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Efficacy of superabsorbent polymer on the stress condition of cowpea (*Vigna unguiculata* L.)

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Abstract

The study was conducted to evaluate the effect of superabsorbent polymer (SAP) and irrigation interval on cowpea from June 15, 2021, to August 31, 2021, at Cagayan State University, Lallo Campus Sta. Maria, Lallo, Cagayan. The treatments considered in the experiment were: Factor A (SAP Levels): S_1 –0.15g SAP/ 5 kg soil, S_2 – 0.20g SAP/ 5 kg soil and S_3 – 0.25g SAP/ 5 kg soil. Factor B (Irrigation Interval): T_1 –Irrigation at Planting, T_2 – 7 days irrigation interval, T_3 – 14 days irrigation interval and T_4 – 21 days irrigation interval. The pots were filled up with five kilograms of dried soil and the SAP was mixed thoroughly in the soil following its treatments. The study was laid out in Completely Randomized Design in Factorial with three replications. Wherein the parameters to be gathered are the following; plant height at 20, 40 and 60 days after planting, number of branches per plant, number of green pods per plant, the weight of green pods per plant, and pod length. The study result shows that the application of 80-100 kg SAP ha^{-1} at 14 days irrigation interval attained the tallest plants, the most number of pods per plant, more number of branches per plant, the heaviest pods per plant, and longest pods per plant. Using 80- 100 kg superabsorbent polymer per hectare and irrigation at 14 days interval is recommended for cowpea production.

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Introduction

Drought is the major factor that limits the yield of beans because beans are usually shallow-rooted plants. A major feature of bean crops is the unreliability of yield and the yield fluctuation widely from season to season as well as from farms due to drought. Relatively, little is known about the physiological mechanism of the effect of the drought on beans during generative development, leading to the reduction in yield. In cowpea cultivation, the most sensitive stages to water deficit or water stress are the early vegetative stage, flowering stage, podding stage and seed filling stage (Carvalho *et al.*, 2000). High and stable yields of growing plants can reliably be obtained only by supplementing crop water requirements through irrigation (Bošnjak, 2001).

The use of Super Absorbent Polymers (SAP) that are produced from potassium polyacrylate and polyacrylamide co-polymers, when exposed to water, are able to absorb and preserve water fast and several times their volume. They increase the ability of soil to preserve the water and with decreasing drought stress, approve the growth of the plant (Roshan, 2005). These polymers improve the physical properties of soil, also serve as buffers against temporary drought stress and reduce the risk of plant failure during its establishment (Mansour *et al.*, 2005; Foyer and Noctor, 2003). The application of super absorbent polymer may effectively increase water and fertilizer use efficiency in crops (Islam *et al.*, 2011a). When the polymers are incorporated into the soil, it presumes the retaining of large quantities of water supply (Islam *et al.*, 2011b).

Vegetable crops require more water and more frequent irrigations than most field crops. Consequently, significant savings can be achieved for water usage, labor and energy in irrigation and fertilization.

Cowpea seed consists of 25% protein and has a very low-fat content (Rangel *et al.,* 2003). Cowpea starch is digested more slowly than the starch from cereals, which is more beneficial to human health. The grain is a rich source of folic acid, an important vitamin that helps prevent neural tube defects in unborn babies (Witthoft *et al.*, 2016). Cowpea is not only for human consumption but also for animal feed, wherein the stems, leaves, and vines are often stored for use during the dry season. Its adaptability to different types of soil and intercropping system and ability to improve soil fertility and prevent soil erosion makes it an important economic crop not only in the Philippines but also in many developing countries.

Optimal water consumption in agricultural production as one of the most important environmental factors affecting plant growth and development. Optimization of the factors which positively affect the production and management of water application on the farm helps to save the limited water resources, improves soil conservation, and also boosts the quality of the products. However, there have been lots of efforts up to now to decrease water consumption by crop plants.

The objective of the study was conducted to evaluate the application of super absorbent polymer (SAP) to alleviate the effects of water stress on cowpea (*Vigna unguiculata* L.).

Materials and methods

Time and Place of Study

The study was conducted at th nursery of the Cagayan State University, Lal-lo Campus, Sta. Maria, Lallo, Cagayan.

