بسم الله الرحمن الرحيم

Sudan University of Sciences and Technology

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Growth and flowering responses of *Wedelia trilobata* L. Hitch Plant to Nutritional Regimes in Khartoum State

استجابة النمو والازهار في نبات الويديليا لمنظومات غذائية في ولاية الخرطوم

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DEDICATION

To my mother who left us with her body, but she still exists through her actions and words.....

To the soul of my dear brother Moez and Mohammed......

To my father, the generous man, my God grants him health and wellness......

To my dear husband........

To my little children with beautiful laughter......

To my dear brother and lonely sister......

To students and researchers......

I dedicate to you the fruit of my labor and my humble thesis......

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ABSTRACT

Wedelia (*Wedelia trilobata* L.) plant was studied in the nursery of Department of Horticulture College of Agricultural Studies, Sudan University of Science and Technology، Shambat at Khartoum, Sudan, during 2018 and 2019. Five levels of sulphur 0.0, 0.2, 0.4, 0.8, 1.6 g/plant, NPK 0.0, 1.0, 2.0, 4.0, 8.0 g/plant and urea 0.0, 1.5, 3.0, 4.5, 6.0 g/plant were tested as soil application to potted media in 30× 60 cm^3 plastic pages. In addition, a micro elements foliar treatment was also tested. The foliar application was 50 mg/L of (Fe, Mn, Zn and B). The treatments were arranged in a complete randomize design. Each treatment was replicated four times. Data were collected according to the plants ages after (40, 125, 215 and 300 days from adding the fertilizers). Shoot length, number of branches, leaves and flowers, leaf length, width and area, final number of flowers, fresh and dry mass weight, chlorophyll measurement and analysis of leaf tissues were measured. The results showed significant differences between the five sulphur treatments on vegetative and flowering growth. General increase in vegetative growth occurred by adding the highest dose of sulphur 1.6 g/plant and the best level to increase in the number of flowers was when 0.8 g/plant was added. Data analysis showed significant difference in growth parameters when NPK was added. The highest values of measured parameters were obtained from the 8 g/plant. ANOVA showed significant differences in vegetative growth parameters treated with urea compared to the control, except for the shoot length. The highest values were obtained from the 6.0 g/plant for all parameters. The treatments of Zinc and Manganese as foliar application fertilizers gave the highest values of vegetative growth. No significant difference was found in all treatments regarding leaf width. Boron is the moderated nutrient used to increase number of flowers of *w. trilobata* plants.

المستخلص

اجريت دراسة لنبات الويديليا في مشتل قسم البساتين، كلية الزراعة، جامعة السودان للعلوم والتكنولوجيا، شمبات، الخرطوم بحرى، السودان، خلال الموسميين 2018 و 2019 . خمسة مستويات من الكبريت 0.0، 0.2، 0.4، 0.8، 1.6 جرام/ النبات. والسماد المركب NPK 0.0، 1.0، 2.0، 4.0، 8.0 جرام/ النبات و اليوريا 0.0، 1.5، 3.0، 4.5، 6.0 جرام/ النبات. تم الاختبار باضافة السماد للتربة المعباة في اكياس تعبئة 60 × 30 سم^3. بالاضافة للعناصر الصغري وهي حديد، منجنيز، زنك، بورون والشاهد. وتم الاختبار بالتسميد الورقي 50 مليجرام/ لتر. صممت التجارب باستخدام التصميم العشوائي الكامل وكررت كل معاملة اربعة مرات. وجمعت البيانات وفقا لاعمار النبات بعد 40، 125، 215، 300 يوم من اضافة السماد وذلك لدراسة طول النبات، عدد الافرع، الاوراق، الازهار، طول وعرض الورقة، مساحة سطح الورقة ،عدد الازهار، الوزن الرطب والجاف للنبات، قباس الكلورفيل و التحليل النسيجي للاوراق. من النتائج لوحظ وجود فروقات معنوية بين الخمسة معاملات من سماد الكبريت علي النمو الخضري والزهري. ووجدت زيادة عامة في قياسات النمو الخضري وذلك باضافة اعلي جرعة من الكبريت وهي 1.6 جرام/ النبات وكان افضل جرعة من سماد الكبريت لزيادة عدد الازهار هو 0.8 جرام/ النبات. ومن تحليل التباين اتضح وجود فروقات معنوية بين قياسات النمو المختلفة ماعدا طول النبات بالنسبة للنباتات المعاملة بسماد NPK . اعلي قيم للنمو وجدت في الجرعة 6.0 جرام/ النبات بالنسبة لكل القياسات . معاملات التسميد الورقي بالزنك والمنجنيز اعطت اعلي قيمة للنمو الخضري. لايوجد فرق معنوي في كل المعاملات عند قياس عرض الورقة. معاملات التسميد الورقي بالبورون اعطت اعلي قيمة للنمو الزهري لنبات الويديليا.

LIST OF CONTENTS

Title	**Page No.**
DEDICATION	I
ACKNOWLEDGMENTS	II
ABSTRACT	IV
ABSTRACT IN ARABIC	V
LIST OF CONTENTS	VI
LIST OF TABLES	XIII
CHAPTER ONE	
1.INTRODUCTION	1
CHAPTER TWO	
2. LITERATURE REVIEW	6
2.1. Scientific names	6
2.2. Description of Wedelia	6
2.2.1. Habitat	6
2.2.2. Geographical distribution	7
2.2.3. Botanical description	8
2.3. Uses and managements	9
2.4. Ethno pharmacological uses	11
2.5. Essential nutrients for plant growth	12
2.5.1. Macro elements	14
2.5.1.1. Nitrogen	14
2.5.1.1.1. Effect of nitrogen fertilizers on growth of plant	14

Title	**Page No.**
2.5.1.1.2. Nutrient functions	16
2.5.1.2. Effect of phosphorus on growth of plant	16
2.5.1.2.1 Nutrient functions	18
2.5.1.3. Effect of potassium on growth of plant	18
2.5.1.3.1. Nutrient functions	19
2.5.1.4. Effect of sulphur on growth of plant	20
2.5.1.4.1. Nutrient functions	22
2.5.2. Micro elements	22
2.5.2.1. Boron	23
2.5.2.1.1. Nutrient functions	24
2.5.2.2. Iron	24
2.5.2.2.1. Nutrient functions	24
2.5.2.3. Manganese	24
2.5.2.3.1. Nutrient functions	25
2.5.2.4. Zinc	25
2.5.2.4.1. Nutrient functions	25
CHAPTER THREE	
3. MATERIALS AND METHODS	26
3.1. Experiment site	26
3.2. Planting materials	26
3.3. Nutrients used were	26
3.3.1. Control without nutrient	26
3.3.2. Test of sulphur	27

Title	**Page No.**
3.3.3. Test of micro-elements	27
3.3.4. Test of NPK	27
3.3.5. Test of urea	27
3.4. Treatments	27
3.5. Cultural practices	27
3.5.1. Soil preparation	27
3.5.2. Irrigation	27
3.6. Nutrition	28
3.7. Data collected	28
3.7.1. Plant growth parameters (Plant characters)	28
3.7.1.1. Number of leaves per plant	28
3.7.1.2. Number of primary branches per plant	28
3.7.1.3. Number of secondary branches per plant	28
3.7.1.4. Shoot length (cm)	28
3.7.1.5. Leaf length (cm)	29
3.7.1.6. Leaf width (cm)	29
3.7.1.7. Leaf area (cm^2)	29
3.7.2. Yield components	29
3.7.2.1. Number of flowers per plant	29
3.7.2.2. Final number of flowers per plant	29
3.7.2.3. Chlorophyll content	29
3.7.2.4. Analysis of plant tissue (dry Ashing)	30
3.7.2.5. Shoot and root of fresh and dry weight (g) / plant	31

Title	**Page No.**
3.8. Experimental design and Statistical analysis	31
CHAPTER FOUR	
4. RESULTS	32
4.1. Experiment one: Effect of sulphur on vegetative growth and flowering of Wedelia plant.	32
4.1.1. Shoot length (cm)	32
4.1.2. Number of primary branches per plant	35
4.1.3. Number of secondary branches per plant:	37
4.1.4. Number of leaves per plant	39
4.1.5. Leaf length (cm)	41
4.1.6. Leaf width (cm)	43
4.1.7. Leaf area (cm^2)	45
4.1.8. Number of flowers per plant	47
4.1.9. Final number of flowers per plant	49
4.1.10. Chlorophyll measurement (mg/g)	49
4.1.11. Shoot fresh and dry weight (g)	51
4.1.12. Root fresh and dry weight (g)	51
4.1.13. Analysis of leaf plant tissue (g)	53
4.2. Experiment two: Effect of micro elements on vegetative growth and flowering of Wedelia plant	55
4.2.1. Shoot length (cm)	55
4.2.2. Number of primary branches per plant	57
4.2.3. Number of secondary branches per plant	59

Title	**Page No.**
4.2.4. Number of leaves per plant	61
4.2.5. Leaf length (cm)	63
4.2.6. Leaf width (cm)	65
4.2.7. Leaf area (cm2)	67
4.2.8. Number of flowers per plant	69
4.2.9. Final number of flowers per plant	71
4.2.10. Chlorophyll measurement (mg/g)	71
4.2.11. Shoot fresh and dry weight (g) per plant	73
4.2.12. Root fresh and dry weight (g) per plant	73
4.2.13. Analysis of leaf plant tissue (g)	75
4.3. Experiment three: Effect of NPK on growth and flowering of Wedelia plant.	77
4.3.1. Shoot length (cm)	77
4.3.2. Number of primary branches per plant	79
4.3.3. Number of secondary branches per plant	81
4.3.4. Number of leaves per plant	83
4.3.5. Leaf length (cm)	85
4.3.6. Leaf width (cm)	87
4.3.7. Leaf area (cm^2)	89
4.3.8. Number of flowers per plant	91
4.3.9. Final number of flowers per plant	93
4.3.10. Chlorophyll measurement (mg/g)	93
4.3.11. Shoot fresh and dry weight (g) per plant	95

Title	**Page No.**
4.3.12. Root fresh and dry weight (g) per plant	95
4.3.13. Analysis of leaf plant tissue (g)	97
4.4. Experiment four: Effect of urea levels on Wedelia plant	99
4.4.1. Shoot length (cm)	99
4.4.2. Number of primary branches per plant	101
4.4.3. Number of secondary branches per plant	103
4.4.4. Number of leaves per plant	105
4.4.5. Leaf length (cm)	107
4.4.6. Leaf width (cm)	109
4.4.7. Leaf area (cm^2)	111
4.4.8. Number of flowers per plant	113
4.4.9. Final number of flowers per plant	115
4.4.10. Chlorophyll measurement (mg/g)	115
4.4.11. Shoot fresh and dry weight (g) per plant	117
4.4.12. Root fresh and dry weight (g)	117
4.4.13. Analysis of leaf plant tissue (g)	119
CHAPTER FIVE	
5. DISCUSSION	
5.1. Effect of sulphur elemental on growth and flowering of Wedelia plant	121
5.1.1. Vegetative growth	121
5.1.2. Flowering	123
5.1.3. The shoot and root fresh/ dry weight (g)	124
5.1.4. Analysis of leaf plant tissue (g)	125

Title	**Page No.**
5.2. Effect of micro elements on growth and flowering of Wedelia plant	126
5.2.1. Vegetative growth	126
5.2.2. Flowering	129
5.2.3. Shoot and roots fresh/ dry weight (g)	130
5.2.4. Analysis of leaf plant tissue (g)	131
5.3. Effect of NPK fertilizer on vegetative growth and flowering of Wedelia plant	132
5.3.1. Vegetative growth	132
5.3.2. Flowering	136
5.3.3. Shoot and root fresh/ dry weight (g)	138
5.3.4. Analysis of leaf plant tissue (g)	139
5.4. Effect of urea fertilizer on vegetative growth and flowering of Wedelia plant	140
5.4.1. Vegetative growth	140
5.4.2. Flowering	142
5.4.3. Shoot and root fresh/ dry weight (g)	143
5.4.4. Analysis of leaf plant tissue (g)	144
CHAPTER SIX	
CONCLUSIONS AND RECOMMENDATIONS	145
CHAPTER SEVEN	
REFERENCES	146
Appendix (1)	162
Appendix (2)	163

LIST OF TABLES

Table		**Page No.**
1	Mean shoot length (cm) of Wedelia plant treated with five different levels of sulphur	34
2	Mean number of primary branches per plant of Wedelia plants treated with different levels of sulphur	36
3	Mean number of secondary branches per plant of Wedelia plants treated with five different levels of sulphur	38
4	Mean number of leaves per plant of Wedelia plant treated with five different levels of sulphur	40
5	Mean leaf length (cm) of Wedelia plant (*Wedelia trilobata* L) treated with five different levels of sulphur	42
6	Mean leaf width of Wedelia plant (*Wedelia trilobata* L.) treated with five different levels of sulphur	44
7	Mean leaf area (cm^2) of wedelia (*Wedelia trilobata* L.) plant treated with five different levels of sulphur	46
8	Mean number of flowers per plant of wedelia (*Wedelia trilobata* L.) plant treated with five different levels of sulphur	48
9	Mean final number of flowers per plant and chlorophyll (mg/g) of Wedelia plant treated with different levels of sulphur	50

Table		**Page No.**
10	Mean shoot and root fresh and dry weight (g) of wedelia plant treated with the different levels of sulphur	52
11	leaf contents of N, P and K (%) of Wedelia plant after adding different levels of sulphur	54
12	Mean shoot length (cm) of Wedelia plant treated with five different levels of micro- elements	56
13	Mean number of primary branches per plant of wedelia plant treated with five different levels of micro- elements	58
14	Mean number of secondary branches per plant of wedelia plant treated with five different levels of micro- elements	60
15	Mean number of leaves per plant of wedelia plant treated with five different levels of micro- elements	62
16	Mean leaf length (cm) of wedelia plant treated with five different levels of micro- elements	64
17	Mean leaf width (cm) of wedelia plant treated with five different levels of micro- elements	66
18	Means leaf area (cm^2) of wedelia plant treated with five different levels of micro- elements	68
19	Mean number of flowers per plant of wedelia plant treated with five different levels of micro- elements	70
20	Mean final number of flowers and Chlorophyll of Wedelia plant treated with five different levels of micro- elements	72

Table		**Page No.**
21	Mean shoot and root fresh and dry weight of wedelia plant treated with five different levels of micro- elements	74
22	leaf contents of N, P and K (%) of Wedelia plant after adding different levels of micro- elements	76
23	Mean shoot length (cm) of Wedelia plant treated with five different levels of NPK	78
24	Mean number of primary branches per plant of wedelia plant treated with NPK	80
25	Mean number of secondary branches per plant of wedelia plant treated with NPK	82
26	Mean number of leaves per plant of wedelia (*Wedelia trilobata* L.) plant treated with NPK	84
27	Mean leaf length (cm) of wedelia (*Wedelia trilobata* L.) plant treated with NPK	86
28	Mean leaf width (cm) of wedelia (*Wedelia trilobata* L.) plant treated with NPK	88
29	mean leaf area (cm^2) of wedelia (*Wedelia trilobata* L.) plant treated with NPK	90
30	Mean number of flowers per plant of wedelia (*Wedelia trilobata* L.) plant treated with NPK	92
31	Mean final number of flowers per plant and chlorophyll of Wedelia (Wedelia trilobata. L) Plant treated with NPK	94

Table		**Page No.**
32	Mean shoot and root fresh and dry weight (g) of Wedelia (*Wedelia trilobata* L.) plant treated with NPK	96
33	leaf contents of N, P and K (%) of Wedelia plant after adding different levels of NPK	98
34	Mean shoot length (cm) of wedelia (*Wedelia trilobata* L.) plant treated with urea	100
35	mean number of primary branches per plant of wedelia (*Wedelia trilobata* L.) plant treated with urea	102
36	Mean number of secondary branches per plant of wedelia (*Wedelia trilobata* L.) plant treated with urea	104
37	Mean number of leaves per plant of wedelia (*Wedelia trilobata* L.) plant treated with urea	106
38	Mean leaf length (cm) of wedelia (*Wedelia trilobata* L.) plant treated with urea	108
39	Mean leaf width (cm) of wedelia (*Wedelia trilobata* L.) plant treated with urea	110
40	mean leaf area (cm^2) of wedelia (*Wedelia trilobata* L.) plant treated with urea	112
41	Mean number of flowers per plant of wedelia (*Wedelia trilobata* L.) plant treated with urea	114
42	Mean final number of flowers per plant and chlorophyll of Wedelia (Wedelia trilobata L.) plant treated with urea	116
43	Mean shoots and roots fresh and dry weight (g) of Wedelia (*Wedelia trilobata* L.) plant treated with urea	118

Table		**Page No.**
44	leaf contents of N, P and K (%) of Wedelia plant after adding different levels of urea	120

CHAPTER ONE

INTRODUCTION

When most people think of groundcovers, they think of low-growing perennials, such as periwinkle (*Vinca minor*), Bugleweed (*Ajuga reptans*), Sweet Woodruff (*Gallium odoratum*) or Lily-of-the-Valley (*Convalaria majallis*) but Deciduous woody shrubs growing up to 4 feet tall can also fill the groundcover niche in different variety of soil types and different sun conditions (Blackburn and Bassuk, 2005).

