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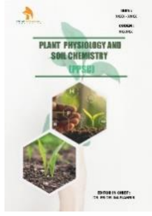
Plant Physiology and Soil Chemistry (PPSC)

DOI: http://doi.org/10.26480/ppsc.02.2023.82.85

ISSN: 2805-5063 (Online)
CODEN: PPSCCU



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RESEARCH ARTICLE

EFFECT OF MOISTURE ON SEEDLING STAGE OF SOYBEAN (*GLYCINE MAX*)

Rajesh Neupane[b], Sandip Panth[a*], Sabina Aryal[a], Bandana Khanal[c]

[a] Institute of Agriculture and Animal Science (IAAS), Kirtipur, Nepal
[b] Institute of Agriculture and Animal Science (IAAS), Khairahani, Chitwan, Nepal
[c] Institute of Agriculture and Animal Science (IAAS), Paklihawa, Bhairahawa, Nepal
Corresponding author email: panthsandip47@gmail.com

ARTICLE DETAILS

Article History:

Received 25 June 2023
Revised 12 July 2023
Accepted 17 August 2023
Available online 22 August 2023

ABSTRACT

The research was conducted at Rampur Campus, Khairahani, Nepal to analyze the effect of moisture on different soybean (*Glycine max*) genotypes under a partially controlled environment. The experiment was carried out in a Completely Randomized Design (CRD) with 16 distinct genotypes and 3 water levels (waterlogged, control and drought) as treatment and replicated with 3 times. Various parameters including germination percentage, plant mortality, plant height, number of leaves, and number of branches were measured at different stages of growth. The results showed that genotypes SBO122 and TGX1891116FN exhibited early germination with the highest germination percentage recorded at 5 days after sowing (DAS). TGX1891116FN showed the highest germination percentage of 100% at 15 DAS. However, the germination percentages were lower in other genotypes, which could be attributed to the lower temperatures during the research period. The mortality rate of soybean seedlings varied among genotypes and moisture treatments. Genotype CM9125 showed the highest mortality rate of 100%, followed by Puja and GC8234GC-13 with a mortality rate of 88.87%. Plant height was significantly affected by different genotypes and moisture treatments. Under normal conditions, genotype Puja exhibited the highest plant height at 20 DAS, while under waterlogging conditions, TGX1989-19F had the highest height. Drought conditions also affected plant height, with genotype GC8234GC13 showing the highest height at 30 DAS. These findings can contribute to the development of soybean varieties that are resistant to moisture stress and improve soybean production in Nepal.

KEYWORDS

Soybean, Waterlogging, Drought, Seedling Growth, Genotypes

1. INTRODUCTION

Glycine max, commonly known as soybean, is a widely cultivated legume species native to East Asia. It has been domesticated and cultivated for its edible bean, which has numerous uses such as soy milk, soy sauce, fermented bean paste, and tofu (Manandhar, 2021). Soybean is not only an important source of oil and protein worldwide but also contains vitamins B, C, and E, minerals, and dietary fibers. In addition to its culinary uses, soybean products are extensively utilized in animal feed, industrial applications, and as ingredients in meat and dairy substitutes (Singh and Krishnaswayi, 2022). In Nepal, soybean is often considered a secondary crop and is commonly intercropped with maize in the hilly regions. Maize and soybean are staple crops for food and feed in Nepal, and their intercropping practices help maintain soil fertility through symbiotic nitrogen fixation (Paudel, 2016).

However, there are a number of obstacles to soybean production, including abiotic stresses brought on by environmental elements such as salt, heavy metals, saltwater intrusion and drought (Deshmukh et al., 2014). Among these, waterlogging is a common abiotic stress during the monsoon season, leading to a loss of nearly 16% in soybean productivity worldwide. Waterlogging affects the early stages of soybean growth including emergence, cotyledon, and vegetative leaf stages (Adegoye et al., 2023). Genotypes with tolerance to pre-germination waterlogging can help the crop to withstand flooded conditions. Breeding for resistance to waterlogging during the early stages of soybean growth is limited however genotyping based on important characteristics and responses can help in the selection of tolerant cultivars (Sathi et al., 2022).

