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Research Article

Contribution of Superabsorbent Polymers to Growth and Yield of African Leafy Vegetables

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Superabsorbent polymers (SAPs) have been used as water-saving materials for limited irrigation water resources in arid and semi-arid areas. The purpose of this study was to optimize SAP application dosage and irrigation intervals on the growth of African leafy vegetables (ALVs) under greenhouse conditions. A factorial experiment was conducted under greenhouse conditions to determine the optimal SAP application, dosage, and irrigation intervals for the growth and production of African leafy vegetables. Two species of African leafy vegetables were studied: cowpea (*Vigna unguiculata*) and African nightshade (*Solanum scabrum*). The experiment was performed in a randomized complete block design comprising 25 treatments: a factorial combination of five superabsorbent polymer application doses (0 g, 0.5 g, 1 g, 1.5 g, and 2 g) SAP/Kg of soil substrate and five irrigation intervals (3 days, 4 days, 5 days, 6 days, and 7 days) with three replications. Statistical analysis of the results showed that the use of SAP in irrigation can significantly promote the growth and yield of African leafy vegetables. SAP, irrigation, and their interactions significantly affected ($P < 0.005$) the plant height, stem diameter, leaf area, number of mature leaves/plant, and dry weight of leafy vegetables. Treatment with SAP showed higher growth parameters and yield of vegetables compared to the treatments. Treatment with 1 g SAP/kg of soil substrate and 5-day irrigation interval recorded the highest plant growth and yield, with 24%, 11.7%, 11.1%, and 85.9% increase in cowpea plant height, leaf area, number of mature leaves, and dry weight/plant, respectively. The treatment with 1 g SAP/kg of soil substrate and 5-day irrigation interval was observed as the best for the optimal production of African leafy vegetables under greenhouse conditions. Hence, SAP could be a good strategy for food production within arid and semi-arid lands where water resources are scarce.

1. Introduction

Water scarcity has been a global crisis over the years due to the decline of annual rainfall levels and overexploitation of renewable water resources [1]. Effects of climate change coupled with the increasing water demand from the rapidly growing population have escalated the water scarcity impacts experienced all over the world. Irrigated agriculture has been one of the coping strategies towards food security. However, the water available for irrigation is limited and therefore inadequate to meet the irrigation needs for crop growth, especially within arid and semi-arid areas. Superabsorbent polymers (SAP) have been used to conserve the available irrigation water resources in arid and semi-arid areas worldwide [2].

Superabsorbent polymers are cross-linked hydrophilic networks that can absorb and retain 1000 times more water than their original size and weight [3–5]. SAPs are synthetic macromolecular materials that have high affinity and accumulation of water up to 100% of their own weight through osmosis process [6]. Superabsorbent polymers can store a lot of water in the hydrophilic networks owing to their high swelling capacity [5]. Most SAPs are commonly produced from acrylic acid, its salts, and acrylamide through solution or inverse suspension polymerization processes. They are mostly made from the polymerization of acrylic acid blended with sodium hydroxide in the presence of an initiator to form a poly-acrylic acid and sodium salt, which is also referred to as cross-linked sodium polyacrylate [7]. SAPs are classified into two main categories, synthetic like petrochemical-based and natural—including polysaccharide and polypeptide-based SAPs, and come in different forms including granules, balls, and beads with varying sizes varying from coarse powder to marbles [8]. For this research, polysaccharide-based SAP granules were used.

SAPs have a wide range of applications including agriculture, medicine, disposable diapers, feminine napkins, and cosmetic due to their water absorption and retention capacity [9]. In irrigation, superabsorbent polymers are used as water-saving materials and soil conditioners that absorb and retain water supply and release water slowly around the root zone on demand. They are used to reduce the loss of soil water and increase crop yield [10]. SAPs are mostly used within the arid and semi-arid areas of the world to control water shortage issue [11].