Wedelia or Rabbits Paw *(Wedelia trilobata*. L.) is a member of the family Asteraceae the sunflower or daisy family. The species is commonly referred to by its former name, *Wedelia trilobata* (L). The genus *Wedelia* has about 70 species with tropical and subtropical distribution. The species is native to Mexico, Central America and throughout the Caribbean. As one of the most commonly introduced ornamental plants, *W. trilobata* has spread across vast regions of the world. It is becoming widely naturalized in South Africa, the southeast of USA (e.g. Florida and Louisiana), tropical Asia (e.g. Indonesia, Papua New Guinea, and southern China), northern and eastern Australia and many Pacific islands (e.g. American Samoa, the Cook Islands, and Fiji) (Zhonge *et al*., 2015).

It has been used in the landscape as an interesting groundcover in warm conditions. The species name "*trilobata*" comes from the latine for "3-lobed" of individual leaves. It is introduced from tropical America and propagated through division seeds or easily by tip cuttings. People like Wedelia because of its beautiful yellow-orange flowers and its fast growth habit. It is a mat forming perennial herb with rounded stems. New plants arise from nods that root at the soil surface. Seed production is low and generally does not reproduce prolifically via seed (Swaefy and Basuny, 2011).

The plant species is usually introduces as an ornamental or ground cover in gardens and reproduces by vegetative mode. It rapidly forms a dense ground cover, crowding away and preventing other plant species from regenerating. *W. trilobata* has been used as traditional folk medicinal plant for the treatment of various ailments (Raj Rv, 2018). With deeply lobed, fleshy leaves, growing up to 10 inch tall, spreading like a mat, it produces a dense cover, and blossoms profusely with orange and yellow flowers. It is an interesting source of potentially bioactive molecules such as iridoid compounds, flavonoids, diterpenoid derivatives, and phytosteriods with antioxidant, anti-inflammatory, anti-microbial, hepatoprotective, analgesic, antihistamine, anti-implantation, anti-asthmatic and anti-cancer activity (Keerthiga, *et al*. 2012)

Ashriya (2016) reported that beauty and suitability of *Wedelia trilobata* as landscape covering plant for Sudan, results showed that 35 cm spacing significantly gave better coverage without crowdedness when compared to either 20 or 50 cm spacing. Wedelia was easily propagated and maintained. It was highly resistant to insects.

The international market has identified two characteristics as key factors in consumer satisfaction: flower quality and longevity have proposed that these factors can be increased by properly managing production, especially nitrogen fertilization (Macz *et al*., 2001). The type of fertilizer selected should be based not only on its cost but also on the types of plants being fertilized, the existing nutrient content of the soil, and the type of growth response desired (Pennisi *et al*., 2020).

The remaining essential elements can be divided into primary macronutrients (N, P, K), secondary macronutrients (S, Mg, Ca) and micronutrients (Fe, Mn, Zn, Cu, B, Mo, Cl, Ni, Co) based on average concentrations in plants. Primary and secondary macronutrients are found in plants at levels of 0.2 to 5.0% or greater, while plant concentrations of micronutrients range from 0.1 to 100 µg/g (Alley and Vanlauwe, 2009). Application of intensive chemical fertilizers to the soil resulted in soil degeneration and environment deterioration. In the other way slow availability of the nutrients and more consistent rate; helping to retain soil moisture; improving soil structure and helping to prevent topsoil erosion (Nanik *et al*., 2010).

Nitrogen is vitally important plant nutrient, the supply of which can be controlled by man. An adequate supply of nitrogen is associated with vigorous vegetative growth and a deep green color. Nitrogen is considered a master element in plant nutrition. Nitrogen uptake as ammonium compounds form serves as starting material for amino acid biosynthesis and additional N-containing compounds such as pyrimidine, purine bases, chlorophyll, proteins, nucleic acid, vitamins, and other organic compounds, therefore, the higher plants require larger amount of nitrogen than is any of the mineral nutrients and the absence of an external supply of nitrogen reduced plant growth, root and stem growth also directly reduce photosynthesis, protein synthesis and respiration (Wahba *et al*., 2014).

Phosphorus is an essential nutrient for plant growth and reproduction. A large number of studies have shown that early season phosphorus supply is critical for optimum crop yield of many field-grown crops, which might have led to the practice of providing P starter fertilizers for greenhouse and nursery crop production, and this practice is still common (Kim and Li, 2016).

Potassium could be a soil exchangeable ion and is actively absorbed by plant root system. It an important element of the many soils and is ultimately derived from the weathering of soil parent materials within the soil. Also, it is regarded as an indispensable element for crop vegetative growth; as it is comprised in much metabolic process thorough activation of several key enzymes systems, protein biosynthesis, assimilate translocation, carbohydrate metabolism and movement of stomata (Ibrahim, 2017).

Sulphur (S) is one of four major macro elements, after nitrogen, phosphorus and potassium, which are considered as indispensable as far as appropriate plant growth and development are concerned (Cholewa and Kieloch, 2015).

According to Eisa *et al*. (2016) the functional chloroplasts are normally rich in sulfur and the chloroplast morphology is considerably affected by sulfur deficiency. Sulfur deficiency upsets photosynthesis in a profound way which, after radiation of external sulfate, can only be corrected slowly through the synthesis of new protein and chloroplasts.

On the other hand, application of chemical fertilizers intensively to the soil resulted in soil degeneration and environment deterioration (Setyowat *et al*., 2010). Micronutrients are to be necessarily taken up by the plants from soil or supplemented through foliar application for good growth and yield of crops and maximizing the efficient use of applied N, P and K. Due to unbalanced use of micronutrient, the plant growth, development and quality of flower are directly affected (Sarkar *et al*., 2020).

Foliar fertilizers are extensively used in vegetable, fruit crops and ornamental plants that contain various macro and micronutrients, which are necessary for the proper growth and yield (Bashir *et al*., 2013).

In Sudan, the response of *Wedelia trilobata* (L.) to chemical nutrition has not been studied as yet, and was not reported earlier from the present Sudan territory by any of the previous workers, this is being recorded here for the first time for Sudan.

There for, the present study was initiated with the following objectives:

1- Observe the effects in the different nutrients of *Wedelia trilobata* and to compare these effects with unnutrients plants (control).
2- To determine the growth and flowering responses of Wedelia trilobata plants to different nutrients in different concentrations.
3- To identifies the major nutrients and suitable for *Wedelia trilobata* growth and flowering.
4- To observe the effects in macro and micronutrients at different stages of plant and effects in different concentration of *Wedelia trilobata growth* and flowering.

CHAPTER TWO

LITERATURE REVIEW

2.1. Scientific names:

Wedelia, now known officially by the scientific name, *Wedelia trilobata* L. (Thaman, 1999). It is a member of the family *Asteraceae* the sunflower or daisy family. *Wedelia trilobata* L is a soil creeper and forms a thick carpet. The genus has about 70 species with tropical and subtropical distribution (Raj Rv, 2018).

In plantations, it will compete with crops for nutrients, light and water, and reduce crop yields. The genus *Wedelia*, named in honor of George Wolfgang Wedel (1645-1721), Professor of Botany at Jena, Germany, comprises about 70 tropical and subtropical species. Though, it is widely known as *Wedelia trilobata* (Emmanuel *et al*., 2018).

The most widely used common name in the Pacific is "*Wedelia*" (after its former genus), although in Australia it is known as "Singapore daisy", in spite of its tropical American origin. Other common names include trailing or creeping daisy, water zinnia, rabbit's paw and creeping or Bay Biscayne oxeye (Thaman, 1999).

2.2. Description of Wedelia:

2.2.1. Habitat:

It is a weed of urban bush land, closed forests, forest margins, open woodlands, water ways, lake margins, wetlands, roadsides, disturbed sites, waste areas, vacant lots, and coastal sand dunes in tropical and sub-tropical regions. It may also encroach into lawns, footpaths and parks from nearby gardens (Neelam *et al*., 2013).

According to Swaefy and Basuny, (2011) showed that Wedelia has been used in the landscape as an interesting groundcover for warm locations, and it has high tolerance to high temperature. Also, it is fairly salt resistant and grows well at the seashore. It needs regular water and fast draining soils. It is especially good for soil retention and erosion control.

When most people think of groundcovers, they think of low-growing perennials, such as periwinkle (*Vinca minor*), Bugleweed (*Ajuga reptans*), Sweet Woodruff (*Gallium odoratum*) or Lily-of-the-Valley (*Convalaria majallis*) (Jamie, 2005).
It would be hard to find another groundcover better suited to hot, dry conditions than wedelia. Attractive, glossy, dark green, lobed leaves, rapidly spreading growth habit, and a continuous display of small, bright yellow, daisy-like blooms create a much-favored landscape plant (Edward, 1999).

2.2.2. Geographical Distribution:

Wedelia is native to India, Chittor district, Mexico, Central America(i.e. Belize, Costa Rica, Guatemala, Honduras, Nicaragua and Panama and throughout the Caribbean, where it is noted as a weed in Trinidad, Puerto Rico, the Dominican Republic, Jamaica, Panama and tropical South America(i.e. French Guiana, Guyana, Surinam, Venezuela, Brazil, Bolivia, Colombia, Ecuador, and Peru). Naturalized in South Africa, Florida, Louisiana, Hawaii, Puerto Rico, and the Virgin Island. Escaped in many tropical regions of the world including Australia (south-eastern Queensland and north-eastern New South Wales). The Pacific Island (i.e. American Samoa, the Cook Island, Fiji, French Polynesia, Guam, Kiribati, the Marshall Islands, Nauru, Niue, New Caledonia, Palau, Western Samoa, Tonga, and Hawaii), Malaysia, Indonesia, India, Papua New Guinea (Sai Prasanna *et al*., 2019), and wide ranging throughout tropical America, in western and northern South America and possibly Florida, this invasive species can also be found in Thailand (Nuttakorn *et al*., 2017).

It is cultivated throughout much of the tropics and subtropics as an ornamental groundcover. It is closely related to the wide spread tropical strand plant or beach daisy (Thaman, 1999).

2.2.3. Botanical Description:

A tropical perennial medicinal herb, with deeply lobed, fleshy leaves, growing up to 10 inch tall with a creeping habit (Keerthiga *et al*., 2012) . The stems are rounded, green or reddish in color with trichomes on it. They grow up to 2 m long with adventitious roots at their nodes. Short, semi-upright (ascending), flowering branches are produced of these creeping stems. The leaves are bright green, simple and show opposite phyllotaxy. These leaves 2-9 cm long and 2-5 cm wide, acute at the apex and winged and sessile at the base usually have three lobes (hence the name *trilobata*) and irregularly toothed (serrated) margins. The single attractive bright yellow flower heads are borne on the end of terminal and axillary stalks (peduncles), with 2 to 4 whorls of bracts forming the involucre at the base of the head. Each head has 8-13 ray florets that are 6-15 mm long with 1- to 3 finely toothed tips and pistillate. In the center of these flower-heads there are numerous tiny yellow tubular disc florets 4-5 mm long, and mixed with chaffy bracts. Both ray and disc florets are yellow. The base of each capitulum is enclosed in a row (involucre) of narrow (lanceolate) green bracts. Flowering occurs throughout the year, but is most common from spring to autumn. The fruit is a 2 to 4-angled achene, with short, narrow pappus scales on the top. The seeds, when present, are 4-5 mm long and topped with a crown of short fringed scales. They are elongated in shape, brown in color and have a rough surface texture (Raj Rv, 2018). However, Neelam *et al*., (2013) reported that very few seeds reach maturity in cultivated or naturalized Plants in Australia.

2.3. Uses and managements:

A large proportion of the world's introduced ornamental plants have become invasive in areas where they were purposely introduced. The intentional import of species for horticultural, landscape, or agricultural purposes contributes most to the presence of alien floras in many regions. For instance, 52% of naturalized alien plant species in Europe were introduced for ornamental or horticultural purposes and 82% of invasive woody plants, in the United States were used by the landscaping sector, In Germany, 50% of the alien flora consists of deliberately introduced species, and more than half of these are ornamentals. The deleterious effects of invasive ornamental plants on economies and biodiversity of natural areas have raised serious concerns in recent years (Zhong *et al*., 2015)**.**

People like Wedelia because of its beautiful yellow-orange flowers and it's fast Growth habit (Swaefy and Basuny, 2011).

Suited to a wide variety of condition, wedelia will cover rough, rocky ground or wet drainage ditches, and even tolerates some degree of foot traffic. Producing the most bloom in full sun, frost-free locations, wedelia will grow in shade and still bloom, wedelia' s rapid growth quickly returns with warm weather (in the northern part of USDA hardiness zone 9), the long, creeping stems rooting where ever they touch moist soil. Set the plants on 18- inch- centers. Creating a dense mat of foliage. Wedelia rarely needs pruning to control its height but can tolerate severe trimming, even occasional mowing on a high setting, if plants need to be rejuvenated. Wedelia has a vine-like habit and will grow up into shrubs and trees planted in the bed. When used as a groundcover in and among shrub, this will make it a high maintences plant. It looks best planted in a mass over large area. Like ivy and other creepers, it will require regular trimming along the edge of the groundcover bed to control its spread. It may be best used as a container plant where it will cascade over the side forming a weeping mound of yellow flowers. It has escaped cultivation in certain areas of south Florida where it proliferates, especially in wet areas. Propagation is easily accomplished by setting uprooted tip cuttings in the landscape soil where new plants are wanted, or by layering, the stems rooting quickly. Though relatively study, wedelia can occasionally is infected with chewing insects and mites. No diseases are of major concern (Edward, 1999).