Reduction in germination percentage is a vulnerable response to pre-germination waterlogging. Developing soybean varieties resistant to moisture stress at any growth stage by exploiting the available genotypic variation is crucial for sustainable soybean production (Rajendran et al., 2019). The study focuses on understanding the impact of waterlogging on seedling growth and crop yield and identifying traits associated with waterlogging tolerance and exploring the potential of local germplasm to develop resistant varieties. By improving crop management practices, irrigation methods and adopting improved varieties the study aims to increase soybean production in Nepal and mitigate the negative effects of abiotic stresses on crop yields.

2. MATERIALS AND METHODS

2.1 Description of the Experimental Site

The experiment was conducted at the Laboratory of IAAS-Rampur Campus, Khairahani, Nepal. Geographical location of research site is 27° 37' 1.1424" N latitude and 84° 33' 57.963" E longitude at the altitude of 199 m above the sea level. The annual mean temperature in this research site is 24.9°Celcius.

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2.2 Experimental Design and Details

The research was conducted using a Completely Randomized Design (CRD) with 16 Genotypes and 3 water levels (Control, Draught, and Waterlogging) as treatments and replicated by three times. Ten seeds were sown per 15L plastic pot, filled with a potting mixture consisting of a 1:3 cocopeat to soil ratio. The treatments were randomly allocated and the three water levels were initiated 10 days after sowing in a random manner. Temperature and relative humidity inside the research facility were recorded using a digital thermometer.

2.3 Observations Recorded

Three plants per pot per replication were randomly selected and the observations were taken for following parameters.

2.3.1 Germination

Germination data was recorded from five days after sowing to fifteen days after sowing. The number of germinated seeds per pot was counted and the germination percentage was calculated using the following formula:

$$\text{Germination\%}=\left[\frac{\textit{Total germinated seeds}}{10}\right]*100\%$$

2.3.2 Mortality

Plant mortality percentage was determined to analyze the effect of treatment (moisture) on the genotype. It was calculated by comparing the number of plants per pot at 10 DAS (Days after Sowing) and 20 DAS. The formula below was used to compute the mortality percentage.

Mortality%= $(Ni-No)/Ni$

Where, Ni= Number of seedlings before treatment

No= Number of seedlings after treatment

2.3.3 Plant Height

Plant height was measured from 20 DAS to 40 DAS using a wooden scale at 5-day intervals. Three random plants per pot were selected, and their heights were measured. The data was averaged to calculate the mean height of the genotype from 20 to 40 DAS.

2.3.4 Number of Leaves

The total number of leaves present in each genotype from 30 DAS to 45 DAS were calculated. Three random plants per pot were selected and the number of leaves per plant were counted. The data was averaged to determine the total number of leaves per plant for each genotype from 30 to 45 DAS.

2.3.5 Number of Branches

The total number of branches present in each genotype was calculated. The number of branches per plant was counted on three randomly chosen plants from each pot. The data was averaged to determine the average number of branches per plant at 40 DAS.

2.3.6 Climatological Observation

Temperature and relative humidity throughout the research period were measured using a digital thermometer.

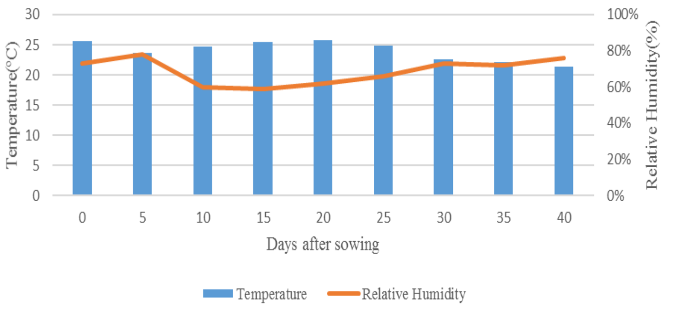

Figure 1: Temperature and Relative Humidity during the research period

2.3.7 Statistical analysis

Data entry and processing was carried out using Microsoft Excel and subsequent statistical analysis was done in R-studio.