Procurement of Seeds and Super Absorbent Polymer

The seeds of cowpea were secured at Cagayan Valley Research Center, City of Ilagan (Isabela). The SAP was procured thru on-line shopping.

Setting up the Experiment, Layout and Design

A pot experiment was employed in the study. One hundred twenty (120) plastic containers were filled with 5 kilograms of garden soil. The different amounts of SAP used per container were S_1- 0.15 grams, S_2-0.20 grams and S_3- 0.25 grams and mixed

thoroughly with the soil before planting. Fertilization was done based on the cowpea production guide (DA, Bureau of Plant Industry). Application of 14-14-14 as basal fertilizer and side-dress with urea (46-0-0) at 1 month after planting. Muriate of Potash (0-0-60) applied during the flowering stage. The treatments were arranged following the procedure of Completely Randomized Design.

Experimental treatments

The following treatments used in the study are the following:

Factor A (SAP Levels)
S_1 – 0.15 g SAP/5 kg soil
S_2 – 0.20 g SAP/5 kg soil
S_3 – 0.25 g SAP/5 kg soil
Factor B (Irrigation Interval)
T_1 –Irrigation at Planting
T_2 – 7 days irrigation interval
T_3 – 14 days irrigation interval
T_4 – 21 days irrigation interval

Planting and thinning

Three seeds of cowpea were planted per pot. Thinning was done at 10 days after seedling emergence leaving 2 healthy seedlings per pot.

Care and management

Cultivation: Shallow cultivation was done 20 days after planting.

Irrigation: Upon planting, all the treatments were irrigated at the same volume of water (1 litre/pot) it's treatment was followed the time of irrigation were T_1-irrigation at planting, T_2 - 7 days irrigation interval, T_3 -14 days irrigation interval, and T4- 21 days irrigation interval. The last time of irrigation was at 68 DAP for T_2 (7 DAI), 54 DAP for T_3 (14 DAI) and 33 DAP for T_4 (21 DAI) which the corresponding irrigation intervals were subsequently followed.

Harvesting

Green pods at the marketable stage were harvested manually at 40 days after sowing. The harvested pods from the samples plants were placed in a plastic bag and tag them accordingly based on treatment to avoid intermixing of samples. This procedure was done every 5 days for 6 primings.

Data gathered

Plant height at 20, 40 and 60 days after planting: The plant height of the ten representative plants was randomly taken and was measured from the base up to the tip of the meristem by using a meter stick at 20, 40, and 60 days after planting.

Number of branches per plant: The number of branches per plant of the 10 sample plants was counted and recorded.

Number of green pods per plant: The number of green pods from the ten representatives was recorded and was summed up to obtain the number of pods per plant.

Weight of green pods per plant: The number of green pods from the ten representatives were recorded and was summed up to obtain the number of pods per plant.

Pod length: The length of ten representative sample pods was measured using a ruler. The total length of the sample pods was divided by ten to get the average length per pod.

Statistical analysis

The data collected were analyzed using the Analysis of Variance for Randomized Complete Block Design using the STAR (Statistical Tool for Agricultural Research) software. The treatment with significant results was compared using Tukey's Honestly Significant Difference.

Results and discussion

Plant height at 20, 40, and 60 days after planting

The effects of superabsorbent polymer and interval on the height of cowpea at 20,40 and 60 days after planting is shown in Table 1, 2, and 3. Table 1 shows, there are significant differences in the effect of levels

of SAP on the height growth of cowpea at 20 days after planting. Plants applied with 0.25 g SAP/5 kg soil were taller with a mean height of 19.89 cm compared with the plants applied with 0.15 g SAP/5 kg soil and 0.20 g SAP/5 kg soil with a respective mean of 17.18 and 18.36 cm. There are significant differences in the effect of irrigation interval on height growth of cowpea at 20 days after planting. Plants irrigated at 7, 14 and 21 days intervals were comparable with each other with mean height ranges from 18.71 to 19.22 centimeters. The shortest was obtained in plants irrigated at planting with 17.20 centimeters. The result explained with Yazdani *et al.* (2007) reported the effect of three irrigation intervals (6, 8 and 10 days) on the growth and yield of soybean under field conditions. Cowpea at 20 days after planting *superabsorbent polymer x irrigation interval.*

Table 1. Effect of superabsorbent polymer and irrigation interval on height (cm) of cowpea at 20 days after planting.