W. trilobata is applied to paddy field as an organic fertilizer and used as green manure for dry land crops by local peasants (Chethan *et al*., 2012) Compost, green manure, animal manure and plant manure, agriculture-based. Industrial waste and municipal waste can be used as source of organic matter. Weeds also can be used as a source of organic fertilizer, wedelia (*Wedelia trilobata*) is green manure increased the growth and yield. Inorganic fertilizer was also can be substitute by organic fertilizer of wedelia. In addition, *Wedelia trilobata* fallow had promising effects on pool soil carbon, pool soil nitrogen and soil structure in the low altitude sites (Nanik *et al*., 2010).

Green plants always fascinate us with their remarkable source of biochemical components. Ancient literature tells as their usage as traditional health remedies is the most popular for 80% of world population in Asia, Latin America and Africa with minimal side effects Presence of these compounds makes them commercially significant. Now a day, many pharmaceutical companies have spent a lot of time and money in developing natural products extracted from plants, to produce more cost effective medicines that are affordable to the common man (Raj Rv, 2018).

2. 4. Ethno pharmacological Uses:

Nisreen and Anil, (2017) reported that *Wedelia trilobata* has been historically used as traditional folk medicinal plant for the treatment of various ailments, fruits, leaves and stem are used in childbirth and in the treatment of bites and stings, fever and infection. Leaves are used in the treatment of kidney dysfunction, cold (The crushed leaves are used as poultice in tea to reduce the symptoms of cold and flu). Wounds and amenorrhea and dysmenorrhea (Raj Rv, 2018). It has a very old tradition of wide medicinal use it a high reputation in Ayurveda, Unani, Siddha, and Traditional Chinese medicine and also in traditional systems of healing in the Caribbean, Central and South America. The extracted essential oil of *Wedelia trilobata* has been found to act itself as an antioxidant, antibacterial, antifungal, anti-inflammatory, cough relieving agent, hepatoprotective, febrifuge, immuno-stimulatory and analgesic agent (Sai Prasanna *et al*., 2019).

Additionally, there are reports indicating that worldwide, over 1200 species of plants have been recorded as traditional medicine for diabetes. Although most of these species have not undergone rigorous scientific evaluation, over 80% of those that have been tested show antidiabetic activity (Kade *et al*., 2010).

The aerial parts of this plant are used in traditional medicine in the Caribbean and Central America against and even as a fertility enhancer. In folk medicine, it is employed to treat backache, muscle cramps, rheumatism, stubborn wounds, sores and swellings, and arthritic painful joints. The Miskito Indians of eastern Nicaragua use leaves for treatment of kidney dysfunctioning, cold, stingray wounds, snakebite, purge and amenorrhea. *W. trilobata*, was utilized in Hong

Kong as a substitute for *W. chinensis*, a traditional Chinese medicine used for the treatment of the common cold, hepatitis, indigestion and infections. In Trinidad and Tobago, used for reproductive problems, amenorrhea, dysmenorrheal. It is used for the treatment of fever and malaria in Vietnam (Neelam *et al.*, 2013).

The plant blooms profusely with one yellow-orange flower resemble marigolds or zinnias, which are borne singly at the end of each stem. The synergistic effects of active compounds in a related species, Wedelia chinensis have their potential against prostate cancer prevention and therapy. *Wedelia paludosa* and *W. trilobata* contain diterpene, eudesmanolide lactones and luteolin with a variety of biological activities, which have antimalarial activity. *Wedelia calendulacea* is also known as good hepatoprotective plant against acute hepatotoxicity in rats, *W. trilobata* is applied to paddy field as an organic fertilizer and used as green manure for dry land crops by local peasants. The literature reveals that the fresh plant is used in molluscicidal activity. This plant is a potential candidate in the management of pathological conditions in human models of diabetes (Chethan *et al*., 2012).

2.5. Essential Nutrients for Plant Growth:

Plants, like all other living things, need food for their growth and development. Plants require 16 essen- tial elements. Carbon, hydrogen, and oxygen are derived

from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, manganese, copper,

Boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organic matter or by organic or inorganic fertilizers (Uchida, 2000).

Also, Alley and Vanlauwe, (2009) mentioned that, eighteen elements have been shown to be essential for higher plants: carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), sulphur (S), magnesium (Mg), calcium (Ca), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl), nickel (Ni) and cobalt (Co). All elements are not essential for all plants. Carbon, H and O are obtained from the atmosphere and water, and are not considered mineral elements. The remaining essential elements can be divided into primary macronutrients (N, P, K), secondary macronutrients (S, Mg, Ca) and micronutrients (Fe, Mn, Zn, Cu, B, Mo, Cl, Ni, Co) based on average concentrations in plants. Primary and secondary macronutrients are found in plants at levels of 0.2 to 5.0% or greater, while plant concentrations of micronutrients range from 0.1 to 100 µg/g.

For plants to utilize these nutrients efficiently, light, heat, and water must be adequately supplied. Cultural Practices and control of diseases and insects also play important roles in crop production. Each type of plant is unique and has an optimum nutrient range as well as a minimum requirement level. Below this minimum level, plants start to show nutrient deficiency symptoms. Excessive nutrient uptake can also cause poor growth because of toxicity. Therefore, the proper amount of application and the placement of nutrients are important. Soil and plant tissue tests have been developed to assess the nutrient content of both the soil and plants. By analyzing this information, plant scientists can determine the nutrient need of a given plant in a given soil. In addition to the levels of plant-available nutrients in soils, the soil pH plays an important role in nutrient availability and elemental toxicity (Uchida, 2000).

2.5.1. Macro elements:

2.5.1.1. Nitrogen:

Symbol: N; available to plants as nitrate (NO_3^-), and ammonium (NH_4) ions. Farmers use chemical fertilizers to improve soil fertility and hence increase the yield of their crops. However, the use of chemical fertilizers causes a great impact on the soil quality and the surrounding environment the main nutrients added in fertilizer are nitrogen, phosphorus, potassium, other nutrients are added in small amounts (Ahmed *et al*., 2017).

Wahba *et al*., (2014) reported that nitrogen is considered a master element in plant nutrition. Nitrogen uptake as ammonium compounds form serves as starting material for amino acid biosynthesis and additional N-containing compounds such as pyrimidine, purine bases, chlorophyll, proteins, nucleic acid, vitamins, and other organic compounds, therefore, the higher plants require larger amount of nitrogen than is any of the mineral nutrients and the absence of an external supply of nitrogen reduced plant growth, root and stem growth also directly reduce photosynthesis, protein synthesis and respiration. Nitrogen has an important role in plant metabolism that affects quantitative and qualitative plant production by stimulating the growth and activating the vital processes in the plant to increase the active substances were studied by many investigators.

2.5.1.1.1. Effect of Nitrogen fertilizers on growth of plants:

Nitrogen is considered to be the most crucial because it is a constituent of protein and nucleic acid which is helpful in plant growth as well as to promotes rapid growth. This is because of higher concentration of nitrogen, which has tendency to increase leaf cell number and cell size with an overall increase in leaf production as reported (Ahmed *et al*., 2017).

A reported by Khan and Ahmad, (2004) in Gladiolus showed that application of N in two equal splits applied at 30 and 60 days after planting promoted sprouting. Another study of Abd El Gayed and Attia, (2018) in *Celosia argentea* showed that Four doses e.g. 0.0, 1.5, 3.0 and 4.5 g/pot of compound fertilizer NPK (20:20:20) were allocated in subplots. The chemical fertilizer NPK (20:20:20) was applied after one month from transplanting.

Pérez *et al*., (2014) found that vegetable production requires large quantities of this element, because it is a constituent of protein, many related metabolites synthesis and energy transfer and nucleic acids, therefore plays an important role in the quality of crops. The NH_4^+ is the inorganic form of N assimilation; if the NH_4^+ is the only N source, it generally has harmful effects on the growth of plants and may result in symptoms of toxicity in many of them; this is due to irreversible alteration of the structure of the thylakoid membrane. For example, cucumber plants were grown in a constant concentration of 5 mm NH_4^+ its growth decreased, meaning that it is a sensitive species. In potato, N uptake in the initial phase of development was in the form of NH_4^+, after 56 d (tuber formation) was asNO_3^-. When, the addition of NH_4^+ to nutrient solutions formulated with NO_3 allows increasing the N absorption rate in rose plants in hydroponics during stem elongation.

On the other hand ALI, S. R. – ÇIG, A, (2018) mentioned that fertilizers are required to bring out the best features of ornamental potted plants. For natural plants to grow and increase they need a number of chemical elements.

Also, Wade, (2011) reported that newly planted ground covers are generally fertilized more frequently than well-established groundcovers to encourage rapid plant establishment and spread. Apply fertilizers during the growing season (March to October) when plants are actively growing. A general purpose fertilizer, such as 10-10-10, applied at four- to six-week Intervals at a rate of 1 pound per 100 square feet during the growing season will encourage rapid plant establishment.

2.5.1.1.2. Nutrient functions:

- N is biologically combined with C, H, O, and S to create amino acids, which are the building blocks of proteins. Amino acids are used in forming protoplasm, the site for cell division and thus for plant growth and development.
- Since all plant enzymes are made of proteins, N is needed for all of the enzymatic reactions in a plant.
- N is a major part of the chlorophyll molecule and is therefore necessary for photosynthesis.
- N is a necessary component of several vitamins.
- N improves the quality and quantity of dry matter in leafy vegetables and protein in grain crops (Uchida, 2000).

2.5.1.2. Effect of Phosphorus on growth of plants:

Symbol: P; available to plants as orthophosphate ions (HPO_4^{2-}, $H_2PO_4^{-}$). Phosphorus is an essential nutrient for plant growth and reproduction. Intensive use of P fertilizers for crop production has led to eutrophication and deterioration of water quality, causing serious environmental concerns. P used in fertilizers is obtained from global phosphate rock reserves, and is a nonrenewable resource that could be depleted in 50–100 years, and therefore, increasing the efficiency with which these reserves are used to produce crops is vital to maintain or increase crop productivity in current crop production systems. P can lead to a loss of crop productivity and yield, and therefore, it is critical to precisely determine the P requirements of crops to ensure crop production and meet the growing environmental challenges, there are only a few reports on the effects of P fertilization on partitioning in relation to their productivity. Such information is critical as it will help design more efficient management strategies for P fertilizer by better aligning the P requirements of crops and the application amount and timing of the nutrient (Kim and Li, 2016).

Ryan and Rashid, (2005) mentioned that all the nutrient elements support life on this earth, phosphorus (P) is the most vital. It comes from the soil itself, which is dependent on P concentration in the rocks from which the soil was formed, or from fertilizers. Soil P deficiency, on a global basis, has negative implications for crop yields and the entire food chain. The widespread use of fertilizers in the developed world largely eliminated serious cases of P deficiency in crops, animals, and humans and was a major factor contributing to increase in food production to feed the world's expanding population.

Also, Razaq *et al*., (2017) reported that Phosphorus, essential for many physiological processes, especially energy functions, is also a major component of numerous plant structural compounds. Some generalizations on soil –plant P relations follow. P plays an important role in lateral root morphology and root branching and influences not only root development, but also the availability of nutrients.

It is essential to assess the single super phosphate as a cheaper source of phosphorus. Single super phosphate not only contains phosphorus but also contain calcium and sulphur, which are essential for the growth of plant (Kalbhor *et al*., 2015).

Saputra *et al*., (2019) on Viola found that the addition of both P and K fertilizers in the vegetative and P in the generative stage, can result in the productivity of

3.28 g $plant^{-1}$ and produce germination energy ≥90%. It is recommended for increasing growth and seed production.

2.5.1.2.1. Nutrient functions:

- In photosynthesis and respiration, P plays a major role in energy storage and transfer as ADP and ATP (adenosine di- and triphosphate) and DPN and TPN (di- and triphosphopyridine nucleotide).
- P is part of the RNA and DNA structures, which are the major components of genetic information.
- Seeds have the highest concentration of P in a mature plant, and P is required in large quantities in young cells, such as shoots and root tips, where metabolism is high and cell division is rapid.
- P aids in root development, flower initiation, and seed and fruit development.
- P has been shown to reduce disease incidence in some plants and has been found to improve the quality of certain crops (Uchida, 2000).

2.5.1.3. Effect of Potassium on growth of plants:

Symbol: K; available to plants as the ion K+. El-Naggar and El-Nasharty, (2016) reported that Potassium is one of the most important macronutrients that affect growth of plants. It is involved in numerous biochemical and physiological processes vital to plant growth, yield, and quality. Potassium plays roles in regulating the opening and closing of stomata and water retention. It promotes the growth of meristematic tissue, activates some enzymatic reactions, aids in nitrogen metabolism, and the synthesis of proteins, catalyzes activities of some mineral elements, and aids in carbohydrate metabolism and translocation.

Potassium is more mobile in the soil than phosphorus but less than nitrates, which can be readily leached from light sandy soil.

Potassium could be a soil exchangeable ion and is actively absorbed by plant root system. It an important element of the many soils and is ultimately derived from the weathering of soil parent materials within the soil, also it is regarded as an indispensable element for crop vegetative growth (Ibrahim, 2017).

Potassium (K) is an essential element for plant nutrition and its ability to influence meristem growth, water status, photosynthesis , long distance transport of assimilates, enhance many enzyme actions, helps translocate sugars and starches, increase protein content as well as control ionic balance Potassium works as a catalyst in many biosynthetic reactions of the photosynthesis and the element K is involved in the synthesis of amino acids and gives resistance to plant against diseases (Khan *et al*., 2012).

Hatamian and Souri, 2018 found that Chlorophyll content and efficiency of photosynthesis of plant leaves have positive correlations with nitrogen and potassium levels.

Also, Khan *et al*., 2012 reported that in the absence of adequate dose of K, higher doses of N are not beneficial to flower quality due to nutritional imbalance. Nitrogen, phosphorus, and potassium greatly influence the growth and flowers.

2.5.1.3.1. Nutrient functions:

- Unlike N and P, K does not form any vital organic compounds in the plant. However, the presence of K is vital for plant growth because K is known to be an enzyme activator that promotes metabolism.

- K assists in regulating the plant's use of water by controlling the opening and closing of leaf stomates, where water is released to cool the plant.
- In photosynthesis, K has the role of maintaining the balance of electrical charges at the site of ATP production.
- K promotes the translocation of photosythates (sugars) for plant growth or storage in fruits or roots.
- Through its role assisting ATP production, K is involved in protein synthesis.
- K has been shown to improve disease resistance in plants, improve the size of grains and seeds, and improve the quality of fruits and vegetables (Uchida, 2000).

2.5.1.4. Effect of sulphur on growth of plants:

Symbol: S; available to plants as the sulphate ion, SO_4^{2-}.Sulphur is now recognized as the fourth major plant nutrient after N, P and K globally and crop responses to S fertilization have been reported from Asia, Africa, Europe, north America, south America and Oceania. Sulphur is now considered as an important component of balanced fertilization of crops. Sulphur is an essential macronutrient for microorganisms, plants, animals and humans. Proteins store most S as regards to its abundance, in both plants and humans. Sulphur in soil comes from the sulphur containing minerals present in parent materials in rocks from which the soils are derived and from the plant and animal residues or from the external addition of elemental S or its minerals (Prasad and Shivay, 2016).

Vala *et al*., (2014) reported that Sulphur takes time to become available to plants. Bahadur and Bala, (2017) found that application of S as sulphate increases crop yield. Sulphur application affects crop yield through the effect on S use efficiency and its components (uptake efficiency and utilization efficiency).

The deficiency of (S) has been reported with increasing frequency over the past several years all over the world (Aulakh, 2003).

