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# Efficiency and Impact of Superabsorbent Polymers (SAP) Hydrogels Application on Growth Performance of Soybean (*Glycine max*) During Water Deficit Conditions

Isma'ila Muhammad[1]*, Pindiga Maryam Abbaji[1], Muhammad Ahmad[1], Usman Abubakar Yuguda[1] and Faizu Abdulmumini[2]

[1]Department of Botany, Faculty of Science, Gombe State University, P.M.B 127, Tudun wada, Gombe, Nigeria.
[2]Department of Agricultural Technology, Federal College of Horticulture Dadinkowa, KM40 Gombe - Biu Rd, Dadin Kowa 762103, Borno, Nigeria.

*Corresponding author:
Isma'ila Muhammad
Department of Botany, Faculty of Science,
Gombe State University,
P.M.B 127, Tudun wada,
Gombe,
Nigeria.
Email: ismuha@gsu.edu.ng

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**ABSTRACT**

Water is becoming the most limiting factor for sustainable crop production. The application of superabsorbent polymer SAP hydrogel as a soil conditioner can improve soil natural environments, water retention and release capacity, nutrient use efficiencies and agricultural produce. This study aimed to determine the efficiency of different superabsorbent polymer rates on soybean growth performance. The superabsorbent polymer used in this study, 0 (Control), 5 g, 10 g and 15 g were mixed thoroughly with the loamy soil and used to fill the 10×10cm poly bags. The experiment was laid out in a Randomized Complete Block Design (RCBD) involving two soybean varieties: TGX- 1951-3F and TGX-448-2E, with four treatments and three replications. The results of this study indicate that, application of 5 g, 10 g and 15 g of super absorbent polymer resulted an increase in plant height, number of leaves, number of branches, stem girth, leaf area, and plant biomass studied as compared to the control 0 g which recorded lower mean performance. Similarly, it was evident from this study that the performance of the traits studied increased with an increase in the number of weeks after plant germination. This increase proves that SAP can improve crop cultivation, especially with pronounced climate change.

## INTRODUCTION

Soybean [*Glycine max* (L.) Merrill], is a specie of legume indigenous to East Asia, widely grown for its edible bean. Soybean was introduced to Africa from China in the late 19th century and is now widespread across the continent. It is an important oilseed crop in the world, belongs to the family of Leguminosae, with 2n=40 chromosome number. Due to high nutritional value and economic importance, it is recognized as a golden bean [1,2]. It is the cheapest source of protein and vegetable oil. Soybean contains about 40-42% high-quality protein, 18-20% oil with polyunsaturated fatty acid (Omega 6 and omega 3), balanced amino acid, 6-7% total mineral, 5-6% crude protein, and 17-19% carbohydrate [3]. It has been preferred especially by vegetarians on account of its richness in protein, fat, carbohydrates, minerals, salts and vitamins. It is eco-friendly legume grain grown for human nutrition and livestock feed around the globe. Soybean improves soil fertility and health, with atmospheric nitrogen fixation and deep root penetration. Soybean fixes 125-150 kg N ha-1and leaves about 30-40 kg N ha-1 for succeeding crops [4]. The low productivity in soybean cultivation is mainly due to insufficient soil moisture and the erratic distribution of rainfall experienced by global climate change. In dryland conditions prolonged dry spells are common during crop growth stages. To provide a solution to the problems of present dryland agriculture, water-saving materials need to be used. The application of superabsorbent polymers is essential for the sustainability of soil fertility and maximizing crop productivity in water scarceness conditions.

Drought stress is a principal factor that restricts crop growth and productivity, causing stomata to close and decreasing $CO_2$ intake and carbon fixation [5]. In the arid and semiarid climates of the world, water scarcity is a major environmental problem due to the low amount of rainfall with irregular spatial and temporal distribution, which seriously hampers the sustainability of agriculture [6]. Abiotic stresses (temperature, salinity, and drought) are the major factors affecting agriculture production,

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and these challenges are expected to worsen due to urbanization and land degradation. Similarly, irrigation water is becoming increasingly scarce, and the world is searching for agricultural practices that promote water use efficiency [7].