Factor B (Irrigation Interval)	Factor A (SAP Levels)			Mean (B)
	0.15 g SAP/ 5 kg soil	0.20 g SAP/ 5 kg soil	0.25 g SAP/ 5 kg soil	
T_1 – At Planting	15.62	18.04	17.95	17.20
T_2 – 7 DI	18.06	18.43	19.63	18.71
T_3 – 14 DI	17.33	17.54	21.46	18.78
T_4 – 21 DI	17.70	19.43	20.53	19.22
Mean (A)	17.18 b	18.36 b	19.89 a	

In a column, means with the same letter are not significantly different.

There is no interaction between the level of SAP and irrigation interval of height growth of cowpea at 20 days after planting. The height of the plants in the different treatment combinations ranged from 15.62 to 21.46 centimeters. This reveals in the study height of the crop during the initial and vegetative stage of the crop growth and until it got to the mid-season stage.

There was no significant ($P \leq 0.05$) difference between the means of the plant height at the initial and vegetative stages among irrigation regimes. This may be due to adequate moisture available for crop growth at these stages of growth. *(Faloye et al., 2016).* In table 2 sows there are significant differences in the effect of levels of SAP on the height growth of cowpea at 40 days after planting. Plants applied with 0.25 g SAP/5 kg soil were taller with a mean height of 61.95 cm compared with the plants applied with 0.15 g SAP/5 kg soil and 0.20 g SAP/5 kg soil with a respective mean of 39.27 and 50.34 cm. There are significant differences in the effect of irrigation interval on height growth of cowpea at 40 days after panting. Plants irrigated at 7, 14 and 21 days intervals were taller with a respective mean height of 56.50, 53.59 and 50.25 centimeters. However, plants irrigated at 21 days intervals failed to outgrow the control plants with 41.75 centimeters. There is an interaction between the level of SAP and irrigation interval of height growth of cowpea at 40 days after planting. Results showed that in the application of 0.15 g SAP/5 kg soil x irrigation interval is shows that the S_1T_2 (0.15 g SAP/5 kg soil x 7 DI) and S_1T_3 (0.15 g SAP/5 kg soil x 14 DI) obtained the taller plants (45.45 and 42.25 cm) over the plants in S_1T_4 (0.15 g SAP/5 kg soil x 21 DI) and S_1T_1 (0.15 g SAP/5 kg soil x At Planting) (33.29 and 36.10 cm). In the interaction of 0.20 g SAP/5 kg soil x irrigation interval shows that S2T1 (0.20 g SAP/5 kg soil x At Planting) obtained the tallest plants (57.86 cm), followed by the interaction of S_2T_3 (0.20 g SAP/5 kg soil x 14 DI) and S_2T_4 (0.20g SAP/5 kg soil x 21 DI) (53.86 and 52.46 cm) and the shortest was obtained in the interaction of S_2T_1 (0.20 g SAP/5 kg soil x At Planting) (37.16 cm). In the interaction of 0.25g SAP/ 5 kg soil x irrigation interval shows that S_3T_2 (0.25 g SAP/5 kg

soil x 7 DI), S_3T_3 (0.25 g SAP/5 kg soil x 14 DI) and S_3T_4 (0.25 g SAP/5 kg soil x 21 DI) were comparable with other with respective mean height ranging from 62.18 to 66.18 cm and the shortest was obtained in the interaction of S_3T_1 (0.25 g SAP/5 kg soil x At Planting) with 54.79 centimeters. The result coincides in the study of Nazarli *et al*., 2010*)* that the effect of different rates of super absorbent polymer and different rates of consumed water in all traits significantly influenced the growth of the plants.

Table 2. Effect of superabsorbent polymer and irrigation interval on height (cm) of cowpea at 40 days after planting.