Kopriva *et al*., (2019) reported that Sulphur deficiency affects the growth, development, disease resistance, and performance of plants and has a great impact on the nutritional Quality of crops.

Sulphur is an essential nutrient for all living organisms. However, S deficiency was rare before the 1990s, due to the presence of S in fertilizers and atmospherics deposition. Over the last decade the S balance has shifted toward deficit as a result of decreased S pollution, increased use of non S-containing fertilizers and increased crop yields (Zhao *et al*., 2001).

McKenzie, (2013) found that Sulphur is essential in the structural and enzymatic components in plants, with total S content in plant tissues ranging from 0.3% to 7.6%.

Plant nutrition due to sulphur deficit has become one of the important problems in modern agriculture, especially in the Northern European countries and many other countries all over the world. The data by the Sulphur Institute, Washington, indicate that in 2000 global sulphur deficit reached 7.5 million tons per year (Scherer, 2001).

According to the Sulphur Institute (TSL), plant nutrient sulphur deficit in 2010 (in tons) was 5.8 mln in Asia, 1.5 mln in North America , 1.5 mln in Africa, 0.9 mln in Latin America and 1.0 mln in Europe. It is estimated that in 2015 the mentioned deficit will amount 12.5 million tons per year (Cholewa and Kieloch, 2015).

2.5.1.4.1. Nutrient functions:

- S is essential in forming plant proteins because it is a constituent of certain amino acids.
- It is actively involved in metabolism of the B vitamins biotin and thiamine and co-enzyme A.
- S aids in seed production, chlorophyll formation, nodule formation in legumes, and stabilizing protein structure (Uchida, 2000).

2.5.2. Micro elements:

Micronutrients such as Fe, Mn, B, Cu, Zn, Mo, Ni and Co are necessary in much lesser amount and essential for plant intensification than those of the primary nutrients. Their adequate concentrations in plants are generally below the 100 parts per million (ppm) level (Lohry, 2007). These are essential because of their immense connotation and involvement to enzyme system in metabolism (Bilal *et al*., 2020).

Micronutrients are to be necessarily taken up by the plants from soil or supplemented through foliar application for good growth and yield of crops and maximizing the efficient use of applied N, P and K. Due to unbalanced use of micronutrient, the plant growth, development and quality of flower are directly affected. Therefor the balanced nutrient application is necessary for healthy plant growth and production of quality flower. In the absence of micronutrients, the plants are known to suffer from physiological disorders which eventually lead to imbalanced growth and low yield of flower (Sarkar *et al*., 2020).

Moreover, Yadegari, (2016) reported that foliar fertilizer is particularly useful technique which can be designed to meet plants specific needs for one or more micro or macronutrients especially trace minerals and enable to correct deficiencies, strengthen weak or damaged crops, speed growth and grow better and healthier plants.

Bilal *et al*., (2020) revealed that foliar fertilization of nutrients can be a useful method of providing balanced plant nutrition in horticulture. Many studies have highlighted the benefits of foliar fertilization in improving plant growth, crop yield, nutrient uptake and product quality.

Foliar fertilization can be sprayed at optimum times and concentrations, according to the requirement of different plants, at different growth ages. This type of fertilization can be more suitable to the plant's needs, in contrast to root fertilization. Foliar fertilization increases micronutrient uptake and physiological and biochemical indexes. Many studies suggest that foliar fertilization may help to stimulate the uptake of soil applied fertilizers, which could provide a solution to salt accumulation in the soil (Bilal *et al*., 2020).

El-Naggar and El-Nasharty, (2016) reported that foliar fertilization is more economical than root fertilization due to the efficiency and lower cost. Foliar application is also less likely to result in ground water pollution.

Also, Bilal *et al*., (2020) revealed that foliar application of micronutrients may be six to 20 times more efficient than soil application in increasing crop production and other growth parameters.

2.5.2.1. Boron:

Symbol: B. Available to plants as borate, H_3BO_3.. Boron is an important micronutrient because of its part in the fertilization and flowering process. It has been known to be component of plants since 1857. Boron application also significantly influenced physical characteristics of plant (Qureshi *et al*., 2015).

2.5.2.1.1. Nutrient functions:

- B is necessary in the synthesis of one of the bases for RNA formation and in cellular activities.
- B has been shown to promote root growth.
- B is essential for pollen germination and growth of the pollen tube.
- B has been associated with lignin synthesis, activities of certain enzymes, seed and cell wall formation, and sugar transport (Uchida, 2000).

Boron deficiency produces in different parts of plants as a wide variety such as internodes becoming nearly shorter and brittle leaves. Flowering is often totally suppressed and flower often fall (Karuppaiah, 2019).

2.5.2.2. Iron:

Symbol: Fe; available to plants as Fe_{2+}, Fe_3+. Iron (Fe) is important to plant growth and development and is integral to many enzymatic functions (Cockson *et al*., 2021).

2.5.2.2.1. Nutrient functions:

- Fe is essential in the heme enzyme system in plant metabolism (photosynthesis and respiration). The enzymes involved include catalase, peroxidase, cytochrome oxidase, and other cytochromes.
- Fe is part of protein ferredoxin and is required in nitrate and sulfate reductions.
- Fe is essential in the synthesis and maintenance of chlorophyll in plants.
- Fe has been strongly associated with protein metabolism (Uchida, 2000).

2.5.2.3. Manganese:

Symbol: Mn; available to plants as Mn^{2+}, Mn^{3+}. Manganese serves as an activator for enzymes in growth processes. It assists iron in chlorophyll formation. It is part of the system where water is split and oxygen gas is liberated (Lohry, 2007).

2.5.2.3.1. Nutrient functions:

- Mn primarily functions as part of the plant enzyme system, activating several metabolic functions. It is a constituent of pyruvate carboxylase.
- Mn is involved in the oxidation-reduction process in photosynthesis.
- Mn is necessary in Photosystem II, where it participates in photolysis.
- Mn activates indole acetic acid oxidase, which then oxidizes indole acetic acid in plants (Uchida, 2000).

2.5.2.4. Zinc:

Symbol: Zn; available to plants as Zn ++. Zinc (Zn) is an essential micronutrient for plants and humans. It is a structural component of many catalytic enzymes and transcription factors (Chen and Ludewig, 2017).

Cockson *et al*., (2021) reported that zinc plays an important role in plants. It is present in many plant enzymes, plays a role in mitigating the production of ethanol under aerobic conditions within meristematic regions.

2.5.2.4.1. Nutrient functions:

- Zn is required in the synthesis of tryptophan, which in turn is necessary for the formation of indole acetic acid in plants.
- Zn is an essential component of several metallo-enzymes in plants (variety mdehydorgenases) and therefore is necessary for several different functions in plant metabolism.
- The enzyme carbonic anhydrase is specifically activated by Zn.
- Zn has a role in RNA and protein synthesis (Uchida, 2000).

CHAPTER THREE

MATERIALS AND METHODS

3.1. Experiment site:

Experiments were conducted during 2018/19 (from March to August) at Shambat, in the nursery of the Department of Horticulture, College of Agricultural Studies, Sudan University of Science and Technology, Khartoum, Sudan.

The mean maximum and minimum temperatures were 38.4ºC and 22.5ºC, respectively, during the growing season. Average relative humidity was 12% and average rainfall was 0.0 mm / annum in the first season. In the second season the mean maximum and minimum was 35.2ºC and 25.3ºC, respectively, during the growing season. Average relative humidity was 56%, and average rainfall was 0.0 mm / annum (Appendix 1).

3.2. Plant materials:

Wedelia plants used in the study were introduced from College of Agricultural Studies, Sudan University of Science and Technology. Vegetative cutting, with length of 20- 30 cm were planted in polyethylene bags and maintained under the Sun.

3.3. Fertilizers:

Different fertilizer treatments were applied to Wedelia plants. These included:

3.3.1. Control without nutrient.

3.3.2. Sulphur in concentrations of 0.0, 0.2, 0.4, 0.8 and 1.6 g/plant. Each plant were received a basal dressing of 2.0 g Di-ammonium phosphate.

3.3.3. Micro-elements: 50 mg/L of FeSO4.7H2O, MnSO4.5H2O, ZnSO4.5H2O and Boric Acid were compared with a control. Each plant received a basal dressing of 2 g NPK.

3.3.4. NPK (20:20:20) concentrations of 0,1,2,4 and 8 g/plant. Each plant received a basal dressing of 0.5 g sulphur (S).

3.3.5. Urea CO (NH2)2 in concentrations of 0.0, 1.5, 3.0, 4.5, and 6.0 g/plant. Each plan received a basal dressing of 0.5 g sulphur (S) and 1.0 g super phosphate (P_2O_5).

3.4. Treatments:

The experiment included 20 treatments randomization of 4 plants × 5 nutrients.

3.5. Cultural practices:-

3.5.1. Soil preparation: Wedelia were planted in a soil mix of: 1sand: 2 River Nile Sedimentary soil (Gureira) in 30×60 cm black polythene bags.

3.5.2. Irrigation:

Irrigation was conducted daily during plant growth, and then irrigated every other day in the summer and every three days after in the winter. Weed control was done manually.

3.6. Nutrition:

The mineral nutrients (sulphur, micro-elements, NPK, and urea) were applied as eight dosses every 40 days after planting from 12 March 2018 to 15 January 2019.

3.7. Data collection:

3.7.1- Plant growth parameters:-

One and healthy plant, from four plants in each polyethylene bag was selected to measure the following parameters:-

3.7.1.1- Number of leaves per plant:-

The number of leaves was determined by counting all leaves per plant.

3.7.1.2- Number of primary branches per plant:-

The number of branches was determined by counting the green and dry branches per plant.

3.7.1.3- Number of secondary branches per plant:-

The number of secondary branches was determined by counting the green and dry branches per plant.

3.7.1.4- Shoot length (cm):-

The plant length was measured from the surface of the soil level to the tip of the plant in centimeter (cm) using distance meter.

3.7.1.5- Leaf length (cm):-

Leaf length was taken from longest leaf from each plant, from the base of the leaf to the apex of the leaf in centimeter (cm) using standard ruler.

3.7.1.6- Leaf width (cm):-

Leaf width was taken from display leaf from each plant; it was from the middle left margin of the leaf to the middle right margin of the leaf in centimeter (cm) using standard ruler.

3.7.1.7- Leaf area (cm^2):-

Leaf area was calculated according to Rodomiro *et al*., (1997)

$$\text{Leaves area} = \text{leaf length} \times \text{leaf width} \times 0.8$$

3.7.2- Yield components:

3.7.2.1- Number of flowers per plant:-

The number of flowers was determined by counting the fresh and dry flowers per plant.

3.7.2.2- Final number of flowers per plant:-

The final number of flowers was determined by counting the fresh and dry flowers per plant after month from the last measure parameters.

3.7.2.3- Chlorophyll Content:-

Determination of leaf chlorophyll (Chl) content (SPAD) was performed according to the method of Arnon, (1949) by using the Plant chlorophyll flourometer (Li- Cor, Lincoln, NE, USA). Two hundred milligrams of fresh leaf samples were ground with 10 ml of 80 % acetone at 4ºC and centrifuged at 2500 rpm for 10 minutes at 4ºC. Three milliliters aliquots of the extract were transferred to cuvette and the absorbance was read at 665 and 649 nm with spectrophotometer after with the chlorophyll was determined by Vernon's models.

3.7.2.4. Analysis of plant tissue (dry Ashing):-

Aweigh of 1 g of dried, ground plant tissue was placed in a porcelain crucible. and ashed in muffle furnace at 500 °C for overnight. Cool and dissolve the ash in 5-mL of 20% HCl, warming the solution, if necessary, to dissolve the residue. Filter the solution through an acid washed filter paper into a 50-mL volumetric flask.

Dilute the solution to volume with deionized water and mix well (A A S, 1994).

$$Mg/k = \frac{R \times V}{Wt}$$

R= reading in mg/L

V= volume of glass wave

wt= weight of dry sample

Every R× 2 s mg/kg

$$g\% = \frac{R \times V \times 100}{10^{6} \times wt}$$

R= reading in mg/L

V= volume of glass wave

106= factor mg/L

Wt= weight of dry sample

3.7.2.5. Shoot and root of fresh and dry weight (g) / plant:-

The fresh shoot and root weight of the every plant were recorded and then dried in oven at 80°C for 48 hours to constant weight.

3.8. Experiment design and Statistical analysis:

A Completely randomized design with four replications was used to layout the experiments. Each plant in a bag was considered a replicate. The data were analyzed using GenStat (Computer Program) Version 4 and the means were separated using Duncan (1955) Multiple Range Test (DMRT) at $P \leqslant 0.05$ (Gomez and Gomez, 1984).

CHAPTER FOUR

RESULTS

4.1. Experiment One: Effect of sulphur on vegetative growth and flowering of Wedelia plant.

4.1.1. Shoot length:

After 40 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. The different between 0.8 g/plant and 1.6 g/plant were not significant. The highest mean for shoot length was 70.2 cm recorded in 1.6 g/plant. While the lowest one was 42.2 cm obtained in the control (table 1).

After 125 days, analysis of variance indicated that there were highly significant differences among the five levels of treatments. Also, differences among 0.4, 0.8 and 1.6 g/plant were not significant. The highest mean for shoot length was 164.5 cm recorded in 1.6 g/plant. While the lowest one was 133.0 cm given in the control (table 1).

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences among 0.4, 0.8 and 1.6 g/plant were not significant. Also, the shoot length was not significantly differences between the control and 0.2 g/plant. The highest mean for shoot length was 180.2 cm recorded in 1.6 g/plant. While the lowest one was 134.0 cm obtained by the control (table 1).

After 300 days, analysis of variance revealed that there were highly significant differences among the five levels of treatments. Differences between 0.4 g/plant and 0.8 g/plant were not significant. The longest shoot was 190.5 cm obtained in 1.6g/plant. While the shortest shoot length was 42.2 cm recorded in the control. (table 1).

Table (1): Mean shoot length (cm) of Wedelia plant treated with five different levels of sulphur.

Sulphur level (g/plant)	**Mean shoot length (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	42.2 c	113.0 b	134.0 b	136.8 c
0.2	46.5 bc	124.0 ab	137.0 b	152.0 bc
0.4	60.2 ab	144.5 a	167.0 a	170.8 ab
0.8	68.0 a	145.2 a	167.5 a	176.8 ab
1.6	70.2 a	146.5 a	180.2 a	190.5 a
5 % LSD	14.01	23.63	23.85	26.48
CV %	16.2	11.6	10.1	10.6

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

4.1.2. Number of primary branches per plant:

After 40 days, analysis of variance indicated that there were significant differences among the five levels of sulphur. The differences among levels 0.4, 0.8 and 1.6 were not significant. The highest mean for number of primary branches was 10.25 recorded in 1.6 g/plant. While the lowest one was 7.25 obtained in control and 0.2 g/plant (table 2).

After 125 days, analysis of variance revealed that there were significant differences among the five levels of treatments. The highest mean for number of primary branches was 17.00 obtained in 1.6 g/plant. While the lowest one was 12.00 recorded in the control (table 2).

After 215 days, analysis of variance indicated that there were significant differences among the five levels of treatments. The differences between levels 0.8 and 1.6 g/plant were not significant. The highest mean for number of primary branches was 20.75 recorded in 0.8 g/plant. While the lowest one was 15.25 obtained in the control (table 2).