Hydrogel, popularly known as "root watering crystal," "water retention granules," or "raindrop," is a quasisolid-phase amorphous material that is regarded as one of the agricultural practices that promote water use efficiency in plants [8]. It has three-dimensional networks of loosely held cross-linked versatile hydrophilic macromolecules interconnected by covalent bonds or physical interactions with specially designed absorbency and biodegradability [9]. These are organic polymers and have a unique capability to absorb a large amount of moisture in their super absorbent structure within a short period when it comes in contact with freely available water. These materials desorb the stored moisture to the surrounding soil and rhizosphere zones during the soil drying process in a uniform manner over an extended period [10]. Having more available water in the soil helps avoid water stress during times of moisture scarcity, which occurs for a longer period [11,12].

As soya beans are an essential crop globally, there is a need to improve their tolerances to drought. Applying super absorbent polymer into the soil could be an effective way to increase the crop's water and nutrient use efficiency. The main objective of this study was to determine the efficiency of different superabsorbent polymer rates on soybean growth performance. This will go a long way in integrating this technique in improving the farming system amid challenges of erratic rainfall and drought stresses coupled with the impacts of climate change.

## MATERIALS AND METHODS

### Study Area

The experiment was conducted at the Botanical Garden of the Department of Botany Gombe State University, Gombe, Nigeria which is located between latitude 10°E 18' and longitude 11° 10' 36.43"E and has an altitude/elevation of 438-478 m above sea level. Similarly, it has a total land size of 270 square meters, which is equivalent to 2.7 hectares.

### Seed collection

The seeds of the two varieties of soybean namely; TGX- 1951-3F and TGX-448-2E used in this study were collected from Institute for Agricultural research (IAR) Ahmadu Bello University Zaria Kaduna state.

### Seed Viability test

The collected seeds were subjected to a viability test using the Floating Test Method. Seeds were put in a water basin and left undisturbed for 3mins. All suspended seeds were discarded and the sunken ones collected. Seeds that sunk were perceived to have had higher specific gravity due to more stored food reserve.

### Method of SAP application

The superabsorbent polymer used, 0 (Control), 5 g, 10 g and 15 g were mixed thoroughly with the loamy soil and used to fill the 10×10cm poly bags.

### Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) involving two varieties of soybean namely; TGX- 1951-3F and TGX-448-2E, four treatments and three replications. The plot size used was 4 m x 4 m and individual plots within a block were separated from each other by 50cm, while the blocks were separated from each other, by a distance of 1m. Inter-row, spacing was 30 cm whereas intra-row spacing was 20 cm. at planting four seeds were sown per stand at a depth of 3-5 cm and thinned to two plants per stand after germination.

### Cultural Practices

The field was cleared of all unwanted debris and labelled properly for easy arrangement and other agronomic practices. Weeds were manually thinned periodically throughout the period of the study. Watering/irrigation were done manually until throughout the period of the study.

### Parameters assessed

The parameters assessed include; Plant height, Number of leaves, Number of branches, Stem girth, Leaf area and plant biomass.

### Data Analysis

The data collected was subjected to analysis of variance (ANOVA) using 'genstat' means showing significant difference separated using LSD.

## RESULTS AND DISCUSSION

The result on the impact of SAP on plant height on selected soya bean varieties is presented in **Table 1**. The result of the analysis of variance (ANOVA) showed that there is highly significant difference ($P>0.05$) between the varieties used in this study except at two weeks after planting, which did not show any significant difference. However, there was no significant difference among the treatments observed except at four weeks which showed significant difference. Similarly, there was no interaction between the varieties by treatments.

The result on the mean plant height among the soybean varieties treated with SAP showed significant variation, the highest mean observed on TGX2E at two weeks was 12.35 (15 g) while the lowest mean observed was 3.17 (5 g) as compared to control which recorded 2.30 (0 g). Similarly, the highest mean observed at four weeks was 8.73 (10 g) while the lowest mean observed was 5.06 (5 g) against the control which recorded 3.28 respectively. At six weeks the highest mean recorded was 14.82 (15 g) while the lowest mean recorded was 8.14 (5 g) while control received 6.11 (0 g). Lastly, the highest mean observed at eight weeks after germination was 15.16 (10 g) while the lowest mean observed was 8.8 (5 g) as compared to control which recorded 6.11 (0 g) respectively.