Factor B (Irrigation Interval)	Factor A (SAP Levels)			Mean (B)
	0.15 g SAP/ 5 kg soil	0.20 g SAP/ 5kg soil	0.25 g SAP/ 5 kg soil	
T_1 – At Planting	33.29 b	37.16 c	54.79 c	41.75 b
T_2 – 7 DI	45.45 a	57.86 a	66.18 a	56.50 a
T_3 – 14 DI	42.25 a	53.86 b	64.66 ab	53.59 a
T_4 – 21 DI	36.10 b	52.46 b	62.18 a	50.25 ab
Mean (A)	39.27 c	50.34 b	61.95 a	

In a column, means with the same letter are not significantly different.

In table 3 shows there are significant differences in the effect of levels of SAP on the height growth of cowpea at 60 days after planting. Plants applied with 0.25 g SAP/ 5 kg soil were the tallest with a mean height of 68.22 cm, followed by the plants applied with 0.20 g SAP/5 kg soil with 60.98 cm and 0.15 g SAP/5 kg soil with 45.24 cm, considered the shortest. There are significant differences in the effect of irrigation interval on height growth of cowpea at 60 days after panting. Plants were taller when irrigated at 7, 14 and 21 days intervals with a respective mean height of 57.13, 60.02 and 67.16 centimeters. The control plants were shorter with a mean height of 46.27 centimeters.

Table 3. Effect of superabsorbent polymer and irrigation interval on height (cm) of cowpea at 60 days after planting.

Factor B (Irrigation Interval)	Factor A (SAP Levels)			Mean (B)
	0.15 g SAP / 5 kg soil	0.20 g SAP / 5 kg soil	0.25 g SAP / 5 kg soil	
T_1 – At Planting	37.71 d	43.99 d	57.11 c	46.27 b
T_2 – 7 DI	52.99 a	72.54 a	75.95 a	67.16 a
T_3 – 14 DI	48.43 b	67.47 b	70.17 b	62.02 a
T_4 – 21 DI	41.81 c	59.93 c	69.64 b	57.13 a
Mean (A)	45.24 c	60.98 b	68.22 a	

In a column, means with the same letter are not significantly different.

The result of the study jibe with the statement of (Nazarli *et al*., 2010). Superabsorbent polymers cause water retention in the soil and reduce the number of irrigation frequencies up to 50 percent. There is an interaction between the level of SAP and irrigation interval of height growth of cowpea at 60 days after planting. The interaction of 0.15 g SAP/5 kg soil and irrigation interval shows taller plants were obtained in the combination of S_1T_2 (0.15 g SAP/5 kg soil x 7 DI) with 52.99 cm which did not differ to S_1T_3 (0.15 g SAP/5 kg soil x 14 DI) with 48.43 cm. It was followed by the plants grown under S_1T_4 (0.15 g SAP/5 kg soil x 21 DI) with 41.81 cm and the shortest was obtained in plants in S_1T_1 (0.15 g SAP/5 kg soil x At Planting) with

37.71 centimeters. The interaction of 0.20 g SAP/5 kg soil and irrigation interval shows that the plants in S_2T_2 (0.20 g SAP/5 kg soil x 7 DI) had the tallest height with 72.54 cm. It was followed by S_2T_3 (0.20 g SAP/5 kg soil x 14 DI) with 67.47 cm. The S_2T_4 (0.20 g SAP/5 kg soil x 21 DI) obtained 59.93 cm and the shortest was obtained in S_2T_1 0.20 g SAP/5 kg soil x At Planting) with 43.99 cm. In the interaction of 0.25 g SAP/5 kg soil and irrigation interval showed that the plants in S_3T_2 (0.25 g SAP/ 5 kg soil x 7 DI) produced tallest plants with 75.95 cm, followed by the plants in S_3T_3 (0.25 g SAP/5 kg soil x 14 DI) and S_3T_4 (0.25 g SAP/5 kg soil x 21 DI) with 70.17 and 69.64 cm. The shortest was obtained in plants in S_3T_1 0.25g SAP/5 kg soil x At Planting) with 57.11 centimeters. The above result showed that the incorporation of SAP with soil improved the soil physical properties, enhanced seed germination, seedling emergence, crop growth and yield (Yazdani *et al.,* 2007).