After 300 days, analysis of variance showed that there were significant differences among the five levels of treatments. The differences between 0.8 and 1.6 g/plant were not significant. The highest number of primary branches was 27.25 recorded in 1.6g/plant followed with 25.75 obtained in 0.8g/plant. While the lowest one was 16.25 recorded in the control (table 2).

Table (2): Mean number of primary branches per plant of Wedelia plant treated with different levels of sulphur.

Sulphur level (g/plant)	**Mean number of primary branches/plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	7.25 b	12.00 c	15.25 c	16.25 c
0.2	7.25 b	13.75 bc	16.75 b	17.00 c
0.4	9.00 a	14.50 abc	18.00 b	23.25 b
0.8	9.50 a	15.50 ab	20.75 a	25.75 a
1.6	10.25 a	17.00 a	20.00 a	27.25 a
5 % LSD	1.42	2.48	1.47	2.10
CV %	10.9	11.3	5.4	6.3

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

4.1.3. Number of secondary branches per plant:

After 40 days, analysis of variance indicated that there were significant differences among five levels of treatments. The highest means for number of secondary branches was 9.50 per plant recorded in 1.6g/plant, followed by 9.00 secondary branches in level 0.8g/plant. While the lowest one was 4.00 obtained in control and 0.2 g/plant (table 3).

After 125 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of secondary branches was 15.25 obtained in 1.6 g/plant. While the lowest mean one was 7.00 found in the control (table 3).

After 215 days, analysis of variance revealed that there were significant differences among the five levels of treatments. The highest mean for number of secondary branches was 18.50 recorded in 1.6 g/plant. While the lowest mean one was 8.50 obtained in 0.0 g/plant (table 3).

After 300 days, analysis of variance indicated that there were highly significant differences among the five levels of treatments. The highest number of secondary branches was 23.75 recorded in 1.6 g/plant. While the lowest one was obtained in control (table 3).

Table (3): Mean number of secondary branches per plant of Wedelia plant treated with five different levels of sulphur.

Sulphur level (g/plant)	Mean number of secondary branches/plant after			
	40 days	**125 days**	**215 days**	**300 days**
0.0	4.00 c	7.00 d	8.50 e	10.75 c
0.2	4.00 c	10.25 c	10.50 d	13.00 c
0.4	7.50 b	12.00 bc	13.00 c	18.25 b
0.8	9.00 ab	13.00 b	15.00 b	19.00 b
1.6	9.50 a	15.25 a	18.50 a	23.75a
5 % LSD	1.65	2.11	1.70	2.53
CV %	16.1	12.2	8.6	9.9

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

4.1.4. Number of leaves per plant:

After 40 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. The highest mean for number of leaves per plant was 250.5 obtained in 1.6 g/plant. While the lowest one was 105.5 recorded in the control (table 4).

After 125 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. In addition, differences between the two treatments 8.0g/plant and 1.6 g/plant were not significant. The highest mean for number of leaves per plant was 301.0 obtained in level 1.6 g/plant, followed with 282.0 found in 0.8 g/plant. While the lowest one was 155.0 recorded in 0.2 g/plant (table 4).

After 215 days, analysis of variance showed that there were highly significant among the five levels of treatments. Differences between levels 0.8 g/plant and 1.6 g/plant were not significant. The highest number of leaves was 281.8 obtained in 1.6 g/plant. While the lowest one was 194.2 recorded in the control (table 4).

After 300 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. Differences among the three levels of treatments 0.4, 0.8 and 1.6 g/plant was not significant. The highest mean for number of leaves was 299.2 recorded in 1.6 g/plant, then 294.0 found in level 0.8g/plant. The lowest value was 210.0 obtained in the control (table 4).

Table (4): Mean number of leaves per plant of Wedelia plant treated with five different levels of sulphur.

Sulphur level (g/plant)	**Mean number of leaves/plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	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
5 % 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".

4.1.5. Leaf length (cm):

After 40 days, analysis of variance showed that there were significant differences between the control and the four levels of sulphur treatments. Differences among the four levels of treatments were not significant. The highest mean for leaf length was 4.75 cm obtained in 1.6 g/plant and the lowest one was 3.65 cm recorded by the control (table 5).

After 125 days, analysis of variance showed that there were significant differences between the control and the four levels of sulphur treatments. Differences among the four levels of treatments were not significant. The highest mean for leaf length was 4.93 cm found in 1.6 g/plant. While the lowest one was 3.95 cm recorded in the control (table 5).

After 215 days. Analysis of variance illustrated that there were significant differences between the control and the four levels of sulphur treatments. There was no significant difference among the four levels of treatments. The highest mean for leaf length was 5.20cm obtained in level 0.2g/plant, followed with 5.08 cm obtained in 0.4g/plant. While the lowest length 4.13 cm was obtained in the control (table 5).

After 300 days, analysis of variance showed that there were significant differences among the five levels of treatments. The leaf length was not significant different among 0.4, 0.8 and 1.6 g/plant. The highest mean for leaf length was 5.10 cm obtained by 1.6 g/plant. While the lowest one was 4.15 cm found in the control (table5).

Table (5): Mean leaf length (cm) of Wedelia plant (*Wedelia trilobata* L) treated with five different levels of sulphur.

Sulphur level (g/plant)	**Mean leaf length (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	3.65 b	3.95 b	4.13 b	4.15 b
0.2	4.58 a	4.75 a	5.20 a	4.62 ab
0.4	4.50 a	4.88 a	5.08 a	4.85 a
0.8	4.70 a	4.90 a	4.95 a	4.85 a
1.6	4.75 a	4.93 a	4.83 a	5.10 a
5 % LSD	0.71	0.44	0.66	0.57
CV %	10.7	6.3	9.0	8.0

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

4.1.6. Leaf width (cm):

After 40 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between 0.8 g/plant and 1.6 g/plant were not significant. The widest leaf width was 4.33 cm obtained in 1.6 g/plant, followed with 4.17 cm obtained in 0.8 g/plant. While the narrow leaf width was 3.30 cm recorded in control (table 6).

After 125 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for leaf width was 4.30 obtained in 1.6 g/plant. While the lowest one was 3.40 cm recorded in control (table 6).

After 215 days analysis of variance showed that there were no significant differences among the five levels of treatments. The highest mean for leaf width was 4.00 cm recoded in 1.6 g/plant. While the lowest one was 3.50 cm obtained in control (table 6).

After 300 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between 0.8 g/plant and 1.6 g/plant were not significant. The widest leaf width was 3.40 cm recorded in 1.6 g/plant. While the narrow leaf width was 2.93 cm obtained in control (table 6).

Table (6): Mean leaf width of Wedelia plant (*Wedelia trilobata* L.) treated with five different levels of sulphur.

Sulphur level (g/plant)	**Mean leaf width (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	3.30 b	3.40 b	3.50 a	2.93 b
0.2	3.73 ab	4.25 ab	3.75 a	3.40 ab
0.4	3.88 ab	4.20 ab	3.88 a	3.25 ab
0.8	4.17 a	3.92 ab	3.92 a	3.35 a
1.6	4.33 a	4.30 a	4.00 a	3.40 a
5 % LSD	0.73	0.81	0.71	0.42
CV %	12.4	13.5	12.4	8.5

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

4.1.7. Leaf area (cm^2):

After 40 days, analysis of variance showed that there were significant differences between the five treatments and the control. The differences among the four levels of treatments were not significant. The maximum mean for leaf area was 16.40 cm^2 recorded in level 1.6g/plant, followed by 15.75cm^2 obtained by 0.8 g/plant. While the minimum one was 9.79 cm^2 recorded in control (table 7).

After 125 days, analysis of variance showed that there were significant differences between the five levels of treatments and the control. Differences among the four levels other than the control of treatments were not significant. The highest mean for leaf area was 16.86 cm^2 obtained in 1.6 g/plant. While the lowest one was 10.79 cm^2 recorded in control (table 7).

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for leaf area was 15.83cm^2 obtained in 0.4 g/plant. While the lowest one was 11.62 cm^2 recoded in 0.0 g/plant (table 7).

At 300 days, analysis of variance showed that there were significant differences between the five levels of treatments and the control. Differences among the four levels other than the control of treatments were not significant. The highest mean for leaf area was 13.87 cm^2 obtained in 1.6 g/plant. While the lowest one was 9.75 cm^2 recorded in 0.0 g/plant (table 7).

Table (7): Mean leaf area (cm^2) of wedelia (*Wedelia trilobata* L.) plant treated with five different levels of sulphur.

Sulphur level (g/plant)	**Mean leaf area (cm^2) after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	9.79 b	10.79 b	11.62 b	9.75 b
0.2	13.62 a	16.14 a	15.49 ab	12.82 a
0.4	13.96 a	16.40 a	15.83 a	12.59 a
0.8	15.75 a	15.41 a	15.57 ab	13.00 a
1.6	16.40 a	16.86 a	15.48 abc	13.87 a
5 % LSD	3.55	3.27	3.72	2.10
CV %	17.0	14.3	16.7	11.2

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

4.1.8. Number of flowers per plant:

After 40 days, analysis of variance showed that there were significant of differences among the five levels of treatments. The highest mean for number of flowers was 9.75 obtained in 8.0 g /plant. While the lowest one was 3.25 recorded in 1.6 g/plant (table 8).

After 125 day, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of flowers was 9.00 obtained in 0.8 g/plant. While the lowest one was 2.75 recorded in 1.6 g/plant (table 8).

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of flowers was 11.00 recorded in level 0.8 g/plant. While the lowest one was 6.50 obtained in 0.0g/plant (table 8).

After 300 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of flowers was 9.50 obtained in 0.8 g/plant. While the lowest one was 4.00 recorded in 0.0 g/plant (table 8).

Table (8): Mean number of flowers per plant of wedelia (*Wedelia trilobata* L.) plant treated with five different levels of sulphur.

Sulphur level (g/plant)	**Mean number of flowers per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	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
5 % LSD	1.40	1.31	1.78	2.07
CV %	15.5	14.8	13.9	22.1

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

4.1.9. Final number of flowers per plant:

Analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for final number of flowers was 7.00 obtained in 1.6 g/plant. While the lowest one was 3.00 recorded in the control (table 9).

4.1.10. Chlorophyll measurement (mg/g):

Analysis of variance showed that there were significant differences among the five levels of treatments in chlorophyll. The highest mean of chlorophyll was 40.02 mg/g obtained in 1.6 g/plant. While the lowest one was 33.95 mg/g obtained in the control (table 9).

Table (9): Mean final number of flowers per plant and chlorophyll (mg/g) of Wedelia plant treated with different levels of sulphur.

Sulphur level (g/plant)	**Final number of flowers/ plant**	**Chlorophyll (mg/g)**
0.0	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
5 % LSD	1.39	1.94
C.V.	19.8	3.4

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

4.1.11. Shoot fresh and dry weight (g):

Analysis of variance showed that there were highly significant differences among the five levels of treatments in shoot fresh weight. Differences between 8.0 g/plant and 1.6 g/plant were not significant. The highest values of shoot fresh weights was 245.7g/plant obtained in 1.6 g/plant, flowered by 245.6g/plant recoded in 0.8 g/plant. While the lowest one was 127.0 g/ plant found in the control (table 10).

Analysis of variance showed that there were highly significant differences among the five levels of treatments in shoot dry weight. The highest mean for shoot dry weight was 83.7g/plant recorded in 1.6 g/plant. While the lowest one was 50.0 g/plant obtained in the control (table 10).

4.1.12. Root fresh and dry weight (g):

Analysis of variance showed that there were significant differences among the five levels of treatments in root fresh weight. Differences between 0.8 g/plant and 1.6 g/plant were not significant. The highest mean for root fresh weight was 33.05g/plant obtained in 1.6 g/plant. While the lowest one was 9.98g/plant recorded in the control (table10).

Analysis of variance showed that there were significant differences among the five levels of treatment. Differences between levels 0.8 g/plant and 1.6 g/plant were not significant. The highest mean for root dry weight was 14.82 g/plant obtained in 0.8 g/plant. While the lowest one was 4.02 g/plant recoded in the control (table 10).

Table (10): Mean shoot and root fresh and dry weight (g) of wedelia plant treated with the different levels of sulphur.

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
5 % LSD	35.41	20.93	2.61	2.42
C.V.	12.3	22.0	8.0	17.0

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

4.1.13. Analysis of leaf plant tissue (g):

Analysis of variance showed that the uptake and accumulation of macro elements represented in N, P and K content were significantly differences among the five levels of treatments. The highest mean for nitrogen content was 2.09 % obtained in 1.6 g/plant. While the lowest one was 1.62 % recoded in the control (table 11).

Analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for phosphorus content was 0.75 % obtained in 1.6 g/plant. While the lowest one recorded in 0.4 g/plant (table 11).

Analysis of variance showed that there were significant differences among the five level of treatment. The highest mean for potassium content was 2.35 % obtained in 1.6 g/plant. While the lowest one was 1.69 % recorded in level 0.4 g/plant (table 11).

Table (11): leaf contents of N, P and K (%) of Wedelia plant after adding different levels of sulphur.

Sulphur level (g/plant)	**Nitrogen %**	**Phosphorus %**	**Potassium %**
0	1.62 c	0.33 d	1.69 d
0.2	1.65 c	0.38 c	1.96 c
0.4	1.65 c	0.25 e	2.01 b
0.8	1.83 b	0.64 b	2.02 b
1.6	2.09 a	0.75 a	2.35 a
5 % LSD	0.144	0.016	0.026
C.V.%	4.5	1.8	0.7

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

4.2. Experiment two: Effect of micro elements on vegetative growth and flowering of Wedelia plant:

4.2.1. Shoot length (cm):

After 40 days, analysis of variance indicated that there were not significant differences observed among the five levels of treatments. The highest mean for shoot length was 39.50 cm obtained in Fe. While the lowest one was 31.80 cm recorded in the control (table 12).

After 125 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. The highest mean for shoot length was 192.0 recorded in Zn. While the lowest one was 110.5 obtained in control (table 12).

After 215 days, statistical analysis revealed that there were highly significant differences among the five levels of treatments. Differences between Mn and Zn were not significant. The highest mean for shoot length was 195.8 cm obtained in Mn. Followed with 195.2 cm recorded in Zn. While the lowest one was 111.0 obtained in the control (table 12).

After 300 days, analysis of variance indicated that there were highly significant differences among the five levels of treatments. The highest mean for shoot length was 210.2 cm obtained in Mn. While the lowest one were 138.0 cm recorded in the control (table 12).

Table (12): Mean shoot length (cm) of Wedelia plant treated with five different levels of micro- elements.

Micro-elements Level (50mg/L)	**Mean shoot length (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0	31.80 a	110.5 d	111.0 d	138.0 d
Fe	39.50 a	129.5 c	154.8 c	169.8 c
Mn	37.00 a	181.5 ab	195.8 a	200.8 ab
Zn	37.50 a	192.0 a	195.2 a	210.2 a
B	33.20 a	170.5 b	175.8 b	182.2 bc
5 % LSD	7.09	14.96	15.38	18.88
CV %	13.1	6.3	6.1	7.0

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

4.2.2. Number of primary branches per plant:

After 40 days, analysis of variance indicated that there were significant differences among the five levels of treatments. Differences between Mn, Zn and B were not significant. The highest mean for number of primary branches was 9.25 obtained in Mn, Zn and B. while the lowest one was 5.00 recorded in the control (table 13).

After 125 days, analysis of variance showed that there were significant differences among the five levels of treatments. The maximum mean for number of primary branches was 15.50 obtained in B. while the minimum one was 8.75 recorded by the control (table 13).

