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Research Article

Effects of Sulphur Nutrition on *Wedelia trilobata* (L.) Hitch Plant Growth, Leaves, and Flowering

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ABSTRACT

The experiment was carried out in the nursery of the Department of Horticulture College of Agricultural Studies, Sudan University of Science and Technology, Khartoum, Sudan, from March 2018 to August 2019, to see how different levels of Sulphur fertilizer (0.0, 0.2, 0.4, 0.8, and 1.6g/plant) affected plant growth and flowering. The experiment was set up in a completely randomized design with four replications in each plant, with data collected on six parameters at 40, 125, 215, and 300 days after application. Maximum treatments had a significant effect on various parameters over the control treatments. Application of sulphur 1.6 g/plant delayed flower initiation in treated plants than in those receiving low levels of this nutrition. Sulphur application 1.6g/plant promoted vegetative growth, while moderated dose 0.8 g/plant increased number of flowers per plant.

Keywords: *Sulphur Nutrition, Wedelia, trilobata, Flowers, Seed production*

INTRODUCTION

Wedelia, also known as Rabbits Paw, belongs to the Asteraceae family (*Wedelia trilobata* L.). It's been used in the landscape as an interesting groundcover for warm climates. The name "trilobata" comes from the Latin word "trilobata," which refers to leaves with three lobes. A tropical American plant can be propagated through division, seeds, or tip cuttings. Wedelia is well-known for its beautiful yellow-orange flowers and rapid growth rate. It's a mat-forming perennial herb with rounded stems. New plants are produced by nods that root at the soil surface. Seed production is low, and seed reproduction is ineffective in the majority of cases (Swaefy & Basuny, 2011). Wedelia species have been used for centuries to revitalize the liver and treat liver dysfunction and disease. Amenorrhea and childbirth were treated with the plant's flowers and leaves in females.

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Local peasants (Chethan et al., 2012) use it as an organic fertilizer in paddy fields and green manure for dry land crops Wedelia trilobata. It may be able to meet the rising demand for organic fertilizer (Setyowati, et al., 2010). According to Jianfan, et al. (2019). Wedelia trilobata has been found to successfully invade in highly fluctuating water depths with high nutrient concentrations.

Sulphur (S) is now recognized as the fourth major plant nutrient, alongside nitrogen (N), phosphorus (P), and potassium (K).

In recent years, there has been an increase in the number of reports of (S) deficiency all over the world (Aulakh, 2003). Sulphur is a vital element for all living things and serves a variety of purposes. Because plants are our primary source of the essential amino acid methionine, plant sulphur nutrition is especially important. Sulphur deficiency has an impact on plant growth, development, disease resistance, and performance, as well as the nutritional quality of crops (Kopriva, et al., 2019).

Sulphur is a component of the amino acids cystine, cysteine, and methionine, which are necessary for Chlorophyll, according to Vala, et al. (2014) and Poonia. (2000) in sunflower studies. In the chemical makeup of seeds, sulphur is also important. When sulphur was applied at a rate of 25 kg S ha-1, sunflower yields increased significantly in terms of oil percentage, dry matter, plant height, head diameter, number and weight of seeds, test weight, seed, and biological yields.

All living organisms require sulphur as a nutrient. Due to the presence of sulphur in fertilizers and atmospheric deposition, sulphur deficiency was uncommon prior to the 1990s. As a result of decreased sulphur pollution, increased use of non-sulphur-containing fertilizers, and increased crop yields over the last decade, the sulphur balance has shifted into deficit (Zhao, et al., 2001).

Plant nutrition due to sulphur deficiency has become one of the most pressing issues in modern agriculture, particularly in developing countries. According to the Sulphur Institute in Washington, the global sulphur deficit reached 7.5 million tons per year in 2000. (Scherer, 2001). Plant nutrient sulphur deficits in 2010 (in tons) were 5.8 million in Asia, 1.5 million in North America, 1.5 million in Africa, 0.9 million in Latin America, and 1.0 million in Europe, according to the Sulphur Institute (TSL). The aforementioned deficit is expected to reach 12.5 million tons per year in 2015. (Cholewa & Kieloch, 2015). The goal of the study was to see how different levels of sulphur nutrition affected the growth and flowering of Wedelia trilobata. L in Khartoum.

MATERIALS AND METHODS

- Location:

The experiment was conducted and studied at the Sudan University of Science and Technology's Department of Horticulture, College of Agricultural Studies. During the growing season, the average maximum and minimum temperatures were 36.9°C and 21.2°C, respectively, with an average relative humidity of 19% and annual rainfall of 0.0 mm.