SAPs enhance soil nutrient retention and water-holding capacity, thus increasing irrigation water use efficiency [12–15]. Reference [16] concluded that the use of SAP in arid and semi-arid regions can enhance soil properties and increases soil water-holding capacity and soil water retention, thus improving irrigation efficiency, increasing crop growth, and increasing water productivity of the crop. Reference [17] indicated that the use of SAP in light soils could increase its soil water-holding capacity. Reference [1] concluded that using an adequate amount of superabsorbent polymer increases the yield of tomato in both deficit and full irrigation conditions. Moreover, Ref. [9] indicated increased soil moisture retention capacity and crop's growth parameters with increased SAP application, and the best results were as a result of the combination of the highest SAP doses and the highest watering capacity. Reference [18] reported that SAP and irrigation levels have a significant effect on the available soil moisture, high doses of SAP resulted in the highest water use efficiency, and SAP application increased crop yields. With the recent massive adoption of using SAP in irrigation, there is no clear data on the right dosage for optimal growth and production of crops.

African leafy vegetables (ALVs) are known for their superior nutritional value; they are rich in vitamins, minerals, and trace elements. References [19, 20] stated that ALVs are rich in numerous amounts of health-promoting compounds that help in fighting against infectious diseases and maintenance of good health. African nightshade leaves comprise 4.6 g protein, 442 mg calcium, 12 mg iron, 8.8 mg vitamin A, and 131 mg vitamin C per 100 g of fresh weight. Cowpea contains 4.7 g protein, 152 mg calcium, 39 mg iron, 5.7 mg vitamin A, and 57 mg vitamin C per 100 g of fresh weight [21]. However, despite the known benefits of African leafy vegetables and the increased campaigns towards their consumption, data on their irrigation water requirements and irrigation scheduling are still scanty or not available. This article focuses on the optimization of superabsorbent polymers and irrigation intervals on the growth and yield of African leafy vegetables (ALVs) under greenhouse conditions.

2. Methods and Materials

2.1. Experimental Design. The study was conducted in a greenhouse within Green Fingers Farm, located at latitude 1°21′ 29.1″ south and longitude 38°01′16.7″ east, in the years 2020 and 2021. The study was carried out as a factorial experiment in a randomized complete block design (RCB) comprising 25 treatments. The 25 treatments were a factorial combination of five SAP application levels (0 g/pot (S_1), 1.5 g/pot (S_2), 3 g/pot (S_3), 4.5 g/pot (S_4), and 6.0 g/pot (S_5) concentrations of SAP) and five irrigation intervals (three days (I_1), four days (I_2), five days (I_3), six days (I_4), and seven days (I_5)). Each treatment was done in three replicates, and each replicate consisted of one pot. SAP used was polysaccharide-based SAP in form of granules. The African leafy vegetables (ALVs) studied were cowpea (*Vigna unguiculata)* and African nightshade (*Solanum scabrum)*. Each pot contained three (3) kilograms of soil substrate prepared by mixing soil and chicken manure in the ratio of 3 : 1, and SAP granule doses according to the experimental design. Based on the number of treatments and their corresponding replicates, 150 planting pots were used for the experiment. The drip irrigation method was used as the irrigation water application technique for the project. The project's experimental design is presented in Table 1.

Note. S—SAP. I—irrigation frequency. $_C$—Cowpea. $_N$—African nightshade.

2.2. Soil Study. Three (3) soil samples were randomly collected from three (3) different locations inside and outside the greenhouse and from a depth of 0–20 cm and taken to the lab for physical and chemical quality analysis. Soil analysis was carried out for its classification, pF, saturated hydraulic conductivity (Ksat), and chemical composition. The soils were air-dried for 48 hrs, and crushed and sieved through a 2-mm sieve before lab analysis. Potassium (K) and sodium (Na) levels were determined by leachates using flame photometer (Na and K), whereas calcium (Ca) and magnesium (Mg) by atomic absorption spectrophotometer (Ca and Mg). Electrical conductivity (EC) was done using a conductivity bridge meter. The nitrogen (N) level in the soil is measured by using the Kjeldahl method [22]. Phosphorus (P) was extracted using the Olsen method, and the soil texture was determined using the Bouyoucos hydrometer method [23].

2.3. Crops' Management. The pots were filled with equal volumes of sandy clay loam soil substrate (3 kilograms) prepared by mixing soil and chicken manure in the ratio of 3 : 1. SAP concentrations were applied to each pot accordingly and mixed with the soil substrate properly and the pots arranged in the greenhouse accordingly and appropriately with a spacing of 40 cm along the rows. Planting for both vegetables was performed by direct sowing in the prepared pots. The drip irrigation method was used as the irrigation water application technique for the study. Irrigation operation was carried out each day in different irrigation intervals of 3, 4, 5, 6, and 7 days based on the experimental design. Five seeds of cowpeas were planted per pot. Irrigation was applied uniformly to the treatments on the planting date for the vegetables and varied thereafter according to the irrigation interval treatments. Thinning was performed 14 days after sowing to maintain three (3) plants

Table 1: Field layout of the experimental design.