After 215 days, analysis of variance revealed that there were significant differences among the five levels of treatments. Differences between Mn and Zn were not significant. The highest mean for number of primary branches was 19.00 obtained in Mn. While the lowest one was 8.75 recorded in the control (table 13).

After 300 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between Mn, Zn and B were not significant. The highest mean for number of primary branches was 26.00 obtained in Mn. While the lowest one was 18.25 recorded in the control (table 13).

Table (13): Mean number of primary branches per plant of wedelia plant treated with five different levels of micro- elements.

Micro-elements Level (50mg/L)	**Mean number of primary branches per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0	5.00 b	8.75 c	8.75 c	18.25 b
Fe	6.00 b	9.00 c	10.25 c	19.75 b
Mn	9.25 a	11.75 b	19.00 a	26.00 a
Zn	9.25 a	12.50 b	18.75 a	24.50 a
B	9.25 a	15.50 a	15.25 b	25.00 a
5 % LSD	1.92	1.97	2.24	3.40
CV %	16.4	11.3	10.3	9.9

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

4.2.3. Number of secondary branches per plant:

After 40 days, analysis of variance indicated that there were significant differences among the five levels of treatments. The highest mean for number of secondary branches was 7.25 obtained in B. while the lowest one was 2.75 recorded in the control (table 14).

After 125 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of secondary branches was 7.75 obtained in B. while the lowest one was 3.75 found in the control (table 14).

After 215 days, analysis of variance revealed that there were significant differences among the five levels of treatments. Differences between Zn and B were not significant. The highest mean for number of secondary branches was 23.00 recorded in Mn. While the lowest one was 5.00 recorded in the control (table 14).

After 300 days, analysis of variance indicated that there were significant differences among the five levels of treatments. The highest mean for number of secondary branches was 25.25 obtained in Mn. While the lowest one was 14.00 recorded in the control (table 14).

Table (14): Mean number of secondary branches per plant of wedelia plant treated with five different levels of micro- elements.

Micro-elements Level (50 mg/L)	Mean number of secondary branches per plant after			
	40 days	**125 days**	**215 days**	**300 days**
0	2.75 c	3.75 c	5.00 d	14.00 c
Fe	3.25 c	5.25 bc	8.75 c	14.25 c
Mn	4.50 bc	7.00 ab	23.00 a	25.25 a
Zn	5.75 ab	7.00 ab	13.25 b	23.00 ab
B	7.25 a	7.75 a	11.75 b	20.25 b
5 % LSD	1.91	2.28	2.41	4.01
CV %	26.9	24.6	12.9	13.8

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

4.2.4. Number of leaves per plant:

After 40 day, analysis of variance indicated that there were highly significant differences among the five levels of treatments. The highest mean for number of leaves was 220.5 obtained in Mn. While the lowest one was 128.8 recorded in Zn (table 15).

After 125 day, analysis data showed that there were highly significant differences among the five levels of treatments. The highest mean for number of leaves was 241.0 obtained in Mn. While the lowest one was 196.2 found in B (table 15).

After 215 day, statistical analysis revealed that there were highly significant differences among the five levels of treatments. Differences between levels Fe, Mn and Zn were not significant. The maximum mean for number of leaves was 271.5 obtained in Mn. While the lowest one was 212.0 recorded in B (table 15).

After 300 day, analysis of variance indicated that there were highly significant differences among the five levels of treatments. Differences between the control and Fe, B were not significant. The highest mean for number of leaves was 297.2 obtained in Mn. While the lowest one was 233.5 recorded in B (table 15).

Table (15): Mean number of leaves per plant of wedelia plant treated with five different levels of micro- elements.

Micro-elements Level (50mg/L)	**Mean number of leaves per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0	180.2 b	218.2 bc	241.2 ab	245.8 b
Fe	190.8 b	222.0 ab	250.8 a	263.2 b
Mn	220.5 a	241.0 a	271.5 a	297.2 a
Zn	128.8 c	197.8 cd	253.5 a	266.0 ab
B	182.0 b	196.2 d	212.0 b	233.5 b
5 % LSD	18.38	20.61	36.13	32.04
CV %	6.8	6.4	9.8	8.1

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

4.2.5. Leaf length:

After 40 day, analysis of variance indicated that there were significant among the five levels of treatments. The highest mean for leaf length was 5.00 cm obtained in Zn. While the lowest one was 3.65 cm recorded in the control (table 16).

After 125 days, analysis of variance indicated that there were significant differences among the five micro element treatments. The maximum mean for leaf length was 5.40 cm recorded by Fe (table 16). While the minimum one was 4.45cm obtained in Mn.

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. The leaf length was not significantly different between the control and micro treatments Mn, Zn and B. The maximum mean for leaf length was 5.35 cm obtained in Fe. While the minimum one was 4.55 cm found in the control (table 16).

After 300 days, analysis of variance showed that there were significant differences among the five levels treatments. Differences between the control and micro element Mn were not significant (table 16). The longest leaf length was 5.15 cm obtained in B. while the shortest leaf length was 4.53 cm recorded in the control.

Table (16): Mean leaf length (cm) of wedelia plant treated with five different levels of micro- elements.

Micro-elements Level (50mg/L)	**Mean leaf length (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0	3.65 c	5.08 ab	4.55 b	4.53 c
Fe	4.58 ab	5.40 a	5.35 a	4.78 bc
Mn	4.25 bc	4.45 b	4.83 b	4.60 c
Zn	5.00 a	4.80 ab	4.70 b	4.95 ab
B	4.75 ab	4.90 ab	4.83 b	5.15 a
5 % LSD	0.65	0.77	0.44	0.27
CV %	9.6	10.4	6.0	3.7

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

4.2.6. Leaf width (cm):

After 40 days. Analysis data revealed that there were not significant differences among the five levels of micro element treatments. The highest mean for leaf width was 4.47 cm obtained in Mn. While the lowest one was 3.65 cm recorded in the control (table 17).

After 125 days. Analysis of variance indicated that there were not significant differences among the five levels of treatments. The highest mean for leaf width was 4.45 cm recorded in Mn. whereas, the lowest one was 4.03 cm obtained in the control (table 17).

After 215 days, statistical analysis showed that there were not significant differences among the five levels of treatments. The highest mean for leaf width was 4.62 cm obtained in Mn. While the lowest one was 4.03 cm recorded in B (table 17).

After 300 days, analysis of variance illustrated that there were not significant differences among the five levels of treatments. The highest mean for leaf width was 4.70 cm obtained in Mn, while the lowest one was 4.05 cm recorded in Zn (table 17).

Table (17): Mean leaf width (cm) of wedelia plant treated with five different levels of micro- elements.

Micro-elements Level (50Mg/L)	**Mean leaf width (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0	3.65 a	4.03 a	4.25 a	4.30 a
Fe	4.35 a	4.38 a	4.33 a	4.45 a
Mn	4.47 a	4.45 a	4.62 a	4.70 a
Zn	4.40 a	4.23 a	3.95 a	4.05 a
B	4.45 a	4.43 a	4.03 a	4.17 a
5 % LSD	0.77	0.56	0.71	0.71
CV %	12.0	8.7	11.0	10.8

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

4.2.7. Leaf area (cm^2):

After 40 days, analysis data indicated that there were significant difference between the control and the four micro element treatments. No significant differences were observed among treatments in leaf area. The highest mean for leaf area was 17.54 cm^2 obtained in Zn. While the lowest one was 10.63 cm^2 recorded in the control (table 18).

After 125 days, analysis of variance showed that there were not significant differences among the five levels of treatment (table 18). The highest mean for leaf area was 18.99 cm^2 obtained in Fe. While the lowest one was 10.63 cm^2 recorded in the control.

After 215 day, analysis of variance revealed that there were significant differences among the five levels of treatments. The leaf area was not significantly different between the control and micro elements treatments Zn and B. the highest mean for leaf area was 18.48 cm^2 obtained in Fe. While the lowest one was 14.89 cm^2 obtained in Zn (table 18).

After 300 day, analysis of variance indicated that there were not significant differences among the five levels of treatments. The highest mean for leaf area was 17.30 cm^2 obtained in Mn. While the lowest one was 15.58 cm^2 recorded in the control (table 18).

Table (18): Means leaf area (cm^2) of wedelia plant treated with five different levels of micro- elements.

Micro-elements Level (50mg/L)	**Mean leaf area (cm^2) after**			
	40 days	**125 days**	**215 days**	**300 days**
0	10.63 b	16.19 a	15.41 b	15.58 a
Fe	15.80 a	18.99 a	18.48 a	17.04 a
Mn	15.21 a	16.59 a	17.88 ab	17.30 a
Zn	17.54 a	16.20 a	14.89 b	16.12 a
B	16.97 a	17.23 a	15.49 b	17.20 a
5 % LSD	3.08	3.32	2.83	3.01
CV %	13.4	12.9	11.4	12.0

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

4.2.8. Number of flowers per plant:

After 40 days, analysis of variance indicated that there were significant differences among the five levels of treatments. The number of flowers was not significantly different between the control and micro element treatments Fe and Mn. The highest mean for number of flowers per plant was 5.00 recorded in B, followed with 4.00 obtained in Zn. While the lowest one was 3.00 recorded in Fe, Mn and the control (table 19).

After 125 day, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between Mn, Zn and B were not significant. The highest mean for number of flowers was 6.00 obtained in Zn and B. while the lowest one was 2.00 found in the control (table 19).

After 215 days, analysis of variance indicated that there were significant differences among the five levels of treatments. Differences between Mn, Zn and B were not significant. Number of flowers was not significantly between the control and treatment Fe (table 19). The highest mean for number of flowers was 7.00 obtained in Zn. While the lowest value was 4.00 recorded in the control and Fe.

After 300 days, statistical analysis revealed that there were significant differences among the five levels of treatments. No significant differences were observed among the three level of treatment Mn, Zn and B. the highest mean for number of flowers was 6.00 obtained in B. while the lowest one was 3.50 recorded in the control (table 19).

Table (19): Mean number of flowers per plant of wedelia plant treated with five different levels of micro- elements.

Micro-elements Level (50mg/L)	**Mean number of flowers per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0	3.00 b	2.00 c	4.00 b	3.50 b
Fe	3.00 b	3.50 b	4.00 b	4.50 ab
Mn	3.25 b	5.00 a	6.00 a	5.50 a
Zn	4.00 ab	6.00 a	7.00 a	5.50 a
B	5.00 a	6.00 a	6.50 a	6.00 a
5 % LSD	1.28	1.40	1.17	1.46
CV %	23.2	20.7	14.1	19.3

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

4.2.9. Final number of flowers per plant:

Analysis of variances indicated that there were significant differences among the five levels of treatments. Differences between Mn and B were not significant (table 20). The highest mean for final number of flowers per plant was 8.50 obtained in B. while the lowest value was 3.50 recorded in Zn.

4.2.10. Chlorophyll measurement (mg/g):

Analysis of variance showed that there were significant differences among the five levels of treatments. Chlorophyll was not significantly different between Fe, Zn and B. the highest mean for chlorophyll content was 39.08 obtained in Zn. While the lowest one was 35.55 recorded in the control (table 20).

Table (20): Mean final number of flowers and Chlorophyll of Wedelia plant treated with five different levels of micro- elements.

Micro-elements(50mg/L)	**Final No. of flowers/ plant**	**Chlorophyll (mg/g)**
0	5.50 b	35.55 b
Fe	4.00 bc	38.38 a
Mn	7.50 a	37.30 ab
Zn	3.50 c	39.08 a
B	8.50 a	38.15 a
5 % LSD	1.83	2.41
C.V.	20.9	4.2

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

4.2.11. Shoot fresh and dry weight (g):

Analysis of variance illustrated that there were highly significant differences among the five levels of treatments. Differences between Mn and Zn were not significant. The highest mean for shoot fresh weight was 165.6 g/plant obtained in Zn. While the lowest one was 62.3 found in the control (table 21).

Analysis of variance indicated that there were highly significant differences among the five levels of treatments in shoot dry weight. The highest mean for shoot dry weight was 50.1 g/plant obtained in Zn. While the lowest value was 28.2 g/plant recorded in the control (table 21).

4.2.12. Root fresh and dry weight (g):

Analysis of variance revealed that there were highly significant differences among the five levels of treatments in root fresh weight. The highest mean for root fresh weight was 74.50 g/plant obtained in Zn. While the lowest one was 29.25 g/plant recorded in the control (table 21).

Analysis of variance showed that there were highly significant differences among the five levels of treatments in root dry weight. The highest root dry weight was 74.25 g/plant obtained in Zn. While the lowest one was 20.08 recorded in the control (table 21).

Table (21): Mean shoot and root fresh and dry weight of wedelia plant treated with five different levels of micro- elements.

Microelements (50 mg/L)	**shoot fwt (g/plant)**	**shoot dwt (g/plant)**	**Root fwt (g/plant)**	**Root dwt (g/plant)**
0	62.3 b	35.4 ab	29.25 e	20.08 d
Fe	86.8 b	37.4 ab	64.85 b	56.90 b
Mn	132.7 a	40.3 ab	43.08 d	26.92 c
Zn	165.6 a	50.1 a	74.50 a	74.25 a
B	88.8 b	28.2 b	55.45 c	32.20 c
5 % LSD	38.52	14.31	6.53	5.83
C.V.	23.8	24.8	8.1	9.3

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

4.2.13. Analysis of leaf plant tissue (g):

Analysis of variance showed that there were significant differences among the five levels of treatments. Nitrogen content was not significantly different between the control and microelement treatments Mn and Zn. The highest mean for nitrogen was 1.75 % obtained in Fe. While the lowest one was 1.15 % recorded in B (table 22).

According to table (22) statistical analysis revealed that there were significant differences among the five levels of treatments. Differences between the control and micro element treatments Fe and Zn were not significant. The highest mean of phosphorus was 0.60 % obtained in B. while the lowest one was 0.26 % found in the control.

Analysis of variance indicated that there were significant differences among the five levels of treatments. The highest mean of potassium content was 2.56 % obtained in Mn. While the lowest one was 1.57 % recorded in the control (table 22).

Table (22): leaf contents of N, P and K (%) of Wedelia plant after adding different levels of micro- elements.

Micro-elements (50 mg/L)	**Nitrogen %**	**Phosphorus %**	**Potassium %**
0	1.42 b	0.26 b	1.57 e
Fe	1.74 a	0.37 b	1.68 d
Mn	1.42 b	0.45 ab	2.56 a
Zn	1.42 b	0.37 b	2.23 b
B	1.15 c	0.60 a	1.87 c
5 % LSD	0.182	0.186	0.043
C.V.	7.0	24.9	1.2

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

4.3. Experiment three: Effect of NPK on vegetative growth and flowering of Wedelia plant.

4.3.1. Shoot length (cm):

After 40 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The longest shoot length of wedelia was 43.5 cm obtained in 8 g/plant. Whereas, the shortest shoot length was 34.8 recorded in the control and 1 g/plant (table 23).

After 125 days, analysis of variance showed that there were not significant differences among the five levels of treatments (table 23). The highest mean for shoot length was 119.5 cm obtained in 8 g/plant. While the lowest one was 101.0 cm found in the control.

After 215 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest mean for shoot length was 131.0 cm obtained in 8 g/plant. While the lowest one was 103.8 cm recorded in the control (table 23).

After 300 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. Differences between levels 4 g/plant and 8 g/plant were not significant (table 23). The highest mean for shoot length was 143.0 recorded in 8 g/plant. While the lowest one was 109.2 obtained in the control.

Table (23): Mean shoot length (cm) of Wedelia plant treated with five different levels of NPK.