3. Results and Discussion

3.1 Germination

Genotypes SBO122 and TGX1891116FN showed early germination, with the highest germination percentage recorded at 5 days after sowing (DAS). Both SBO122 and TGX1891116FN had a germination percentage of 20%, while all other genotypes showed germination percentages below 20% at 5 DAS. At 15 DAS, TGX1891116FN displayed 100% germination, which was the highest among all genotypes. Puja and Ankur genotypes followed closely with 90% germination at 15 DAS.

According to a group researchers freshly harvested soybeans do not require drying to achieve maximum viability and continue to develop normal seedlings (Miles et al., 1988). This aligns with the germination percentages observed in the study, where genotypes were able to germinate without the need for a desiccation period and showed early germination as early as 5 DAS.

Similar results were reported by indicating that the optimal temperature for soybean germination was 30°C and the germination rate decreased significantly on this temperature (Lamichhane et al., 2020). The study's average temperature was 23 °C, with maximum and minimum temperatures of 25.7 °C and 22.1 °C, respectively. Lower temperatures during seed germination and emergence can have a negative impact on germination.

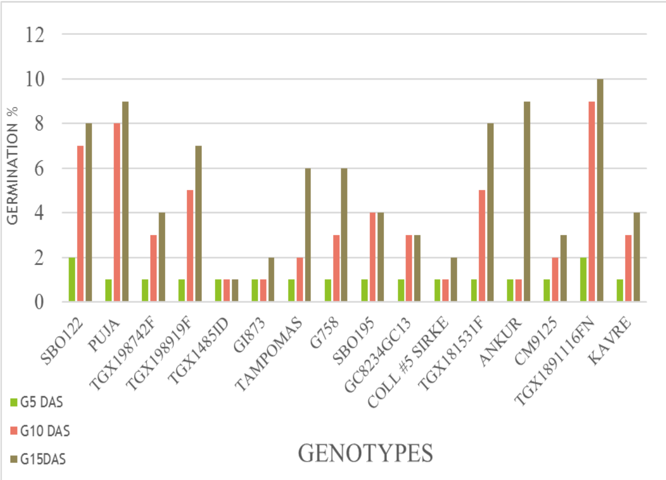

Figure 2: Germination percentage at 5,10, and 15 DAS.

3.2 Mortality

Plants exhibit visible responses when exposed to changes in their environment. In this study, the mortality rate of each genotype was calculated after introducing three different moisture levels. The initial number of plants was recorded before initiating the moisture treatments, and the number of surviving plants was counted after five and ten days of treatment to determine the mortality percentage for each genotype.

Genotype CM9125 showed the highest mortality rate of 100%, followed by genotypes Puja and GC8234GC-13 with a mortality rate of 88.87%. Moderate drought stress during the vegetative stages can have adverse effects on soybean plant growth, such as reduced plant height and seed yield. However, if this stress is alleviated during this period, soybean plants are likely to recover and compensate for the effects of water stress (Gajić et al., 2018).

A group researchers found in their previous research that soybean germination is rapid, with 50% germination achieved in just 17°C days under optimal conditions (Lamichhane et al., 2020). Minimum, optimum and maximum temperatures were determined at 4°C, 30°C, and 40°C, respectively. During the research period, the temperature was found to be within the range of the base and optimum temperatures, contributing to a higher percentage of germination.

However, water stress experienced during vegetative growth phase resulted in mortality of soybean seedlings. This finding aligns with the results of a study conducted by where higher seedling mortality was observed and attributed to prolonged waterlogging conditions lasting more than 14 days (Sathi et al., 2022).