		IRRIGATION LEVELS				
		I_1(3 days)	I_2 (4 days)	I_3 (5 days)	I_4 (6 days)	I_5 (7 days)
SAP DOSAGE LEVELS	S_1 (0 g/Pot)	S_1I_1C	S_1I_2C	S_1I_3C	S_1I_4C	S_1I_5C
		S_1I_1N	S_1I_2N	S_1I_3N	S_1I_4N	S_1I_5N
	S_2 (1.5 g/Pot)	S_2I_1C	S_2I_2C	S_2I_3C	S_2I_4C	S_2I_5C
		S_2I_1N	S_2I_2N	S_2I_3N	S_2I_4N	S_2I_5N
	S_3 (3 g/Pot)	S_3I_1C	S_3I_2C	S_3I_3C	S_3I_4C	S_3I_5C
		S_3I_1N	S_3I_2N	S_3I_3N	S_3I_4N	S_3I_5N
	S_4 (4.5 g/Pot)	S_4I_1C	S_4I_2C	S_4I_3C	S_4I_4C	S_4I_5C
		S_4I_1N	S_4I_2N	S_4I_3N	S_4I_4N	S_4I_5N
	S_5 (6 g/Pot)	S_5I_1C	S_5I_2C	S_5I_3C	S_5I_4C	S_5I_5C
		S_5I_1N	S_5I_2N	S_5I_3N	S_5I_4N	S_5I_5N

Key :

Cowpea Treatment

African nightshade Treatment

Note:

S - SAP

I - Irrigation Frequency

C - Cowpea

N - African nightshade

per pot for cowpeas, whereas for African nightshade, thinning was performed 30 days after sowing to maintain four (4) plants per pot.

2.4. Data Collection. The key crops' growth parameters studied included the height of the plant, diameter of the stem, number of mature leaves per plant, and mature leaf area. Two plants per pot were randomly identified and marked for monitoring. Measurements of the key crops' growth parameters were carried out on the identified plants once a week over the growth period. The plant height was measured from the plant base to the apex using a tape measure, whereas the diameter of the stem was measured at the plant base using a Vernier caliper. The number of mature leaves per plant was determined by physically counting the leaves. The leaf area was determined by measuring the longest point (length) and the broadest point (width) of the leaf using tape measure [24]. Leaf area (A) was estimated using the following equation:

$$A_L = L \times W, \quad (1)$$

where A_L is the leaf area (m^2), L length (m), and W width (m).

The number of leaves, size of the leaves, plant height, and diameter were monitored once every seven days on each pot for 5 weeks (starting at 5 weeks after planting for African nightshade and at 2 weeks after planting for cowpeas).

Harvesting of African nightshade was performed at 13 weeks from planting by removing the whole plant from the pots. Harvesting of cowpeas was performed in two states: wet state and dry state. For the wet state, harvesting was performed at 12 weeks from planting by removing the whole plant from the pots, whereas the dry state (when the pods and the entire plant were dry) harvesting was performed at 13 weeks from planting by plucking the dry pods. Weights in the wet state for the entire plant, leaves, and pods were measured after harvesting using a weighing scale.

The harvest was oven-dried at a temperature of 50°C in the Food and Processing Laboratory in the Department of Environmental and Biosystems Engineering, University of Nairobi. After drying, the weight in the dry state of the leaves and pods was also measured using a weighing scale. The number of pods per plant and seeds per plant were also counted.

3. Results and Discussions

3.1. Soil Analysis. The soils are classified as sandy clay loam with neutral pH values ranging from 6.70 to 6.86 as presented in Table 2. This range of soil pH is recommended for irrigation as it is considered to have the maximum availability of most macronutrients that are essential for plant growth and yield [25]. The soils showed low total nitrogen percentage of less than 0.2%. Chicken manure was added to the soil to fix low nitrogen percentage. The addition of chicken manure to the soil increases the level of nitrogen and potassium nutrients [26]. Organic carbon is a measure of soil organic matter and is very important in agricultural soils. The recommended range for soil organic carbon percentage is 2.5 to 4%. The soils showed low to moderate percentage of organic carbon ranging from 1.3% to 1.5%. However, the addition of chicken manure also increases the levels of organic carbon in the soil. Phosphorous and potassium contents were ranging from 75.2 to 82.8 ppm, and 0.2 to 0.38 cmol/kg soil, respectively. This is considered sufficient for plant growth.