The result on the mean plant height recorded in TGX3F treated with different levels of SAP showed significant variation; the highest mean observed at two weeks was 6.26 (10 g) while the lowest mean observed was 5.47 (15 g) against control which recorded 6.94 (0 g). Correspondingly, the highest mean observed four weeks after germination was 12.58 (10 g) while the lowest mean observed was 11.55 (5 g) compared to control, which recorded 9.94 respectively. Equally, six weeks after germination, the highest mean recorded was 19.28 (5 g), while the lowest mean recorded was 17.56 (5 g), and the control received 17.22 (0 g). Finally, at eight weeks after germination, the highest mean observed was 20.34 (10 g), while the lowest mean observed was 18.02 (15 g), which was against the control that recorded 16.46 (0 g).

**Table 1.** Showing the effect of superabsorbent polymer on mean plant height.

| Variety | Treatment | PHWK2 | PHWK4 | PHWK6 | PHWK8 |
|---|---|---|---|---|---|
| TGX2E | 0 g (Control) | 2.30±3.09 | 3.28±5.08 | 6.11±9.34 | 6.11±9.49 |
| | 5 g | 3.17±2.88 | 5.06±4.87 | 8.14±7.87 | 8.80±8.41 |
| | 10 g | 3.97±2.90 | 8.73±4.32 | 13.81±7.30 | 15.16±6.56 |
| | 15 g | 12.35±25.47 | 8.03±4.46 | 14.82±9.31 | 13.80±9.05 |
| TGX3F | Control | 6.94±3.16 | 9.94±4.38 | 17.22±7.70 | 16.46±7.43 |
| | 5 g | 6.25±3.73 | 11.55±5.04 | 19.28±9.39 | 19.46±9.11 |
| | 10 g | 6.26±2.88 | 12.58±3.91 | 17.56±6.05 | 20.34±6.76 |
| | 15 g | 5.47±3.49 | 11.61±4.55 | 19.20±6.28 | 18.02±7.86 |
| Variety | | 0.727 | 0.000 | 0.000 | 0.000 |
| Treatment | | 0.472 | 0.055 | 0.153 | 0.115 |
| Var×Trt | | 0.265 | 0.632 | 0.198 | 0.513 |
| Mean | | 5.84 | 8.85 | 14.77 | 14.77 |
| S.D | | 9.46 | 5.37 | 8.93 | 9.08 |

Note: PH: Plant height, WK: Week Var: Variety, Trt: Treatment

The result on the effect of SAP on the number of leaves among the soya bean varieties used in this study is presented in **Table 2**. The result showed that there is significant difference (P<0.05) between varieties and among the treatments except at eight weeks after germination which did not show any significant difference. There is no significant interaction between the varieties and treatments. The result on the mean number of leaves showed significant variation, the highest mean observed on TGX2E at two weeks was 5.77 (10 g), whereas the lowest mean observed was 3.11 (5 g) against the control that scored 2.55 (0 g) respectively. Also, the highest mean number of leaves observed four weeks after germination was 15.11 (10 g), whereas the lowest mean observed was 7.44 (5 g) compared to the control, which recorded 3.55.

The highest mean recorded at six weeks was 19.11 (15 g), whereas the lowest mean observed was 8.66 (5 g) against control which recorded 8.66 (0 g). Similarly, at eight weeks, the highest mean observed was 19.11 (15 g) while the lowest mean observed was 9.88 (5 g) as compared to control, which recorded 7.11 (0 g) respectively. In TGX3F variety, the result showed significant variation among the treatments. Two weeks after germination, the highest mean observed was 6.88 (10 g), whereas the lowest mean observed was 4.66 (5 g) compared to the control, which recorded 5.22 (0 g). Subsequently, the highest mean observed four weeks after germination was 22.66 (15 g), and the lowest mean observed was 10.88 (5 g) against the control, which was recorded at 8.66. Likewise, at six weeks after germination, the highest mean observed was 29.88 (10 g), while the lowest mean observed was 23.66 (5 g) when compared with the control that received 20.55 (0 g), respectively. Subsequently, the highest mean observed at eight weeks after germination was 19.88 (5 g) whereas the lowest mean observed was 17.22 (15 g) against control, which scored 15.66 (0 g) respectively.