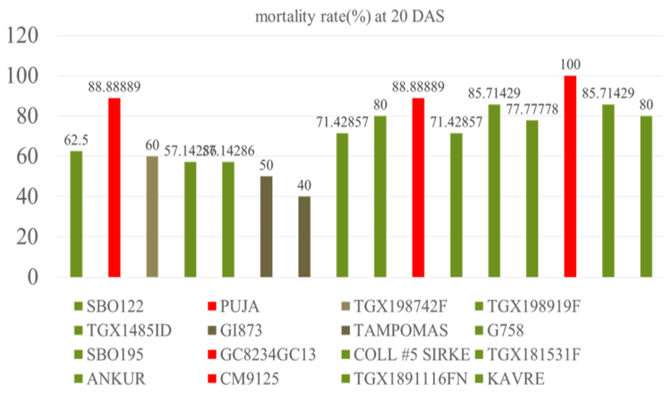

Figure 3: Mortality rate (%) at 20DAS

3.3 Plant Height

Plant height varied among different genotypes and water levels at 15, 20, 25, and 30 days after sowing (DAS). At 15 DAS, TAMPOMAS showed the greatest plant height of 34 cm in drought conditions, followed by Puja with a height of 32.67 cm in normal conditions. Waterlogging conditions reduced plant height at 15 DAS. TGX1989-19F had the highest plant height of 30.21 cm. TGX1891106FN had the lowest plant height at 7 cm.

At 20 DAS, Puja showed the highest plant height of 36.33 cm in normal conditions, followed by G758 with a mean height of 35.67 cm in the same conditions. Under drought conditions, TAMPOMAS had the highest height of 34 cm, while under waterlogging conditions, TGX1989-19F reached a height of 32 cm, followed by Puja at 31.67 cm. The lowest plant height at 20 DAS was observed in TAMPOMAS under waterlogged conditions at 12 cm. SBO122 exhibited the highest plant height of 43 cm at 25 DAS under irrigated conditions. At 30 DAS, SBO122 and TGX198919F had the highest heights of 47 cm under irrigated conditions. TGX198919F performed better in terms of height under waterlogged conditions, reaching a mean height of 34 cm at 25 DAS and 37 cm at 30 DAS. Under drought conditions, Puja had the highest plant height of 37 cm at 25 DAS, and GC8234GC13 had the highest height of 44 cm at 30 DAS.

The results are consistent with the findings of reported that moisture stress during vegetative growth period reduced plant height and other yield-related characteristics (Sathi et al., 2022). Water stress reduces number of shoots and stem height in soybean, as found by Desclaux, (Huynh and Roumet, 2000). Similar reductions in plant height due to water stress was also observed in cowpea (Aderolu, 2000). Water stress in this study resulted in decreased dry matter production, with the most significant reduction observed under vegetative stress followed by flowering stress. Plants with larger leaf area absorb more sunlight and produce greater amounts of dry matter through photosynthesis, resulting in higher seed yields.