3.2. Statistical Analysis. Statistical analysis of variance (ANOVA) of the results was performed at 95% confidence interval using Microsoft Excel 2016. Two-way ANOVA with three replications was used to assess the effect of superabsorbent

Table 2: Physico-chemical properties of soil.

Site	pH (H_2O)	%N	%O.C.	K (cmol/kg)	P (ppm)	EC (ds/m)	Bulk density (g/cm^3)	Porosity	K_{Sat} (cm/hr)
1	6.86	0.09	1.31	0.38	75.2	0.14	1.40	47.3	3.82
2	6.70	0.16	1.50	0.20	80.5	0.18	1.43	46.1	3.47
3	6.78	0.12	1.40	0.26	82.8	0.14	1.46	45.0	3.15

polymer (SAP) on growth parameters and yield of ALVs for different SAP levels and irrigation frequencies. The statistical analysis indicated that the effect of various levels of superabsorbent polymer and irrigation frequencies were significant for African leafy vegetables' plant height, stem diameter, leaf size, number of leaves per plant, and yield.

3.3. Effect of Superabsorbent Polymers on ALVs' Growth Parameters

3.3.1. Cowpea. For cowpea, significant effects of superabsorbent polymers, irrigation, and their interactions ($P < 0.05$) on plant height, stem diameter, and number of mature leaves are observed as shown in Table 3. However, there were no significant effects ($P > 0.05$) of superabsorbent polymers and irrigation on leaf area. Irrigation frequency had higher significant effects ($P < 0.05$) on the vegetable's plant height, stem diameter, and number of mature leaves. A significant interaction effect of the interaction of SAP and irrigation interval on plant height and the number of mature leaves was also observed.

High significant effect of SAP, irrigation, and their interaction ($P < 0.05$) on plant height, leaf area, and number of mature leaves was recorded in the first 21 days from emergence as presented in Table 4.

Under S_1 (no SAP) treatment, the highest cowpea plant height, stem diameter, leaf area, and number of mature leaves per plant were 53.6 cm, 2.5 cm, 0.94 cm^2, and 9, respectively, whereas for S_2 treatment, the highest plant height, stem diameter, leaf area, and number of mature leaves per plant were 57.9 cm, 2.4 cm, 0.98 cm^2, and 10, respectively. Under S_3 treatment, the highest plant height, stem diameter, leaf area, and number of mature leaves per plant were 66.7 cm, 2.5 cm, 1.05 cm^2, and 10, respectively. For S_4 treatment, the highest plant height, stem diameter, leaf area, and number of mature leaves per plant were 57.3 cm, 2.5 cm, 0.99 cm^2, and 10, respectively, and for S_5 treatment, the highest plant height, stem diameter, leaf area, and number of mature leaves per plant were 52.2 cm, 2.5 cm, 0.89 cm^2, and 10, respectively. The highest cowpea plant height, plant stem diameter, and leaf area were recorded under treatment S_3I_3 (3 g of SAP per pot and 5-day irrigation interval) as presented in Figure 1. The lowest cowpea plant height, plant stem diameter, leaf area, and number of mature leaves per plant were recorded under treatment S_1I_1. The difference between all treatments with SAP and the treatments without SAP is significant. Treatments with varying doses of SAP recorded higher growth parameters compared to the treatments without SAP. This means that superabsorbent polymers promote crop growth and development as discussed in Ref. [27]. For optimal crop production, SAP application dosage should be up to an optimal level. Excessive superabsorbent polymer application dosage can lead to soil water logging, hence stunted growth and low yields.

3.3.2. African Nightshade. There were no significant effects of SAP, irrigation, and the interaction of SAP and irrigation ($P > 0.05$) on plant height. Irrigation showed high significance ($P < 0.05$) on stem diameter, leaf area, and number of mature leaves per plant as presented in Table 5. However, like cowpea, high significant effects of SAP, irrigation, and their interaction ($P < 0.05$) on plant height, leaf area, stem diameter, and number of mature leaves were recorded in the first 21 days from emergence.