**Table 2.** Effect of superabsorbent polymer on mean number of leaves.

| Variety | Treatment | NLW2 | NLW4 | NLW6 | NLW8 |
|---|---|---|---|---|---|
| TGX2E | Control | 2.55±3.39 | 3.55±5.47 | 7.11±11.63 | 7.11±11.30 |
| | 5 g | 3.11±2.71 | 7.44±7.12 | 8.66±9.04 | 9.88±9.77 |
| | 10 g | 5.77±3.15 | 15.11±9.67 | 16.44±8.14 | 15.00±8.03 |
| | 15 g | 5.33±3.70 | 14.22±9.44 | 19.11±13.09 | 19.11±12.06 |
| TGX3F | Control | 5.22±2.86 | 8.66±4.33 | 20.55±11.57 | 15.66±9.83 |
| | 5 g | 4.66±2.95 | 10.88±8.10 | 23.66±12.10 | 19.88±9.15 |
| | 10 g | 6.88±3.17 | 18.66±7.44 | 29.88±7.12 | 18.33±7.31 |
| | 15 g | 6.22±4.08 | 22.66±23.06 | 26.00±12.04 | 17.22±8.84 |
| Variety | | 0.049 | 0.048 | 0.000 | 0.019 |
| Treatment | | 0.053 | 0.002 | 0.057 | 0.219 |
| Var×Trt | | 0.853 | 0.890 | 0.753 | 0.265 |
| Mean | | 4.97 | 12.65 | 18.93 | 15.02 |
| S.D | | 3.41 | 11.83 | 13.74 | 10.14 |

Note: NL: number of leaves, W: Week Var: Variety, Trt: Treatment

The result of the mean number of branches on soya bean varieties treated with different rates of SAP is presented in **Table 3**. There is no significant difference (P>0.05) between the two varieties used except at two weeks after germination, which showed no significant variation. Similarly, therer was significant variation among the treatments except at two and eight weeks which no significant variation was observed. However, there was no significant interaction between the variety by treatment throughout the study period.

The result on the mean number of branches among the soybean varieties treated with SAP showed significant variation, the highest mean recorded on TGX2E at two weeks was 0.77 (10 g) whereas the lowest mean observed was 0.33 (5 g) when compared with the control that recorded 0.33 (0 g) respectively. Equally, the highest mean observed at four weeks was 4.22 (15 g) whereas the lowest mean recorded was 1.66 (5 g) compared to the control which scored 1.00. Similarly, at six weeks after germination, the highest mean recorded was 7.66 (15 g) while the lowest mean observed was 3.66 (5 g) against control which recorded 2.66 (0 g). Subsequently, at eight weeks after germination the highest mean recorded was 6.22 (15 g) whereas the lowest mean recorded was 2.88 (5 g) against control which recorded 2.11 (0 g) respectively.

Equally, the result on the mean number of branches recorded in TGX3F showed significant variation, the highest mean recorded at two weeks was 1.00 (15 g) while the lowest mean observed was 0.66 (5 g) as compared to the control which recorded 0.33 (0 g). Similarly, the highest mean observed four weeks after germination was 5.44 (5 g, 15 g) whereas the lowest mean observed was 5.00 (0 g) compared to the control, which recorded 3.66. Correspondingly, at six weeks after germination, the highest mean recorded was 7.66 (10 g, 15 g) while the lowest mean recorded was 6.88 (5 g) while control received 6.22 (0 g). At eight weeks after germination, the highest mean observed was 7.77 (10 g) and the lowest mean observed was 5.88 (5 g, 15 g) against control that recorded 5.11 (0 g), respectively.

**Table 3.** Effect of superabsorbent polymer on mean number of branches per plant.

| Variety | Treatment | NBWK2 | NBWK4 | NBWK6 | NBWK8 |
|---|---|---|---|---|---|
| TGX2E | Control | 0.33±0.50 | 1.00±1.50 | 2.66±4.35 | 2.11±4.01 |
| | 5 g | 0.33±0.50 | 1.66±1.73 | 3.66±3.77 | 2.88±3.01 |
| | 10 g | 0.77±0.66 | 3.77±1.92 | 6.77±3.89 | 4.66±2.50 |
| | 15 g | 0.66±0.86 | 4.22±2.72 | 7.66±4.55 | 6.22±3.92 |
| TGX3F | Control | 0.33±0.50 | 3.66±1.93 | 6.22±3.56 | 5.11±3.29 |
| | 5 g | 0.66±0.70 | 5.44±2.50 | 6.88±3.85 | 5.88±3.10 |
| | 10 g | 0.88±0.78 | 5.00±2.34 | 7.66±3.64 | 7.77±3.66 |
| | 15 g | 1.00±0.86 | 5.44±3.08 | 7.66±4.30 | 5.88±3.62 |
| Variety | | 0.236 | 0.000 | 0.047 | 0.008 |
| Treatment | | 0.079 | 0.009 | 0.056 | 0.067 |
| Var×Trt | | 0.852 | 0.270 | 0.471 | 0.360 |
| Mean | | 0.62 | 3.77 | 6.15 | 5.06 |
| S.D | | 0.70 | 2.67 | 4.21 | 3.68 |