The result could be explained that SAPs could absorb and store water up to several times their own weight. This property has great importance in confronting water shortage and reducing the harmful effects of drought stress (Haghighi *et al.*, 2014; Wu *et al.*, 2008). Superabsorbent polymers cause water retention in the soil and reduce the number of irrigation frequency up to 50% (Nazarli *et al.*, 2010).

Table 4. Effect of superabsorbent polymer and irrigation interval on the number of branches per plant.

Factor B (Irrigation Interval)	Factor A (SAP Levels)			Mean (B)
	0.15 g SAP/ 5 kg soil	0.20 g SAP/ 5 kg soil	0.25 g SAP/ 5 kg soil	
T_1 – At Planting	3.67 b	4.33 b	5.00 b	4.33 c
T_2 – 7 DI	7.00 a	7.00 a	7.67 a	7.22 a
T_3 – 14 DI	6.33 a	6.67 a	4.67 b	5.89 b
T_4 – 21 DI	3.00 b	4.33 b	7.00 a	4.78 bc
Mean (A)	5.00b	5.58b	6.09a	

In a column, means with the same letter are not significantly different.

Number of branches per plant.

The effect of super absorbent polymer and time of irrigation on the number of branches of cowpea is shown in Table 4. There are significant differences in the effect of levels of SAP on number of branches per plant at maturity. Plants applied with 0.25 g SAP/5 kg soil produced more number branches per plant with 60.09 while the plants applied with 0.20 g SAP/5 kg soil were comparable in terms of the number of branches with a respective mean of 5.00 to 5.58. The result of the study jibe with the statement of Kumari *et al.* (2017) that SAP also increases absorption of nutrient elements, photosynthesis efficiency and other properties of crops during growth. There are significant differences in the effect of irrigation interval on number of branches per plant at maturity. Plants irrigated at 7 days intervals produce the greatest number of branches per plant at 7.22, followed by the plants which were irrigated 14 and 21days interval with 5.89 and 4.78, respectively. The control plants which were irrigated only at planting produced the least number of branches per plant with 4.33. Results of this study revealed that the excess watering treatment had a significant effect on the number of branches per plant, which implies that the cowpea plants that received more water showed vigorous growth, as stated by Fallahi *et al.* (2015).

There is a significant interaction between the level of SAP and irrigation interval on the number of branches per plant at maturity. The interaction in the application of 0.15 g SAP/5 kg soil and irrigation interval shows that the plants in S_1T_2 (0.15 g SAP/5 kg soil x 7 DI) and S_1T_3 (0.15 g SAP/5 kg soil x 14 DI) had the more number of branches per plant (7.00 and 6.33) over the plants in S_1T_1 (0.15 g SAP/5 kg soil x At Planting) and S_1T_4 (0.15 g SAP/5 kg soil x 21 DI) (3.67 and 3.00). More branches were produced in the

combination of S_2T_2 (0.20 g SAP/5 kg soil x 7 DI) S_2T_3 (0.20 g SAP/5 kg soil x 14 DI) (7.00 and 6.67) while S_2T_1 (0.20 g SAP/5 kg soil x At Planting) and S_2T_4 (0.20 g SAP/5 kg soil x 21 DI) (4.33). In the combination of 0.25 g SAP per 5 kg soil and irrigation interval shows that S_3T_2 (0.25 g SAP/5 kg soil x 7 DI) and S_3T_4 (0.25 g SAP/5 kg soil x 21 DI) produced more branches (7.67 and 7.00 while S_3T_1 (100 kg SAP ha^{-1} x At Planting) and S_3T_3 (of 0.25 g SAP per 5 kg soil x 14 DI) produced a lesser number of branches (5.00 and 4.67). The result of the study implies that SAP reduces water stress during irrigation intervals (Dahbi *et al.*, 2013; Rahbar and Banedjschafie, 2009; Rousta *et al.*, 2013).

Table 5. Effect of superabsorbent polymer and irrigation interval on the number of pods per plant.