- Experiment:

The nursery experiment was conducted from March 2018 to August 2019 to investigate the effects of five different levels of sulphur fertilizer on Wedelia trilobata growth and flowering. Wedelia plants were laid out in a completely randomized design with five treatments and four replications, and each plant in a bag was considered a replicate. Culture was grown and maintained under the sun, used vegetative cutting with length 20- 30 cm in each black polyethylene bags 30×60 cm filling by soil mix of 1 sand : 2 river Nile sedimentary soil (Gureira).

-Treatments:

Sulphur was applied as eight doses every 40 days after planting from 12 March 2018 to 15 January 2019 in concentration 0.0, 0.2, 0.4, 0.8 and 1.6g per plant, and each plant were received a basal dressing of 2.0g Di-Ammonium Phosphate (DAP). Irrigation was applied according to need.

- Data Collection:-

A random sample was taken from each plant after 40, 125, 215 and 300 days from planting and was used for determining of growth and flowering parameters. The observation was recorded on six characters: Leaf chlorophyll measurement (mg/g) with the help of Plant Chlorophyll Fluorometer (Oakoch OK-Y104, made in China) (Li-Cor, Lincoln, NE, USA) was used to measure the leaf chlorophyll content (SPAD) and leaf NPK contents were analysis of plan (A A S. 1994). Duncan (1955) Multiple Range Test (DMRT) at P0.05 was used to separate the means, and the data was statistically analyzed using Gen Stat (Computer Program) Version 4. (Gomez & Gomez, 1984).

RESULTS

- Number of leaves/plant:

At 125 day, analysis of variance indicated that there was a highly significant difference between the treatments. 125 day had the highest number of leaves per plant was (301.0) obtained by (1.6 g/plant), followed with (299.0) at 300 days were recorded by (1.6 g/plant) (table 1), generally from analyzed the data the best treatment of sulphur nutrition to increased vegetative growth of wedelia for all ages of plant was (1.6g/plant).

- Number of flowers/ plant:

At 215 day, analysis of variance indicated that there was a highly significant difference between the control and treatments. 215 days had the highest number of flowers (11.00) recorded by level (0.8g/plant) and followed with (9.75) at 40 days (table 2). On the other hand, the lowest number of flowers was (2.75) obtained by higher level (1.6g/plant) at 125 days. At 40 day and 125 day the highest dose of sulphur resulted in significant decreased in number of flowers and the attractive and most effect dose to equally increase number of flowers per plant was level (0.8g/plant).

Table (1): Effect of sulphur levels on number of leaves /plant of wedelia plants

Sulphur level (g/plant)	Plant age (days)			
	40 day	**125 day**	**215 day**	**300 day**
0	105.5 e	157.0 c	194.2 c	210.0 c
0.2	138.8 d	155.0 c	200.8 c	261.8 b
0.4	171.8 c	234.2 b	239.5 b	286.0 a
0.8	233.0 b	282.0 a	277.5 a	294.0 a
1.6	250.5 a	301.0 a	281.8 a	299.2 a
LSD	14.25	21.99	14.67	15.63
CV %	5.3	6.5	4.1	3.8

* Means with the same letter within each column are not significantly different, according to Duncan's Multiple Range Test.

Table (2): Effect of sulphur levels on number of flowers /plant of wedelia plants

Sulphur level (g/plant)	Plant age (days)			
	40 day	**125 day**	**215 day**	**300 day**
0	3.75 c	4.25 b	6.50 c	4.00 c
0.2	6.00 b	4.50 b	7.50 c	6.00 bc
0.4	7.25 b	8.75 a	9.50 ab	7.00 b
0.8	9.75 a	9.00 a	11.00 a	9.50 a
1.6	3.25 c	2.75 c	8.00 bc	5.00 bc
LSD	1.40	1.31	1.78	2.07
CV %	15.5	14.8	13.9	22.1

* "Means with the same letter within each column are not significantly different, according to Duncan's Multiple Range Test".

- The total number of flowers/ treatment and chlorophyll test:

Data in table (3) show that increasing the dose of sulphur from (0.2 to 1.6g/plant) increased the total number of flowers per plant, significantly different from the control. On the other hand, the treatment of sulphur at (1.6g/plant) increased flowers, which is the better dose to produce attractive plants and many flowers. However, the maximum value of Chlorophyll has resulted from plants nutrient with sulphur at high dose (1.6g/plant) with a significant difference from the control.