Significant difference between all treatments with SAP and the treatments without SAP was recorded for African nightshade growth. The highest plant height, stem diameter, leaf area, and number of mature leaves per plant were recorded under Treatment S_3I_3 (3g of SAP per pot and 5-day irrigation interval) as 51 cm, 2.7 cm, 1.92 cm^2, and 16, respectively. The lowest were recorded under S_1I_1 treatment as 34.6 cm, 2.4 cm, 1.52 cm^2, and 10, respectively, as shown in Figure 2.

The results showed that an interaction of SAP application and irrigation can promote the growth of vegetables. This agreed with the study of Ref. [15], which indicated that the application of SAP increases plant height, leaf area index, and dry matter. In all irrigation intervals, the application of SAP enhanced plant vegetative growth parameters including height, stem diameter, leaf area, and number of mature leaves per plant. SAPs enhance the water- and nutrient-holding capacity of soil lending them continuously available at the root zone for optimal absorption by plants, hence better plant performance. Superabsorbent polymers increase plant height [28], as indicated in the results of this research.

3.4. Effect of Superabsorbent Polymers on the Yield of ALVs. Reference [2] indicated that dry matter is a vital measure of crop growth and yield. Dry matter yield is an important indicator of fertilizer efficiency [29]. Dry weight of leaves and pods of the African leafy vegetables was considered in yield determination.

3.4.1. Cowpea. SAP, irrigation, and their interactions demonstrated significant effects ($P < 0.05$) on the dry weight of cowpea as presented in Table 6. Irrigation showed a significant effect on the number of pods per plant. However, there was no significant effect on the number of seeds per pod. The highest dry matter yield for cowpea was recorded under treatment S_3I_3 as 171 g/plant, whereas the lowest yield

TABLE 3: ANOVA for dependent variables and their interaction with cowpea plant at 95% confidence level.

Source of variation	*P*-values at 95% confidence level			
	Plant height	Stem diameter	Leaf area (ns)	No. of mature leaves/plant
SAP	0.145^{ns}	0.428^{ns}	0.455	0.275^{ns}
Irrigation	0.001^{*}	$<0.001^{*}$	0.083	$<0.001^{*}$
SAP × irrigation	$<0.001^{*}$	0.5457^{ns}	0.314	0.001^{*}

*Represents significance at 0.05 confidence level. ^ns^represents nonsignificance.

TABLE 4: Variation of ANOVA over 32 days of cowpea plant from emergence.

No. of days from emergence	Source of variation	*P*-values at 95% confidence level			
		Plant height	Stem diameter	Leaf area	No. of mature leaves/plant
14 days	SAP	$<0.001^{*}$	0.056^{ns}	$<0.001^{*}$	0.004^{*}
	Irrigation	$<0.001^{*}$	0.085^{ns}	$<0.001^{*}$	$<0.001^{*}$
	SAP × Irrigation	0.007^{*}	0.542^{ns}	0.061^{ns}	$<0.001^{*}$
21 days	SAP	0.010^{*}	$<0.001^{*}$	0.279^{ns}	0.059^{ns}
	Irrigation	0.008^{*}	0.164^{ns}	0.304^{ns}	0.002^{*}
	SAP × Irrigation	0.388^{ns}	0.115^{ns}	0.307^{ns}	0.070^{ns}
28 days	SAP	0.857^{ns}	0.064^{ns}	0.084^{ns}	0.421^{ns}
	Irrigation	0.020^{*}	0.008^{*}	0.078^{ns}	$<0.001^{*}$
	SAP × Irrigation	0.091^{ns}	0.321^{ns}	0.149^{ns}	0.042^{*}
35 days	SAP	0.199^{ns}	0.987^{ns}	0.429^{ns}	0.141^{ns}
	Irrigation	0.065^{ns}	$<0.001^{*}$	0.025^{*}	$<0.001^{*}$
	SAP × Irrigation	0.005^{*}	0.522^{ns}	0.085^{ns}	$<0.001^{*}$
32 days	SAP	0.066^{ns}	0.779^{ns}	0.704^{ns}	0.176^{ns}
	Irrigation	$<0.001^{*}$	$<0.001^{*}$	0.323^{ns}	$<0.001^{*}$
	SAP × Irrigation	$<0.001^{*}$	0.336^{ns}	0.698^{ns}	0.028^{*}

*Represents significance at 0.05 confidence level. ^ns^represents nonsignificance.