Note: NB: number of branches, WK: Week Var: Variety, Trt: Treatment

The result for the effect of SAP on soya bean varieties on stem girth is presented in **Table 4.** The result showed significant difference (P>0.05) between varieties used in the study except at two weeks after germination. The result indicated that there was no significant difference among all the treatments used except four weeks after germination, and there was no significant interaction between the treatments and the variety. Mean stem girth among the soybean varieties treated with SAP showed significant variation, the highest mean observed on TGX2E at two weeks after germination was 0.88 (10 g) while the lowest mean observed was 0.68 (5 g) as compared to the control which recorded 0.48 (0 g).

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At four weeks after germination, the highest mean observed was 1.70 (5 g) while the lowest mean observed was 1.33 (10 g) against the control which scored 1.35. Also, at six weeks after germination the highest mean observed was 1.71 (15 g) while the lowest mean observed was 1.22 (5 g) as compared to control which recorded 0.63 (0 g). At eight weeks after germination the highest mean observed was 1.54 (15 g) while the lowest mean observed was 1.00 (5 g) against control which scored 0.66 (0 g) respectively. However, for TGX3F variety the highest mean stem girth recorded at two weeks after germination was 0.70 (15 g) whereas the lowest mean recorded was 0.64 (5 g) as compared to control which scored 0.73 (0 g).

Equally, the highest mean observed at four weeks after germination was 1.40 (15 g) while the lowest mean recorded was 0.77 (10 g) as compared to the control which recorded 0.57 (0 g) respectively. Subsequently, at six weeks after germination the highest mean observed was 2.20 (15 g) while the lowest mean recorded was 1.97 (10 g) against control which recorded 1.60 (0 g). Similarly, at eight weeks after germination the highest mean observed was 1.85 (10 g) and the lowest mean observed was 1.48 (15 g) as against control which recorded 1.44 (0 g) respectively.

**Table 4.** Showing the effect of superabsorbent polymer on mean stem girth.

| Variety | Treatment | SGWK2 | SGWK4 | SGWK6 | SGWK8 |
|---|---|---|---|---|---|
| TGX2E | Control | 0.48±0.58 | 1.35±0.60 | 0.63±0.95 | 0.66±1.02 |
| | 5 g | 0.68±0.58 | 1.70±0.31 | 1.22±3.1.18 | 1.00±0.96 |
| | 10 g | 0.88±0.47 | 1.33±0.56 | 1.71±3.0.70 | 1.54±0.66 |
| | 15 g | 0.76±0.45 | 1.62±0.29 | 1.28±0.77 | 1.40±0.83 |
| TGX3F | Control | 0.73±0.35 | 0.57±0.69 | 1.60±0.81 | 1.44±0.58 |
| | 5 g | 0.64±0.40 | 0.95±0.95 | 2.10±1.05 | 1.52±0.62 |
| | 10 g | 0.70±0.25 | 0.77±0.74 | 1.97±0.34 | 1.85±0.20 |
| | 15 g | 0.67±0.42 | 1.40±0.60 | 2.20±1.00 | 1.48±0.58 |
| Variety | | 0.856 | 0.000 | 0.001 | 0.016 |
| Treatment | | 0.657 | 0.045 | 0.074 | 0.062 |
| Var×Trt | | 0.521 | 0.535 | 0.607 | 0.532 |
| Mean | | 0.69 | 1.21 | 1.59 | 1.36 |
| S.D | | 0.44 | 0.70 | 0.97 | 0.77 |

Note: SG: stem girth, WK: Week Var: Variety, Trt: Treatment

The result on leaf area in two soya bean varieties treated with different SAP concentration is presented in **Table 5**. There is significant difference ($P<0.05$) between varieties except at two and six weeks. Similarly, there is no significant interaction between the treatments and variety by treatment except at six weeks after germination which showed significant variation among the treatments. TGX2E variety recorded highest mean leaf area (15 g) at two weeks after germination while the lowest mean observed was 2.98 (5 g) against control which scored 5.09 (0 g). Similarly, at four weeks after germination, the highest mean observed was 4.79 (15 g) while the lowest mean observed was 2.98 (5 g) against the control which scored 4.42.