- Weight of fresh and dry mass (g)/ plant:

The heaviest values of fresh herb weights (245.7g and 245.6g/plant) were obtained with sulphur level (1.6g/plant) and (0.8g/plant), whereas the least values were (127.0g) recorded by the control respectively. In this case, sulphur application at levels of (1.6g/plant) and (0.8g/plant) resulted in the highest fresh root values (33.05 and 31.20g). Which of the controls resulted in the lowest fresh root weight value? (9.98g). In terms of the effect of sulphur application, it is clear that as the dose of sulphur was increased up to (1.6g/plant), the total fresh weight of herb per plant increased significantly and gradually. The dry weight of total herb (shoot (83.7 and 75.4g/plant) + root (14.82 and 14.70g/plant) by level (0.8g/plant) and (1.6g/plant) followed the same pattern as the fresh weights (table 4), indicating that treatments that favored fresh weight produced high herb dry weight values.

Table (3): Effect of sulphur levels on total number of flowers and Chlorophyll of Wedelia plant

Sulphur level (g/plant)	Total number of flowers/ treatment	Chlorophyll (mg/g)
0	3.00 d	33.95 d
0.2	3.50 cd	36.17 c
0.4	4.50 bc	37.78 bc
0.8	5.25 b	38.60 ab
1.6	7.00 a	40.02 a
LSD	1.39	1.94
C.V.	19.8	3.4

* "Means with the same letter within each column are not significantly different, according to Duncan's Multiple Range Test".

Table (4): Effect of sulphur application on shoot fresh and dry, root fresh and dry weights of wedelia plant

Sulphur level (g/plant)	shoot fwt (g/plant)	shoot dwt (g/plant)	Root fwt (g/plant)	Root dwt (g/plant)
0	127.0 c	50.0 c	9.98 c	4.02 c
0.2	154.6 bc	50.1 c	11.62 c	4.45 c
0.4	181.9 b	56.2 bc	22.52 b	9.28 b
0.8	245.6 a	75.4 ab	31.20 a	14.82 a
1.6	245.7 a	83.7 a	33.05 a	14.70 a
LSD	35.41	20.93	2.61	2.42
C.V.	12.3	22.0	8.0	17.0

* "Means with the same letter within each column are not significantly different, according to Duncan's Multiple Range Test".

3.5- Analysis of leaf plant tissue (g) (dry ashing):

The uptake and accumulation of macro elements represented in N, P, and K percent were significantly higher in level 1.6 g/plant compared to the control and other treatments, according to leaf analysis (table 5).

Table (5): Effect of sulphur levels on leaf NPK ash contents were analysis of plant tissue of Wedelia plant

Sulphur level (g/plant)	Nitrogen (N)%	Phosphorus (P)%	Potassium (K)%
0	1.62 c	0.33 d	20.38 b
0.2	1.65 c	0.38 c	16.86 d
0.4	1.65 c	0.25 e	19.56 c
0.8	1.83 b	0.64 b	20.18 b
1.6	2.09 a	0.75 a	23.54 a
LSD	0.144	0.016	0.531
C.V.%	4.5	1.8	1.5

* "Means with the same letter within each column are not significantly different, according to Duncan's Multiple Range Test".

DISCUSSION

Sulphur is now the fourth most crucial nutrient for plants worldwide, after nitrogen, phosphorus, and potassium. Sulphur in soils comes from sulphur-containing minerals in the parent materials, as well as residues from plants and animals or from external additions of elemental sulphur or its minerals. The availability of applied sulphur to crops is increased when nitrogen, phosphorus, and potassium are applied. Sulphur assimilation by plants is critical because it is only through plants that it reaches humans (Rajendra & Yashbir, 2016).

- Number of leaves per plant:

The highest number of leaves were found in plants with a high level of sulphur at an earlier age, and the lowest number of leaves were found in plants with a low level of sulphur. Bahadur and Bala. (2017) found the same result in Raphanus Sativus.L. According to the report, the highest number of leaves were found in areas with high levels of sulphur, while the lowest number of leaves were found in areas with low levels of sulphur.

Furthermore, Chowdhury et al. (2020) found that the plant fertilized with 45 kg S ha-1 had the highest leaf number, which was significantly higher than all other levels of S, and the plant fertilized with 4 g S pot-1 had the lowest leaf number, and Eisa., et al. (2016) found that the highest leaf number of Aloe vera was recorded from the application of 4 g S pot-1. The performance of the A. vera crop is largely determined by the number of leaves planted. The leaf yield must increase in lockstep with the number of leaves on the plant.