NPK level (g/plant)	**Mean shoot length (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0	34.8 a	101.0 a	103.8 a	109.2 b
1	34.8 a	107.2 a	124.0 a	126.8 ab
2	40.2 a	110.8 a	127.0 a	128.0 ab
4	41.2 a	117.2 a	130.5 a	142.2 a
8	43.5 a	119.5 a	131.0 a	143.0 a
5 % LSD	16.66	17.16	39.93	27.52
CV %	28.4	10.2	21.5	14.1

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

4.3.2. Number of primary branches per plant:

After 40 days, analysis of variance showed that there were significant differences between the control and the applied levels of treatments in number of primary branches. Differences between the applied levels were not significant. The highest mean for number of primary branches was 11.25 obtained in 8 g/plant. While the lowest one was 6.75 recorded in the control (table 24).

After 125 days, analysis of variance showed that there were significant differences between the control and the four levels of treatments. Differences among the four levels were not significant. The highest mean for number of primary branches was 19.00 obtained in 4 g/plant. Whereas, the lowest one recorded in the control (table 24).

After 215 days, analysis of variance showed that there were significant differences between the control and the four levels of treatments. Differences among the four levels were not significant. The highest mean for number of primary branches was 22.50 obtained in 8 g/plant. While the lowest one was 12.50 recorded in the control (table 24).

After 300 days, analysis of variance illustrated that there were significant differences between the control and the four levels of treatment. The highest mean for number of primary branches was 23.00 recorded in 8 g/plant. While the lowest one was 14.00 obtained in the control (table 24).

Table (24): Mean number of primary branches per plant of wedelia plant treated with NPK.

NPK level (g/plant)	Mean number of primary branches per plant after			
	40 days	**125 days**	**215 days**	**300 days**
0	6.75 b	12.25 b	12.50 b	14.00 b
1	10.25 a	18.50 a	21.75 a	21.75 a
2	10.50 a	18.50 a	21.75 a	21.75 a
4	10.50 a	19.00 a	21.75 a	22.75 a
8	11.25 a	18.75 a	22.50 a	23.00 a
5 % LSD	1.84	1.89	2.34	1.75
CV %	12.4	7.2	7.8	5.6

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

4.3.3. Number of secondary branches per plant:

After 40 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest means for number of secondary branches was 4.75 obtained in 2, 4 and 8 g/plant. While the lowest one was 2.75 recorded in the control (table 25).

After 125 days, analysis of variance showed that there were significant differences among the five levels of treatment. The highest mean for number of secondary branches was 8.00 obtained in 8 g/plant. Whereas, the lowest one was 4.75 recorded in the plant (table 25).

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. Number of secondary branches was not significantly different between levels 4 g/plant and 8 g/plant (table 25). The highest mean for number of secondary branches was 15.75 obtained in 8 g/plant. While the lowest one was 5.00 found in the control.

After 300 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of secondary branches was 19.00 obtained in 8 g/plant. While the lowest one was 6.75 recorded in the control (table 25).

Table (25): Mean number of secondary branches per plant of wedelia plant treated with NPK.

NPK level (g/plant)	Mean number of secondary branches per plant after			
	40 days	**125 days**	**215 days**	**300 days**
0	2.75 a	4.75 c	5.00 d	6.75 d
1	4.00 a	6.00 bc	7.00 c	12.75 c
2	4.75 a	7.00 ab	13.00 b	13.75 bc
4	4.75 a	7.50 ab	15.50 a	15.25 b
8	4.75 a	8.00 a	15.75 a	19.00 a
5 % LSD	2.02	1.64	1.22	1.70
CV %	31.9	16.4	7.2	8.3

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

4.3.4. Number of leaves per plant:

After 40 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. The highest mean for number of leaves was 211.5 obtained in 8 g/plant. While the lowest one was 109.8 found in the control (table 26).

After 125 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. Differences between levels 2, 4 and 8 g/plant were not significant. The highest means for number of leaves was 218.2 obtained in 8 g/plant. While the lowest one was 109.8 recorded in the control (table 26).

After 215 days, analysis of variance showed that there were highly significant of differences among the five levels of treatments. Number of leaves was not significantly different between the two levels 4 g/plant and 8 g/plant. The highest mean for number of leaves was 296.0 recorded in 8 g/plant. Whereas, the lowest one was 138.0 obtained in the control (table 26).

After 300 days, analysis of variance illustrated that there were highly significant of differences among the five levels of treatments. The highest mean for number of leaves was 343.0 obtained in the highest level 8 g/plant compared to the lowest one was 147.0 obtained in the control (table 26).

Table (26): Mean number of leaves per plant of wedelia (*Wedelia trilobata* L.) plant treated with NPK.

NPK level (g/plant)	**Mean number of leaves per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0	109.8 d	136.2 b	138.0 d	147.0 e
1	149.5 c	158.2 b	167.2 c	193.8 d
2	191.0 b	208.0 a	207.8 b	261.0 c
4	198.5 ab	207.8 a	293.0 a	312.8 b
8	211.5 a	218.2 a	296.0 a	343.0 a
5 % LSD	19.37	22.65	22.52	29.17
CV %	7.5	8.1	6.8	7.7

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

4.3.5. Leaf length (cm):

After 40 days, analysis of variance showed that there were not significant differences observed among the five levels of treatments. The highest mean for leaf length was 3.20 cm obtained in 8 g/plant. While the lowest one was 2.93 cm recorded in the control (table 27).

After 125 days, analysis data showed that there were significant differences among the five levels of treatments. Differences between levels 2, 4 and 8 g/plant were not significant. The highest means for leaf length was 4.20 cm obtained in 2, 4 and 8 g/plant. While the lowest one was 3.68 cm recorded in the control (table 27).

After 215 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest mean for leaf length was 4.50 cm obtained in 8 g/plant. Whereas, the lowest one was 4.10 cm recorded in the control (table 27).

After 300 days, analysis of variance illustrated that there were significant differences among the five levels of treatments. Differences between levels 2, 4 and 8 g/plant were not significant (table 27). The highest mean for leaf length was 4.68 cm recorded in 8 g/plant. While the lowest one was 4.18 cm obtained in the control.

Table (27): Mean leaf length (cm) of wedelia (*Wedelia trilobata* L.) plant treated with NPK.

NPK level (g/plant)	**Mean leaf length (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0	2.93 a	3.68 b	4.10 a	4.18 b
1	3.13 a	3.90 ab	4.40 a	4.40 ab
2	3.05 a	4.20 a	4.43 a	4.58 a
4	3.20 a	4.20 a	4.48 a	4.58 a
8	3.20 a	4.20 a	4.50 a	4.68 a
5 % LSD	0.54	0.48	0.56	0.33
CV %	11.6	7.8	8.5	4.9

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

4.3.6. Leaf width (cm):

After 40 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest mean for leaf width was 3.25 cm obtained in 4 g/plant and 8 g/plant. While the lowest one was 2.83 cm recorded in the control (table 28).

After 125 days, analysis data showed that there were significant differences among the five levels of treatments. Differences between the control and levels 1g/plant and 4g/plant. The highest mean for leaf width was 4.20 cm obtained in 4 g/plant. While the lowest one was 2.98 cm recoded in the control (table 28).

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between levels 1, 2 and 8 g/plant were not significant. The highest mean for leaf width was 4.00 cm obtained in 4 g/plant. While the lowest one was 3.20 recorded in the control (table 28).

After 300 day. Analysis of variance showed that there were significant differences among the five levels of treatments. Differences between levels 2, 4 and 8 g/plant were not significant. The highest mean for leaf width was 4.38 cm obtained in 8 g/plant. While the lowest one was 3.58 cm recorded in the control (table 28).

Table (28): Mean leaf width (cm) of wedelia (*Wedelia trilobata* L.) plant treated with NPK.

NPK level (g/plant)	**Mean leaf width (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0	2.83 a	2.98 b	3.20 b	3.58 b
1	3.03 a	3.35 b	3.35 ab	3.95 ab
2	3.10 a	3.38 b	3.45 ab	4.13 a
4	3.25 a	4.20 a	4.00 a	4.15 a
8	3.25 a	3.70 ab	3.75 ab	4.38 a
5 % LSD	0.45	0.70	0.61	0.41
CV %	9.6	13.3	11.5	6.8

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

4.3.7. Leaf area (cm^2):

After 40 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest mean for leaf area was 8.36 cm^2 obtained in 8 g/plant. While the lowest one was 6.67 cm^2 recorded in the control (table 29).

After 125 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for leaf area was 14.15cm^2 recorded in 4 g/plant. Whereas, the lowest one was 6.67 cm^2 obtained in the control (table 29).

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for leaf area was 14.29 cm^2 obtained in 4 g/plant. While the lowest one was 10.47 cm^2 found in the control (table 29).

After 300 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between levels 2 g/plant and 4 g/plant were not significant. The highest mean for leaf area was 16.37 cm^2 obtained in 8 g/plant. While the lowest one was 11.93 cm^2 obtained in the control (table 29).

Table (29): mean leaf area (cm^2) of wedelia (*Wedelia trilobata* L.) plant treated with NPK.

NPK level (g/plant)	**Mean leaf area (cm^2) after**			
	40 days	**125 days**	**215 days**	**300 days**
0	6.67 a	8.79 c	10.47 b	11.93 c
1	7.56 a	10.41 bc	11.48 ab	13.91 b
2	7.56 a	11.42 abc	12.28 ab	15.10 ab
4	8.35 a	14.15 a	14.29 a	15.63 ab
8	8.36 a	12.47 ab	13.60 ab	16.37 a
5 % LSD	2.03	3.01	3.08	1.68
CV %	17.5	17.5	16.4	7.7

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

4.3.8. Number of flowers per plant:

After 40 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of flowers was 6.00 obtained in 8 g/plant. Whereas, the lowest one was 3.50 found in the control (table 30).

After 125 days, analysis of variance showed that there were significant differences between the control and treatments. No significant differences were observed among the applied levels of treatments in number of flowers. The highest mean for flowers number was 6.50 recorded in 8 g/plant. While the lowest one was 3.00 obtained in the control (table 30).

After 215 days, analysis of variance showed that there were significant of differences among the five levels of treatments. Differences between levels 2 g/plant and 4 g/plant were not significant. The highest mean for number of flowers was 9.00 obtained in 4 g/plant. While the lowest one was 4.50 found in the control (table 30).

After 300 days, analysis of variance showed that there were significant differences between the control and the four levels treatments. Differences among the four levels of NPK were not significant. The highest mean for number of flowers was (9.50) obtained in 2, 4 and 8 g/plant (table 30). While the lowest one was 4.50 recorded in the control. The best and economic NPK level was 8 g/plant to increased number of flowers.

Table (30): Mean number of flowers per plant of wedelia (*Wedelia trilobata* L.) plant treated with NPK.

NPK level (g/plant)	**Mean number of flowers per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0	3.50 c	3.00 b	4.50 c	4.50 b
1	4.00 bc	5.50 a	7.00 b	8.00 a
2	4.50 bc	6.00 a	8.00 ab	9.50 a
4	5.00 ab	6.00 a	9.00 ab	9.50 a
8	6.00 a	6.50 a	8.50 a	9.50 a
5 % LSD	1.35	1.56	1.56	1.65
CV %	19.4	19.1	14.0	13.4

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

4.3.9. Final number of flowers per plant:

Analysis of variance indicated that there were significant differences among the five levels of treatments. Differences between 2 g/plant and 4 g/plant were not significant. The highest mean for final number of flowers was 6.00 obtained in 8 g/plant. While the lowest one was 2.00 recorded in the control (table 31).

4.3.10. Chlorophyll measurement (mg/g):

Analysis of data showed that there were significant differences among the five levels of treatments. Chlorophyll was not significantly different between levels 4 g/plant and 8 g/plant. Also, differences between the control and 1, 2 g/plant were not significant. The highest mean for chlorophyll was 43.10 obtained in 8 g/plant. While the lowest one was 38.05 recorded in the control (table 31).

Table (31): Mean final number of flowers per plant and chlorophyll of Wedelia (Wedelia trilobata. L) Plant treated with NPK. .

NPK level (g/plant)	Final No. of flowers/ plant	Chlorophyll (mg/g)
0	2.00 c	38.05 b
1	3.50 b	38.77 b
2	4.50 ab	40.15 b
4	5.00 ab	42.67 a
8	6.00 a	43.10 a
5 % LSD	1.46	2.26
C.V.	23.0	3.7

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

4.3.11. Shoot fresh and dry weight (g):

Analysis of variance showed that there were highly significant differences among the five levels of treatments. The highest shoot fresh weight was 285.9 g obtained in 4g/plant. While the lowest one was 25.1 g recorded in the control (table 32).

According to table (32) analysis data indicated that there were highly significant differences among the five levels of treatments. The highest mean for shoot dry weight was 95.70 g recorded in 4 g/plant. While the lowest one was 6.10 g obtained in the control.

4.3.12. Root fresh and dry weight (g):

Analysis of variance showed that there were significant differences among the five levels of treatments. Differences between levels 4 g/plant and 8 g/plant were not significant (table 32). The highest mean for root fresh weight was 60.45 g obtained in 8 g/plant. Whereas, the lowest one was 5.08 g recorded in the control.

Analysis of variance showed that there were significant differences among the five levels of treatments. Differences between levels 2, 4 and 8 g/plant were not significant. The highest mean for root dry weight was 21.25 g recorded in 8 g/plant. While the lowest one was 2.43 g obtained in the control (table 32).

Table (32): Mean shoot and root fresh and dry weight (g) of Wedelia (*Wedelia trilobata* L.) plant treated with NPK.

NPK level (g/plant)	**shoot fwt (g/plant)**	**shoot dwt (g/plant)**	**Root fwt (g/plant)**	**Root dwt (g/plant)**
0	25.1 d	6.10 d	5.08 d	2.43 c
1	111.6 c	44.00 c	18.62 c	10.47 b
2	254.1 b	75.50 b	35.90 b	19.05 a
4	285.9 a	95.70 a	58.45 a	20.80 a
8	271.8 ab	76.10 b	60.45 a	21.25 a
5 % LSD	28.52	7.84	4.77	2.29
C.V.	10.0	8.7	8.9	10.2

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

4.4.13. Analysis of leaf plant tissue (g):

Analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for nitrogen was 2.31% recorded in 8 g/plant. While the lowest one was 1.43% obtained in the control (table 33).

Analysis of variance indicated that there were significant differences among the five levels of treatments. The highest mean for phosphorus was 0.77 % obtained in 8 g/plant. Whereas, the lowest one was 0.33 % obtained in the control.

Analysis of variance revealed that there were significant differences among the five levels of treatments. The highest mean for potassium was 2.62 % obtained in 8 g/plant. While the lowest one was 1.43 % recorded in the control (table 33).

Table (33): leaf contents of N, P and K (%) of Wedelia plant after adding different levels of NPK.

NPK level (g/plant)	**Nitrogen %**	**Phosphorus %**	**Potassium %**
0	1.43 d	0.33 e	1.43 e
1	1.53 d	0.42 d	2.10 d
2	1.73 c	0.51 c	2.31 c
4	2.11 b	0.58 b	2.44 b
8	2.31 a	0.77 a	2.62 a
5 % LSD	0.198	0.018	0.025
C.V.%	6.0	1.9	0.6

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

4.5. Experiment four: Effect of urea levels on vegetative growth and flowering of Wedelia plant:

4.4.1. Shoot length (cm):

After 40 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest mean for shoot length was 40.5 cm obtained in 4.5 g/plant. While the lowest one was 35.5 cm recorded in the control (table 34).