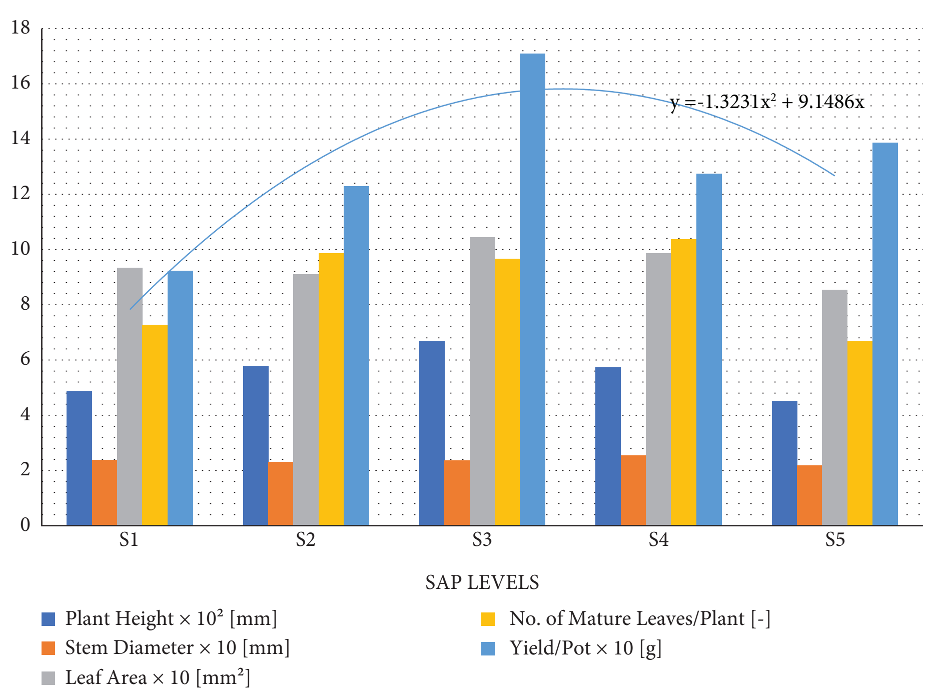

FIGURE 1: Effect of SAP on the growth and yield of cowpea.

Table 5: ANOVA for dependent variables and their interaction with African nightshade plant at 95% confidence level.

Source of variation	P-values at 95% confidence level			
	Plant height (ns)	Stem diameter	Leaf area	No. of mature leaves/plant
SAP	0.094	0.280^{ns}	0.118^{ns}	0.068^{ns}
Irrigation	0.086	0.004^{*}	0.011^{*}	0.012^{*}
SAP × irrigation	0.621	0.389^{ns}	0.777^{ns}	0.046^{ns}

*Represents significance at 0.05 confidence level. ^{ns}represents nonsignificance.

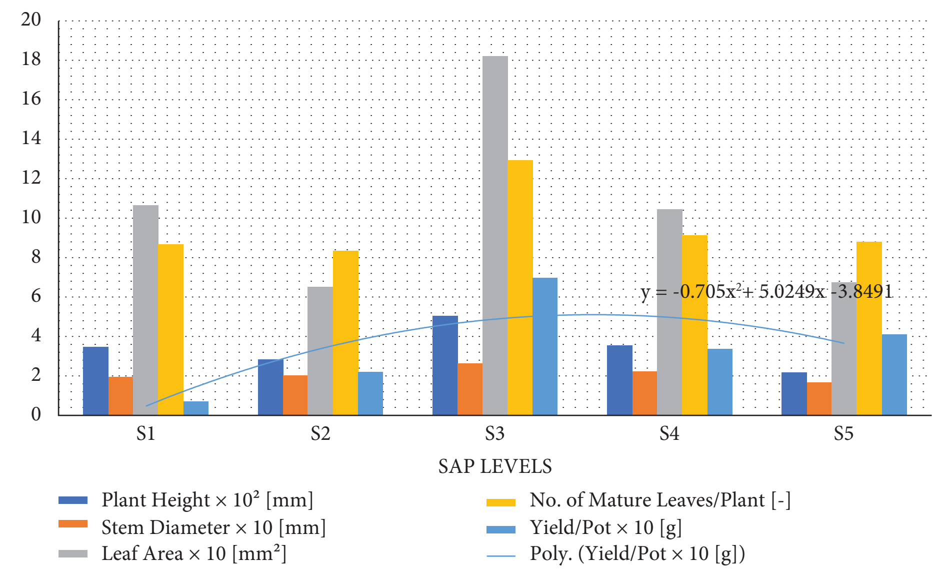

Figure 2: Effect of SAP on African nightshade growth and yield.