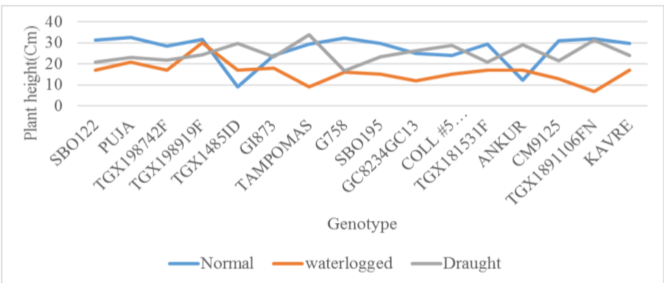

Figure 4: Plant Height at 15 DAS

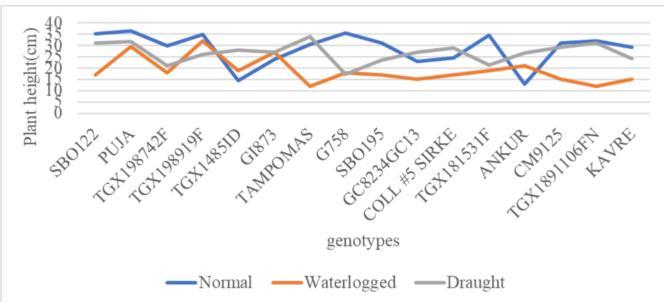

Figure 5: Plant height at 20 DAS

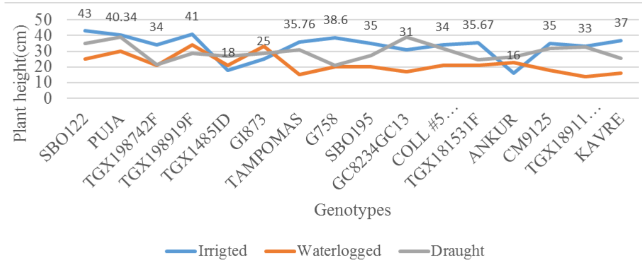

Figure 6: Plant height at 25DAS

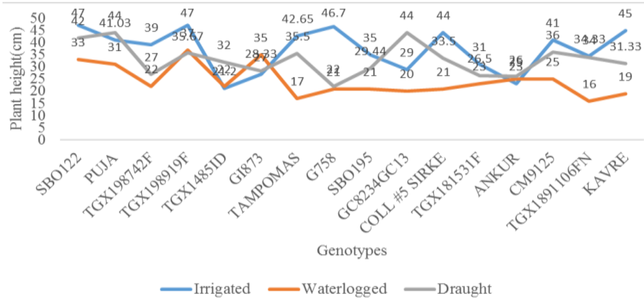

Figure 7: Plant height at 30DAS

3.4 Number of leaves

The number of trifoliate leaves per plant was measured at 35 and 40 days after sowing (DAS). CM9125 had maximum number of leaves per plant with 26 leaves under irrigated conditions at 35 DAS. Under waterlogged conditions, TGX198919F, TAMPOMAS, and SBO195 had the maximum number of leaves per plant, totaling 9 leaves. Under drought conditions, TGX1485ID recorded the maximum number of leaves per plant with 7 leaves at 35 DAS. TGX198742F, TGX198919F, G758, and CM9125 exhibited the maximum number of leaves per plant, totaling 27 leaves at 40 DAS. Under waterlogged conditions, TGX198919F, TAMPOMAS, and SBO195 showed the maximum number of leaves per plant, with 9 leaves. Puja performed relatively well under drought conditions, with 9 leaves per plant at 40 DAS.

When moisture stress occurred during the vegetative stage, the number of leaves produced was drastically reduced. This finding is consistent with previous studies by conducted on cowpea, maize and soybean showed that water stress affects leaf number by reducing leaf rate and leaf area (Aderolu, 2000; Abubakar, 2004; Stolf-Moreira et al., 2010). This ultimately leads to lower photosynthetic activity and reduced leaf growth, resulting in a reduced number of green leaves per plant.

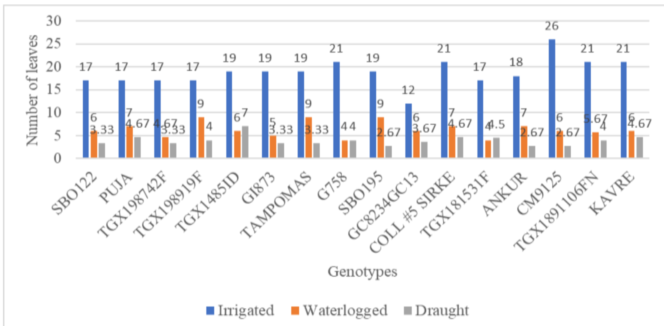

Figure 8: Number of leaves per plant at 35 DAS

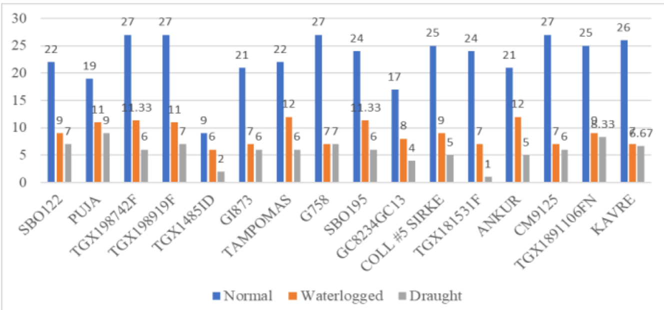

Figure 9: Number of leaves per plant at 40 DAS

Cite The Article: Rajesh Neupane, Sandip Panth, Sabina Aryal, Bandana Khanal (2023). Effect of Moisture on Seedling Stage of Soybean (*Glycine Max*). *Plant Physiology and Soil Chemistry, 3(2): 82-85.*