Furthermore, at six weeks after germination the highest mean observed was 16.95 (10 g) whereas the lowest mean observed was 11.36 (5 g) against control which recorded 11.18 (0 g) respectively. Subsequently, for TGX3F variety the highest mean leaf area recorded at two weeks after germination was 2.61 (15 g) whereas the lowest mean recorded was 1.27 (5 g) as against control which scored 2.63 (0 g). Similarly, the highest mean observed at four weeks after germination was 2.61 (15 g) whereas the lowest mean observed was 1.27 (5 g) as compared to the control which scored 2.63 (0 g) respectively. Consequently, at six weeks after germination the highest mean observed was 27.63 (10 g) whereas the lowest mean scored was 16.61 (5 g) against control which recorded 8.60 (0 g). respectively.

**Table 5**. Effect of superabsorbent polymer on mean leaf area studied.

| Variety | Treatment | LAWK2 | LAWK4 | LAWK6 |
|---|---|---|---|---|
| TGX2E | Control | 5.09±6.55 | 4.42±6.75 | 11.18±8.89 |
| | 5 g | 2.98±3.78 | 2.98±3.78 | 11.36±12.61 |
| | 10 g | 3.22±2.03 | 3.22±2.03 | 16.95±14.46 |
| | 15 g | 4.72±6.65 | 4.79±6.65 | 13.47±15.40 |
| TGX3F | Control | 2.63±2.37 | 2.63±2.37 | 8.60±6.74 |
| | 5 g | 1.27±1.55 | 1.27±1.55 | 16.61±10.11 |
| | 10 g | 2.16±2.10 | 2.16±2.16 | 27.63±13.30 |
| | 15 g | 2.61±2.22 | 2.61±2.22 | 22.04±11.46 |
| Variety | | 0.052 | 0.073 | 0.056 |
| Treatment | | 0.507 | 0.599 | 0.020 |
| Var×Trt | | 0.956 | 0.984 | 0.369 |
| Mean | | 3.09 | 3.00 | 15.98 |
| S.D | | 3.91 | 3.92 | 12.80 |

Note: LA: leaf area, WK: Week Var: Variety, Trt: Treatment

The result on the impact of SAP on Biomass between the two soya bean varieties is presented in **Table 6**. The results indicated highly significant difference in all the traits studied except root dry weight, which showed no significant variation. In TGX2E the highest mean fresh shoot weight recorded was 1.45 (15 g) while the lowest mean recorded was 0.61 (5 g) as compared to control which observed 1.31 (0 g). Similarly, the highest mean shoot dry weight recorded was 0.99 (15 g) whereas as the lowest mean observed was 0.44 (5 g) against the control which scored 0.36 (0 g) respectively. Similarly, for root fresh weight the highest mean observed was 0.64 (15 g) while the lowest mean observed was 0.24 (5 g,10 g) against control, which received 0.29.

Equally, for root dry weight, the highest mean observed was 0.30 while the lowest mean observed was 0.16 when compared with the control, which recorded 0.18 respectively. Subsequently, In TGX3F, the highest mean fresh shoot weight observed was 2.30 (5 g), while the lowest mean recorded was 1.48 (10 g) against control, which scored 1.81 (0 g). Also, the highest mean shoot dry weight recorded was 1.54 (15 g), while the lowest mean recorded was 1.06 (10 g) against the control, which scored 1.16 (0 g). Correspondingly, the highest mean observed for root fresh weight was 1.07 (10 g), while the lowest mean observed was 0.62 (15 g) against control, which received 0.79. Similarly, for root dry weight the highest mean observed was 2.87, whereas the lowest mean observed was 0.32 as compared to the control which recorded 0.47 respectively.

