain production among genotypes may be utilized to enhance distinct development and yield. UAF Soya-1 demonstrated the highest seed yield, which suggests a robust branching capability that can contribute to a higher number of pods and, consequently, higher seed yield. This can be attributed to the genetic makeup of UAF Soya-1, which is potentially more adaptable to high pH soil conditions, thus optimizing its growth and development.

AUTHORS 'CONTRIBUTIONS

Conceptualization: Haroon Zaman Khan, Anjum Naeem and Nasr Ullah Khan, **Field Experimentation, and Data Collection:** Manahil Iftikhar, Muhammad Nazir Khan and Marium Haroon, **Data Analysis:** Manahil Iftikhar and Marium Haroon, **Technical Assistance:** Abdul Majid and Sundas Batool, **Manuscript Drafting:** Nasr Ullah Khan, Anjum Naeem and Manahil Iftikhar. All authors read the manuscript before submission.

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