Factor B (Irrigation Interval)	Factor A (SAP Levels)			Mean (B)
	0.15 g SAP/ 5 kg soil	0.20 g SAP/ 5 kg soil	0.25 g SAP/ 5 kg soil	
T_1 – At Planting	8.13 ab	9.27 c	10.70 c	9.37 bc
T_2 – 7 DI	7.50 bc	8.03 d	9.17 d	8.23 c
T_3 – 14 DI	8.50 a	12.28 a	14.39 a	11.72 a
T_4 – 21 DI	4.70 c	10.93 b	13.05 b	9.56 ab
Mean (A)	7.21 c	10.13 b	11.83 a	

In a column, means with the same letter are not significantly different.

Number of pods per plant

The effect of super absorbent polymer and irrigation interval on the number of pods per plant of cowpea is shown in Table 5. There are significant differences in the effect of levels of SAP on number of pods per plant at maturity. Plants applied with more SAP at 0.25 g SAP/5 kg soil produced the greatest number of pods with 11.83. It was followed by the plants applied with 0.20 g SAP/5 kg soil with 10.13 and 0.15 g SAP/5 kg soil with 7.21. This indicates that the higher the level of SAP enhances the production of pods. Increasing the rate of SAP increase the production of pods of cowpea. Naing and Lay (2017) stated that uses of SAP in soils improve both the nutritional and water status of plants. A proper amount of SAP has the potential to improve soil physical properties, reduce soil erosion and nutrient loss, and as carrier and regulator of nutrient release that improves crop growth, increased yield (Yazdani *et al.,* 2007). The super absorbents in increasing the pod yield can be attributed to a better supply of water and nutrients (Marashi and Mombani, 2020).

There are significant differences in the effect of irrigation interval on the number of pods per plant at maturity. Plants irrigated at 21 and 14 DAI produced the greatest number of pods per plant at 9.56 and 11.72, respectively. The irrigation of the plants at 21 days intervals showed a comparable effect with the control, where it showed a mean of 9.37. The least number of pods per plant observed in the plants irrigated at 7 days intervals with 8.23. The low number of fruits obtained from the shorter interval of irrigation may be because the excess water produced an excessive vegetative growth and viny characteristics of cowpea. And there is a significant interaction between the level of SAP and irrigation interval on the number of pods per plant at maturity. The interaction of 0.15 g SAP/5 kg soil and irrigation interval shows that the combination of S_1T_3 (0.15 g SAP/5 kg soil x 14 DI) and S_1T_1 (0.15 g SAP/5 kg soil x At Planting) produced more number of pods per plants with 8.50 and 8.13. However, S_1T_1 (0.15 g SAP/5 kg soil x At Planting) was comparable to the combination of S_1T_2 (0.15 g SAP/5 kg soil x 7 DI) with 7.50 and yet comparable to the combination of S_1T_4 (0.15 g SAP/5 kg soil x 21 DI) with 4.70. The interaction of 0.20 g SAP/5 kg soil and irrigation interval shows that S_2T_3 (0.20 g SAP /5 kg soil x 14 DI) had the most number of pods with 12.28. It was followed by S_2T_4 (0.20 g SAP /5 kg soil x 21 DI) with 10.93. S_2T_1 (0.20g SAP/5 kg soil x At Planting) had 9.27 and the least was observed in S_2T_2 (0.20 g SAP/5 kg soil x 7 DI) with 8.03. The interaction of 0.25 g

SAP/5 kg soil and irrigation interval shows that the combination of S_3T_3 (0.25 g SAP/ 5 kg soil x 14 DI) produced more number of pods per plant with 14.39. It was followed by S_3T_4 (0.25 g SAP/5 kg soil x 21 DI) with 13.05. The combination of S_3T_1 (0.25 g SAP/5 kg soil x At Planting) produced 10.70 and the least was produced by the combination of S_3T_2 (0.25 g SAP/5 kg soil x 7 DI) with 9.17. Cao *et al.* (2017) stated that super absorbent increases water penetration in soil, soil structure sustainability, reducing the rate of evaporation from soil surface, increasing water use efficiency and reducing the need for irrigation. The same findings was observed by Ramirez (2020); Tuyugon *et al.* (2020); Temanel (2017) in banana.