**Table 6.** Showing the effect of superabsorbent polymer on mean plant biomass.

| Variety | Treatment | FSW | DSW | FRW | DRW |
|---|---|---|---|---|---|
| TGX2E | Control | 1.31±2.34 | 0.36±0.62 | 0.29±0.48 | 0.18±0.29 |
| | 5 g | 0.61±0.94 | 0.44±0.76 | 0.24±0.42 | 0.16±0.30 |
| | 10 g | 0.69±0.88 | 0.45±0.65 | 0.24±0.32 | 0.18±0.28 |
| | 15 g | 1.45±1.83 | 0.99±1.21 | 0.64±0.48 | 0.30±0.21 |
| TGX3F | Control | 1.81±1.50 | 1.16±1.00 | 0.79±0.66 | 0.47±0.30 |
| | 5 g | 2.30±2.76 | 1.42±1.29 | 0.95±0.81 | 2.87±6.49 |
| | 10 g | 1.48±1.02 | 1.06±0.79 | 1.07±1.17 | 0.77±0.85 |
| | 15 g | 2.27±1.91 | 1.54±1.06 | 0.62±0.58 | 0.32±0.27 |
| Variety | | 0.026 | 0.002 | 0.002 | 0.104 |
| Treatment | | 0.627 | 0.347 | 0.954 | 0.355 |
| Var×Trt | | 0.768 | 0.910 | 0.243 | 0.299 |
| Mean | | 1.49 | 0.93 | 0.61 | 0.66 |
| S.D | | 1.78 | 1.00 | 0.70 | 2.37 |

## DISCUSSION

Super absorbent polymers have been used as water-retaining material in agriculture because they can retain large quantities of water and nutrients when incorporated into soil.

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These stored water and nutrients are released slowly as required by the crop to improve growth under limited water supply [13]. [14] Suggested that hydrogel amendment enhances the efficiency of water uptake and utilization of photosynthetic plants grown in soils with water contents close to field capacity. The outcome of this study was similar to the work of [15] where the researchers found out that using SAPs resulted in higher soybean yields compared to a control treatment, and the plants had higher water use efficiency. The researchers attributed this to improved soil water retention and availability for the plants. Similar result was also reported by [16], who reported that the application of SAP is a good approach for enhancing the efficiency of plant water retention and is beneficial in soil moisture conservation.

The results of this study indicated that all parameters studied showed significant responses among all SAP treatment concentrations used when compared with the control. This finding agrees with the work of [17] who studied the effect of SAPs on Zea mays under rainfed conditions and reported that a significant decrease in percolation water quantity is linked with the increase in the soil water storage of SAP treatment. The results revealed that plant growth parameters such as Plant height, leaf area, number of branches and biomass were statistically higher in week four to week eight of the experiment. This is in conformity with the work of [18,19].

Amendment of the soil used with different SAPs concentration has brought about a tremendous progressive impact on the growth parameters in soybean i.e., plant height, number of leaves, number of branches, stem girth, shoot and roots fresh and dry weight. These results consistent with those reported by [20,21,22] on Olive trees and corn plants grown in an arid and semiarid environment in the green house. Therefore, SAPs seem to be appropriate soil conditioners over a wide range of climate and environmental conditions. It has been observed that the application of super absorbent polymers under different water gradients significantly increased the number of leaves, number of branches, and shoot and root biomass compared to the control [23]. Hydrogel has been suggested to improve plant growth and significantly increase shoot and root biomass relative to the control [24]. Additionally, 1% hydrogel has been reported to exhibit superiority in all growth and yield attributes of dry rice, producing the tallest plants and the highest number of tillers [25]. The research result is also similar to the study conducted by [26], in which the researchers also found that using SAP has improved soybeans' growth performance and yield under drought conditions. The researchers attributed this to increased soil water retention and plant availability.

## CONCLUSION

Superabsorbent polymer (Hydrogel) technique is a new concept for water saving, which is recognized to have the maximum water and nutrient saving potentials. This technique may be converted to a practically useful and major technology in water-stressed regions to assist in yield increment in crop production and in improving soil moisture contents. The findings of this study clearly indicated that the application of superabsorbent polymer (Hydrogel) on Soybean under different watering regimes has led to the production of healthy plant with good quality; being eco-friendly, it has demonstrated better performance in all the parameters used. The use of super absorbent polymer can be beneficial in soybean cultivation, particularly in regions where water availability is limited or irrigation systems are inefficient.

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