Table 6: ANOVA for dependent variables and their interaction on cowpea plant yield at 95% confidence level.

Source of variation	P-values at 95% confidence level		
	Dry weight	No. of pods/plant	No. of seeds/pod (ns)
SAP	0.013^{*}	0.991^{ns}	0.330
Irrigation	0.009^{*}	0.007^{*}	0.118
SAP × irrigation	0.002^{*}	0.154^{ns}	0.499

*Represents significance at 0.05 confidence level. ^{ns} represents nonsignificance.

was recorded as 92 g/plant under treatment S_1I_1 as presented in Figure 1. The difference between the treatments with SAP dosage and those without was significant.

3.4.2. African Nightshade. Significant effects of SAP doses ($P < 0.05$) on African nightshade yield were observed. Irrigation and the interaction of SAP and irrigation showed no significant effects on the yield as presented in Table 7. The greatest effect on African nightshade yield was demonstrated in treatment with S_3I_3 (3 g of SAP per pot and 5-day irrigation interval). The highest dry weight of African nightshade leaves was recorded under treatment S_3I_3 as presented in Figure 2.

The interaction of superabsorbent polymers and irrigation showed a significant effect on the yield of African leafy vegetables as indicated in similar studies [2, 30, 31].

An overall ANOVA indicated that the use of superabsorbent polymers in irrigation significantly affected plant height, stem diameter, leaf area, number of mature leaves per plant, and dry matter yield. Superabsorbent polymers absorb and retain irrigation water for longer periods and release it to the crop roots when needed, thus reducing the effects of water deficit in crops [17, 27, 32]. Treatment with superabsorbent polymers showed higher growth parameters and yield of both vegetables compared to the treatments. Treatment S_3I_3 (3 g of superabsorbent polymer per 3 kilograms of soil substrate and 5-day irrigation interval) recorded the highest plant growth and yield compared to all other treatments. For instance, S_3I_3 treatment in cowpea recorded 24%, 11.7%, 11.1%, and 85.9% increase in plant height, leaf area, number of mature leaves, and dry weight per plant in comparison with no SAP and 3-day irrigation interval treatment (S_1I_1). Treatment S_3I_3 was observed as the best for optimal production of African leafy vegetables under greenhouse conditions.

Table 7: ANOVA for dependent variables and their interaction on African nightshade plant yield at 95% confidence level.

Source of variation	SS	df	MS	F	P-value	F crit
SAP levels	739.06	4	184.765	2.673	0.042*	2.557
Irrigation levels	556.988	4	139.247	2.014	0.107ns	2.557
SAP ∗ irrigation levels	744.040	16	46.503	0.673	0.806ns	1.850
Error	3456.567	50	69.131			

*represents significance at 0.05 confidence level. nsrepresents nonsignificance.

4. Conclusions and Recommendations

Use of superabsorbent polymers in irrigation significantly promotes the growth and yield of African leafy vegetables. Incorporation of superabsorbent polymers in soil substrate increases plant height, plant stem diameter, leaf area, and dry biomass of leafy vegetables. Treatment with superabsorbent polymers showed higher growth parameters and yield of both vegetables as compared to the treatments.

Although different superabsorbent polymer doses showed an increase in the growth of African leafy vegetables, treatment S_3I_3 (1 g SAP/kg of soil substrate and 5-day irrigation interval) showed better plant performance than all other treatments. Treatment S_3I_3 was observed as the best for optimal production of African leafy vegetables under greenhouse conditions. Hence, superabsorbent polymers could be a good strategy for food production within arid and semi-arid lands where water resources are scarce.

Further studies on superabsorbent polymers' longevity in the soil and their effects on the growth and production of crops after repeated use on the same soil substrate should be carried out.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest or personal relationships that could have appeared to influence the work reported in this article.

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