3.5 Number of branches per plant

The total number of branches per plant were counted and mean number of branches of each genotype under different moisture levels was calculated. TGX198919F and CM9125 had the highest mean number of branches per plant with 10 branches under irrigated conditions at 35 DAS. Under waterlogged conditions, TAMPOMAS, SBO195, ANKUR, TGX1891106 and KAVRE showed the highest mean number of branches with 4 branches. Similarly in drought conditions TGX198919F and G758 had highest mean number of branches of 3.33 branches at 35 DAS. At 40 DAS, TGX198919F had the highest mean number of branches per plant with 12 branches under irrigated conditions. TGX198742F showed the highest mean number of branches of 10 branches under waterlogged conditions and the same genotype had the highest number of branches with 7 branches under drought conditions.

Moisture stress during the vegetative stage significantly had reduced branch production, consistent with previous studies (Summerfield et al., 1976). A group researchers which reported a decrease in branching under water stress and waterlogging conditions on cowpea and soybean (Miura et al., 2012).

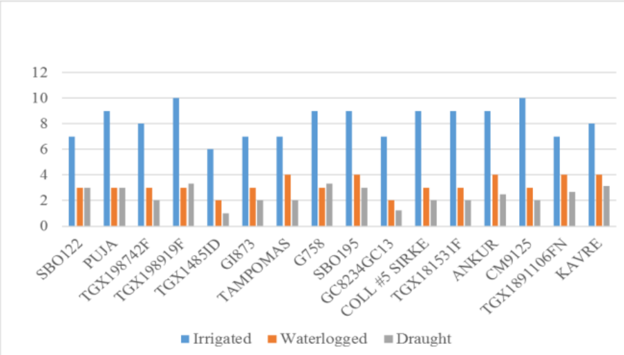

Figure 10: Number of branches per plant at 35 DAS

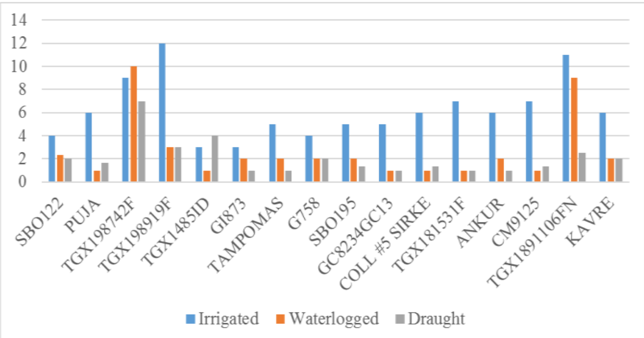

Figure 11: Number of Branches at 40DAS

4. Conclusion

The research was conducted at Rampur Campus, Khairahani, Nepal to analyze the effect of moisture on different soybean (*Glycine max*) genotypes under a partially controlled environment. The findings mentioned earlier lead to the conclusion that both waterlogging and drought conditions had a considerable negative impact on the growth and yield-related traits of all soybean genotypes when compared to adequately irrigated plants. Waterlogging during the vegetative growth stage led to reduced seedling growth and delayed crop maturation. Drought conditions during the vegetative growth stage caused plant shrinkage and stunted growth with reduced leaf number, leaf area and shorter plant height as adaptive responses. Among the 16 genotypes studied, TGX199819F, CM9125 and TGX1891106FN performed better under waterlogged conditions while TGX198742F, TAMPOMAS and TGX1485ID were found to be superior in terms of seedling growth to withstand drought stress.

Acknowledgments

The authors would like to acknowledge Assistant Professor Koshraj Upadhyay, Institute of Agriculture and Animal Science for his continuous support and guidance and also like to thank the staff of Rampur Campus, Khairahani for their assistance in conducting the research.

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