The interaction of irrigation frequency and the amount of polymer significantly affected the average plant height and leaf area increment of the banana plantlets. However, the girth size was only affected by the amount of irrigation and polymer. Moisture retention was observed in the soils treated with the absorbent polymer.

Table 6. Effect of superabsorbent polymer and irrigation interval on the weight (g) of pods.

Factor B (Irrigation Interval)	Factor A (SAP Levels)			Mean (B)
	0.15 g SAP/ 5 kg soil	0.20 g SAP/ 5 kg soil	0.25 g SAP/ 5 kg soil	
T_1 – At Planting	76.27 a	87.61 c	101.98 b	88.62 bc
T_2 – 7 DI	69.41 a	74.95 c	75.84 c	73.40 c
T_3 – 14 DI	79.78 a	127.48 a	120.93 a	109.40 a
T_4 – 21 DI	78.49 a	112.90 b	95.63 b	95.67 ab
Mean (A)	75.99 b	100.74 a	98.60 a	

In a column, means with the same letter are not significantly different.

Weight of pods per plant

Table 6 shown there are significant differences in the effect of the levels of SAP on the weight of pods per plant. Plants applied with higher levels of SAP at 0.20 g SAP/ 5 kg soil and 0.25 g SAP/5 kg soil produced the heaviest of pods with 100.74 and 98.60 grams per plant. The application of the lowest level of SAP at 0.15 g SAP produced pods with the lightest weight at 75.99 grams per plant. This indicates that the higher the level of SAP enhances the production of bigger pods. The plants irrigated at 21 and 14 days intervals produce the heaviest pods at 95.67 and 109.40 per plant, respectively.

The irrigation of the plants at 21 days intervals showed a comparable effect with the control, where it showed a mean of 88.62 grams per plant. The lightest weight of pods per plant is observed in the plants irrigated at 7days intervals with 73.40 grams.

There is a significant interaction between the level of SAP and irrigation interval on the weight of pods per plant. All the treatment combinations on the application of 0.15 g SAP/5 kg soil irrespective to the irrigation interval obtained comparable pod weight with means ranging 69.41 to 79.78 grams. In the interaction of 0.20 g SAP/5 kg soil and irrigation interval shows that in S_2T_3 (0.20 g SAP/5 kg soil x 14 DI) had the heaviest pods with 127.48 grams.

It was followed by S_2T_4 (0.20 g SAP/5 kg soil x 21 DI) had the heaviest pods with 112. 90 grams, while the plants in S_2T_1 (0.20 g SAP/5 kg soil x At Planting) and S_2T_2 (0.20 g SAP/5 kg soil x 7 DI) had the least with 87.61 and 74.95 grams, respectively.

The interaction of 0.25 g SAP/5 kg soil and irrigation interval shows that S_3T_3 (0.25 g SAP/5 kg soil x 14 DI) had the heaviest pods with 120.93 grams. Comparable pod weights were obtained in S_3T_1 (0.25 g SAP/5 kg soil x At Planting) and S_3T_4 (0.25 g SAP/5 kg soil x 21 DI) with 101.98 and 95.63 grams. The least was obtained in S_3T_2 (0.25 g SAP/5 kg soil x 7 DI) with 75.84 grams.

Length of pods.

The effect of super absorbent polymer and irrigation interval on the length of pods is shown in Table 7. There are significant differences in the effect of levels of SAP on the length of pods at maturity. Plants applied SAP at 0.20 g SAP and 0.25 g SAP/5 kg soil produced longer pods with 19.85 and 20.19 centimeters. The lower level of SAP at 0.15 g SAP/5 kg soil produced shorter pods at 15.91 centimeters. This indicates that the higher the level of SAP, the longer the pods that have been produced by the cowpea. The soil with an appropriate amount of SAP can improve flowering time and promote a high yield (Faloye *et al.,* 2016). A high dosage of SAP promotes physiological functions (Arn *et al.*, 2019; Andry *et al.,* 2009).

Table 7. Effect of superabsorbent polymer and irrigation interval on the length (cm) of pods.