- Number of flowers per plant:

Compared to plants grown without sulphur, the plants receiving various doses of sulphur produced more flowers. The highest sulphur dose resulted in a significant reduction in the number of flowers per plant, whereas the most appealing and effective dose to produce an equal number of flowers per plant was level (0.8g/plant) at an earlier stage of the plant. The phosphorous and ammonium (DAP dressing dose) that was applied with sulphur may have improved flowers in these treated plants. According to McKenzie (2013), oilseed crops, particularly canola and forage crops, have a higher sulphur requirement than cereal crops. Sulphur is necessary for the development of fertile canola flowers, as well as good nodule development in legume forages like alfalfa and pulse crop roots like pea and faba bean.

-Total number of flowers and Leaf chlorophyll measurement (mg/g):

According to the findings, sulphur at (1.6g/plant) increased total flowers, indicating that this is the best dose for producing attractive plants with a large number of flowers. Walia and Kumar (2021) discovered that significantly higher leaf + flower biomass (74.80 q ha-1), Chlorophyll resulted in an increase in plant nutrient with increased sulphur to high dose in a study on Wild Marigold. These findings are similar to those of (McKenzie, 2013) and (Vala, et al., 2014), who discovered that Sulphur is a key component of some essential amino acids and is required for protein synthesis. S is also

required for chlorophyll synthesis. Sulphur deficiency can reduce crop growth and yield at any stage of development. Sulphur deficiency causes crop growth to be sped up and maturity to be accelerated.

- The shoot fresh and dry weight (g):

With increasing the sulphur dose up to (1.6g/plant), the total fresh weight of herb per plant increased significantly and gradually. The dry shoot matter showed an isolated effect for S levels and sources. The responses of the shoot dry matter to S applications were inverse first-order positive. Exogenous application of S in S-deficient soils promotes plant growth, according to the findings of this study. S functions in the plant's catalytic, regulatory, and structural functions are linked to these increases (Ibañez1 et al., 2019).

Our findings are in line with those of Chowdhury et al. (2020), who discovered a significant increase in leaf biomass yield with the application of S up to 45 kg ha, before declining at 60 and 80 kg S ha. The plants that did not receive any S fertilizer had the lowest leaf biomass yield. As opposed to the control group. The improved leaf biomass yield observed in this study could be explained by the efficient uptake and metabolism of S available. Sulfur has a synergistic relationship with many essential plant nutrients, particularly nitrogen. N uptake and absorption are restricted in S-deficient soils.

The improvements in vegetative growth and flowering obtained from S application in our study are consistent with Ross, (2005) findings that S application has a positive effect on Aloe plant growth. Eisa, et al. (2016) found that treating Aloe vera with 4 g S resulted in the greatest increase in fresh and dry weights, as well as the highest leaf and gel yield. Mari c. et al. (2021) discovered that high nitrogen fertilization with sulphur (N240 S40; 8050 871 kg ha-1) resulted in higher dry matter yield than high nitrogen fertilization without sulphur in cabbage (N240 S40; 7113 274 kgha-1).

- Root fresh and dry weight (g):

Table 1 summarizes the effect of sulfur applications on root fresh and dry weights (4). All sulphur treatments significantly improved these parameters when compared to the control. Root fresh and dry weights increased the most with the treatment (1.6 g and 0.8 g). The increase was significant when compared to other treatments. The 2 g sulfur treatment significantly increased root fresh and dry weights of Aloe vera, according to Eisa et al. (2016), and ranked first, sharing first place with the 4 g sulfur treatment for root dry weight.

- Analysis of leaf plant tissue (g) (dry ashing):

In comparison to control plants, the values of macronutrients N, P, and K per cent increased steadily with increasing sulphur application rate. The obtained results of increased N, P, or K per cent in plants application of sulphur compared to other treatments. Because Ibanez., et al. (2019) reported that all values remained within the established range adequate for soybean, except for the S content in the leaf with ESPA, which was reflected in a minor increment in yield values when compared to the other sources, this increased N, P, or K per cent results. Total sulphur content in plant tissue ranges from 0.3 per cent to 7.6 per cent, according to Zhao *et al*. (2008), with the latter being found in plants grown in gypsum soils.

CONCLUSION

Sulphur treatment boosted the growth of Wedelia trilobata plants. When compared to un-nutrient plants, all sulphur treatments resulted in significant increases in growth and flowering, with the best level of sulphur (1.6g/plant) for all observations and parameters, followed by the medium level (0.8g/plant).

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Author Contribution
The authors contributed equally to establishing the research and design experiment topic.

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