Factor B (Irrigation Interval)	Factor A (SAP Levels)			Mean (B)
	0.15 g SAP/ 5 kg soil	0.20 g SAP/ 5 kg soil	0.25 g SAP/ 5 kg soil	
T_1 – At Planting	15.63 b	18.73 c	20.30 a	18.22
T_2 – 7 DI	15.23 b	19.20 c	19.57 bc	18.00
T_3 – 14 DI	16.23 a	22.50 a	20.10 ab	19.61
T_4 – 21 DI	16.53 a	20.33 b	19.43 c	18.76
Mean (A)	15.91 b	20.19 a	19.85 a	

In a column, means with the same letter are not significantly different.

There are no significant differences in the effect of the irrigation interval on the length of pods at maturity. Plants irrigated at 7, 14 and 21days intervals produced pods of comparable lengths with 18, 19.61 and 18.76 centimeters, respectively. The irrigation of the plants at planting produced pods of similar length when compared with plants irrigated at 7, 14 and 21 days intervals. It has been reported that water stress leads to a decrease in plant water content, turgor reduction and consequently a decrease in cellular expansion and alteration of various essential physiological and biochemical processes that can affect growth and productivity (Costa *et al.*, 2008; Lobato *et al.,* 2008).

There is a significant interaction between the level of SAP and irrigation interval on the length of pods at maturity. In the interaction of 0.15 g SAP/5 kg soil and irrigation interval shows that longer pods were obtained in plants under S_1T_3 (0.15 g SAP/5 kg soil x 14 DI) and S_1T_4 (0.15 g SAP/5 kg soil x 21 DI) with 16.23 and 16.53 cm while S_1T_1 (0.15 g SAP/5 kg soil x At Planting) and S_1T_2 (0.15 g SAP/5 kg soil x 7 DI) had shorter pods with 15.63 and 15.23 cm. The interaction of 0.20 g SAP/5 kg soil and irrigation interval shows that the plants in S_2T_3 (0.20 g SAP/5 kg soil x 14 DI) had longest pods with 22.50 cm. It was followed by S_2T_4 (0.20 g SAP/5 kg soil x 21 DI) with 20.33 cm. The shortest pods were produced in plants at S_2T_1 (0.20 g SAP/5 kg soil x At Planting) and S_2T_2 (0.20 g SAP/5 kg soil x 7 DI) with 18.73 and 19.20 cm, respectively. In the interaction of 0.20 g SAP/5 kg soil and irrigation interval shows S_3T_1 (0.25 g SAP/5 kg soil x At Planting) and S_3T_3 (0.25 g SAP/5 kg soil x 14 DI) had the longest pods with 20.30 cm and 20.10 cm, respectively. However, the latter was comparable in the combination of S_3T_2 (0.25 g SAP/5 kg soil x 7 DI) with 19.57 and yet comparable to S_3T_4 (0.25 g SAP/5 kg soil x 21 DI) with 19.43 cm. According to Magsi *et al.* (2019), crop yield significantly increased along with the increase of SAP.

Conclusion

Based from the result of the study, the following conclusion were considered:

Application of 80 to 100 kg SAP produced taller plants, more number of branches per plant, more number of pods per plant, longest pods and heaviest pods per plant.

Closer irrigation interval (e.g. 7 D DI) produced taller plants because of the production of excessive vegetative growth.

Irrigation at 7 and 14 DI produced comparable number of branches.

Irrigation at 14 days interval produced more number of pods and heaviest pod weight per plant.

Interaction of 60, 80 and 100 kg SAP ha^{-1} x 7 and 14 DI had the most number of branches per plant and the interaction of 80 to 100 SAP kg ha^{-1} x irrigation 14 and 21 days interval had the most number of pods per plant while longest pods irrespective to time of irrigation.

Irrigation at 14 days interval significantly produced the heaviest pods per plant. The application of 80 to 100 kg SAP ha^{-1} x irrigation at 14 and 21 days interval had the longest pods.

Recommendation

Based on the result and findings of the study indicated that using 80 kg superabsorbent polymer per hectare and irrigation at 14 days interval is recommended for cowpea production.

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