After 125 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest mean for shoot length was 144.0 cm obtained in 6 g/plant. Whereas, the lowest one was 120.8 found in 1.5 g/plant (table 34).

After 215 days, analysis of variance illustrated that there were not significant differences among the five levels of treatments. The highest mean for shoot length was 146.2 cm recorded in 4.5 g/plant. While the lowest one was 139.8 cm obtained in the control (table 34).

After 300 days, analysis of variance illustrated that there were not significant differences among the five levels of treatments. The highest mean for shoot length was 154.0 cm obtained in 6 g/plant. While the lowest one was 138.2 cm recorded in the control (table 34).

Table (34): Mean shoot length (cm) of wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	**Mean shoot length (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	35.5 a	127.8 a	139.8 a	138.2 a
1.5	36.0 a	120.8 a	140.5 a	141.8 a
3.0	38.0 a	139.0 a	140.5 a	144.8 a
4.5	40.5 a	143.2 a	146.2 a	147.5 a
6.0	38.8 a	144.0 a	146.0 a	154.0 a
5 % LSD	8.06	38.91	36.69	29.87
CV %	14.2	19.1	17.1	13.7

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

4.4.2. Number of primary branches per plant:

After 40 days, analysis of variance showed that there were significant differences observed among the five levels of treatments. Differences between 1.5 g/plant and 3.0 g/plant were not significant. The highest means for number of primary branches was 9.00 obtained in 6.0 g/plant. While the lowest one was 6.50 recorded in the control (table 35).

After 125 days, analysis of variance showed that there were significant differences among the five levels of treatments. The number of primary branches was not significant differences between 4.5 g/plant and 6.0 g/plant. Also, differences between 1.5 g/plant and 3.0 g/plant were not significant. The highest mean for number of primary branches was 18.75 obtained in 6.0 g/plant. Whereas, the lowest one was 15.25 recorded in the control (table 35).

After 215 days, analysis of variance illustrated that there were significant differences among the five levels of treatments. The highest mean for number of primary branches was 26.50 obtained in 6 g/plant. While the lowest one was 17.25 recorded in the control.

After 300 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of primary branches was 26.50 recorded in 6.0 g/plant. While the lowest one was 17.25 obtained in the control (table 35).

Table (35): mean number of primary branches per plant of wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	**Mean number of primary branches per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	6.50 c	15.25 b	17.25 d	17.25 d
1.5	7.00 bc	16.75 ab	18.00 cd	18.00 cd
3.0	7.00 bc	17.00 ab	19.75 c	19.75 c
4.5	8.50 ab	18.25 a	23.50 b	23.50 b
6.0	9.00 a	18.75 a	26.50 a	26.50 a
5 % LSD	1.74	1.87	1.97	1.97
CV %	15.2	7.2	6.2	6.2

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

4.4.3. Number of secondary branches per plant:

After 40 day, analysis of variance showed that there were significant differences among the five levels of treatments. In addition, differences between 3.0, 4.5 and 6.0 g/plant were not significant. The highest mean of secondary of branches was 9.50 obtained in 4.5 g/plant. While the lowest one was 6.50 recorded in the control (table 36).

After 125 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between 4.5g/plant and 6g/plant were not significant. The highest mean for number of secondary branches was 14.50 obtained in 4.5 g/plant and 6.0 g/plant. Whereas, the lowest one was 8.50 recorded in the control (table 36).

After 215 days analysis of variance showed that there were significant differences among the five levels of treatments. Differences between 4.5 g/plant and 6.0 g/plant were not significant (table 36). The highest mean for number of secondary branches was 19.50 obtained in 6.0 g/plant. While the lowest one was 11.25 recorded in the control.

After 300 day, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between 4.5 g/plant and 6.0 g/plant were not significant differences (table 36). The highest mean for number of secondary branches was 19.50 recorded in 6.0 g/plant. While the lowest one was 11.25 obtained in the control.

Table (36): Mean number of secondary branches per plant of wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	**Mean number of secondary branches per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	6.50 b	8.50 c	11.25 d	11.25 d
1.5	8.00 ab	10.75 b	13.75 c	13.75 c
3.0	8.25 a	12.25 b	15.75 b	15.75 b
4.5	9.50 a	14.50 a	19.00 a	19.00 a
6.0	9.25 a	14.50 a	19.50 a	19.50 a
5 % LSD	1.63	1.85	1.62	1.62
CV %	13.0	10.1	6.8	6.8

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

4.4.4. Number of leaves per plant:

After 40 days, analysis of variance showed that there were highly significant differences among five levels of treatments. Differences between 1.5, 3.0 and 4.5 g/plant were not significant (table 37). The highest mean for number of leaves was 246.5 recorded in 6.0 g/plant. While the lowest one was 211.2 obtained in the control.

After 125 days, analysis of variance showed that there were highly significant differences among the five levels of treatments. Differences between 4.5 g/plant and 6.0 g/plant were not significant. Also, the number of leaves was not significant between 1.5 g/plant and 3.0 g/plant. The highest mean for number of leaves was 270.5 obtained in 6.0 g/plant. While the lowest one was 210.5 recorded in the control (table 37).

After 215 day, analysis of variance revealed that there were highly significant differences among the five levels of treatments. The highest mean for number of leaves was 308.2 obtained in 6.0 g/plant. Whereas, the lowest one was 230.8 recorded in the control (table 37).

After 300 day, analysis of variance illustrated that there were highly significant differences among the five levels of treatments. Differences between 4.5 g/plant and 6.0 g/plant were not significant (table 37). The highest mean for number of leaves was 326.2 obtained in 6.0 g/plant. While the lowest one was 240.0 recorded in the control.

Table (37): Mean number of leaves per plant of wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	**Mean number of leaves per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	211.2 b	210.5 c	230.8 d	240.0 c
1.5	222.0 ab	235.8 b	257.2 cd	256.2 bc
3.0	223.8 ab	244.5 b	270.2 bc	275.0 b
4.5	233.8 ab	268.2 a	286.5 ab	304.8 a
6.0	246.5 a	270.5 a	308.2 a	326.2 a
5 % LSD	24.67	21.02	27.69	22.38
CV %	7.5	5.7	6.8	5.3

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

4.4.5. Leaf length (cm):

After 40 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest means for leaf length was 4.25 cm obtained in 6.0 g/plant. While the lowest one was 3.55 cm recorded in the control (table 38).

After 125 days, analysis of variance showed that there were significant differences between the control and treatments. The leaf length was not significant differences among the four levels of urea (table 38). The maximum leaf length was 5.62 cm obtained in 6.0 g/plant. While the minimum leaf length was 3.73 cm recorded in the control.

After 215 days, analysis of variance showed that there were significant differences between the control and four levels of urea. Differences among the four levels of urea were not significant. The highest mean for leaf length was 5.53 cm obtained in 4.5 g/plant. While the lowest one was 4.45 cm recorded in the control (table 38).

After 300 days, analysis of variance showed that there were significant differences between the control and the four levels of urea treatments. The leaf length was not significant differences among the four levels of urea treatments (table 27). The highest mean for leaf length was 5.00 cm obtained in 1.5 g/plant. While the lowest one was 4.45 cm recorded in the control (table 38).

Table (38): Mean leaf length (cm) of wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	Mean leaf length (cm) after			
	40 days	**125 days**	**215 days**	**300 days**
0.0	3.55 a	3.73 b	4.45 b	4.45 b
1.5	3.62 a	5.28 a	5.00 a	5.00 a
3.0	3.67 a	5.42 a	5.38 a	4.58 a
4.5	3.90 a	5.60 a	5.53 a	4.58 a
6.0	4.25 a	5.62 a	5.50 a	4.68 a
5 % LSD	0.73	0.68	0.53	0.53
CV %	12.7	8.8	6.8	6.8

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

4.4.6. Leaf width (cm):

After 40 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest mean for leaf width was 3.80 cm obtained in 6.0 g/plant. Whereas, the lowest one was 3.28 cm found in the control (table 39).

After 125 days, analysis of variance showed that there were not significant of differences among the five levels of treatments. The highest mean for leaf width was 4.08 cm obtained in 4.5 g/plant and 6.0 g/plant. While the lowest one was 3.55 cm recorded in the control (table 39).

After 215 days, analysis of variance illustrated that there were significant differences among the five levels of treatments. Differences between 1.5, 3.0 and 4.5 g/plant were not significant. The highest mean for leaf width was 4.18 cm obtained in 6.0 g/plant. While the lowest one was 3.53 cm recorded in the control (table 39).

After 300 days, analysis of variance illustrated that there were significant differences among the five levels of treatments. Differences between 1.5, 3.0 and 4.5 were not significant. The highest means for leaf width was 4.18 cm obtained in 6.0 g/plant. While the lowest one was 3.58 cm recorded in the control (table 39).

Table (39): Mean leaf width (cm) of wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	**Mean leaf width (cm) after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	3.28 a	3.55 a	3.53 b	3.58 b
1.5	3.30 a	3.58 a	3.60 ab	3.60 ab
3.0	3.33 a	3.60 a	3.68 ab	3.68 ab
4.5	3.43 a	4.08 a	4.13 ab	4.13 ab
6.0	3.80 a	4.08 a	4.18 a	4.18 a
5 % LSD	0.52	0.56	0.54	0.54
CV %	10.1	9.9	9.3	9.3

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

4.4.7. Leaf area (cm^2):

After 40 days, analysis of variance showed that there were significant differences among the five levels of treatments. Leaf area was not significant differences between 4.5 g/plant and 6.0 g/plant. Also, differences between the control and 1.5, 3.0 g/plant were not significant. The highest mean for leaf area was 13.33 cm^2 obtained in 4.5 g/plant. While the lowest one was 9.30 cm^2 recorded in the control (table 40).

After 125 days, analysis of variance showed that there were significant differences between the control and the four levels of urea. Differences among the four levels of urea were not significant. The highest mean for leaf area was 18.33 cm^2 obtained in 4.5 g/plant and 6.0 g/plant. Whereas, the lowest one was 10.67 cm^2 recorded in the control (table 40).

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between the control and 1.5 g/plant were not significant. Also, the leaf area was not significant between 4.5 g/plant and 6.0 g/plant. The highest mean of leaf area was 18.38 cm^2 obtained in 6.0 g/plant. While the lowest one was 12.80 cm^2 recorded in the control (table 40).

After 300 days, analysis of variance illustrated that there were significant differences among the five levels of treatments. Differences between the control and 1.5 g/plant were not significant. Also, the leaf area was not significant differences between 3.0 g/plant and 4.5 g/plant (table 40). The highest mean for leaf area was 18.77 cm^2 obtained in 6.0 g/plant. Whereas, the lowest value was 14.12 cm^2 recorded in the control.

Table (40): mean leaf area (cm^2) of wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	**Mean leaf area (cm^2) after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	9.30 b	10.67 b	12.80 b	14.12 b
1.5	9.55 b	15.05 a	14.40 b	14.25 b
3.0	9.76 b	15.71 a	15.75 ab	15.13 ab
4.5	13.33 a	18.33 a	18.27 a	16.90 ab
6.0	12.93 a	18.33 a	18.38 a	18.77 a
% LSD	2.28	3.63	2.89	3.81
CV %	13.8	15.4	12.0	15.9

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

4.4.8. Number of flowers per plant:

After 40 days, analysis of variance showed that there were significant differences among the five levels of treatments. Differences between the control and 4.5 g/plant were not significant. Also, number of flowers was not significant differences between 1.5 g/plant and 3.0 g/plant (table 41). The highest mean for number of flowers was 4.00 obtained in 1.5g/plant and 3.0g/plant. While the lowest one was 2.50 recorded in the highest level (6.0 g/plant).

After 125 days, analysis of variance showed that there were not significant differences among the five levels of treatments. The highest mean for number of flowers was 5.50 obtained in 3.0 g/plant and 4.5 g/plant. While the lowest one was 4.00 recorded in the control (table 41).

After 215 days, analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of flowers was 8.00 recorded in 4.5 g/plant. Whereas, the lowest one was 4.25 found in the control (table 41).

After 300 days. Analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for number of flowers was 8.00 obtained in 4.5 g/plant. While the lowest one was 4.25 recorded in the control (table 41).

Table (41): Mean number of flowers per plant of wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	**Mean number of flowers per plant after**			
	40 days	**125 days**	**215 days**	**300 days**
0.0	3.50 ab	4.00 a	4.25 c	4.25c
1.5	4.00 a	4.50 a	6.00 b	6.00 b
3.0	4.00 a	5.50 a	7.00 ab	7.00 ab
4.5	3.00 ab	5.50 a	8.00 a	8.00 a
6.0	2.50 b	5.00 a	5.50 bc	5.50 bc
5 % LSD	1.35	1.51	1.44	1.44
CV %	26.3	20.4	15.6	15.6

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

4.4.9. Final number of flowers per plant:

Analysis of variance showed that there were significant differences among the five levels of treatments. Differences between the control and 1.5 g/plant were not significant. The highest mean for final number of flowers was 7.50 obtained in 6.0 g/plant. While the lowest one was 5.00 recorded in the control and 1.5 g/plant (table 42). The highest dose of urea 6.0 g/plant resulted in significant increase in the final number of flowers.

4.4.10. Chlorophyll measurement (mg/g):

Analysis of variance showed that there were significant differences between the control and the four levels of urea. Differences among the four levels of urea treatments were not significant. The highest mean for chlorophyll content was 45.50 obtained in 6.0 g/plant. While the lowest one was 40.75 recorded in the control (table 42).

Table (42): Mean final number of flowers per plant and chlorophyll of Wedelia (Wedelia trilobata L.) plant treated with urea.

Urea level (g/plant)	Final No. of flowers/ plant	Chlorophyll (mg/g)
0.0	5.00 c	40.75 b
1.5	5.00 c	44.62 a
3.0	6.00 bc	44.83 a
4.5	6.50 ab	43.77 a
6.0	7.50 a	45.50 a
5 % LSD	1.35	1.95
C.V.	14.9	2.9

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

4.4.11. Shoot fresh and dry weight (g):

Analysis of variance showed that there were highly significant differences among the five levels of treatments. Differences between 3.0 g/plant and 4.5 g/plant were not significant. The highest mean for shoot fresh weight was 249.2 g obtained in 6.0 g/plant. While the lowest one was 195.4 g recorded in the control (table 43).

Analysis of variance illustrated that there were highly significant differences among the five levels of treatments. Differences between 4.5g/plant and 6.0 g/plant were not significant. The highest mean for shoot dry weight was 74.60 g recorded in 6.0 g/plant. Whereas, the lowest one was 42.20 obtained in the control (table 43).

4.4.12. Root fresh and dry weight (g):

Analysis of variance showed that there were highly significant differences among the five levels of treatment. Differences between the control and 1.5g/plant were not significant. Also, the root fresh weight was not significant differences between 3.0 g/plant and 4.5 g/plant (table 43). The highest mean for root fresh weight was 86.40 g obtained in 6.0 g/plant. While the lowest one was 33.20 g recorded in the control.

Analysis of variance showed that there were significant differences among the five levels of treatments. Differences among the four levels 0.0, 1.5, 3.0 and 4.5 g/plant were not significant. The highest mean for root dry weight was 20.70 recorded in 6.0 g/plant. Whereas, the lowest one was 14.03 found in the control (table 43).

Table (43): Mean shoots and roots fresh and dry weight (g) of Wedelia (*Wedelia trilobata* L.) plant treated with urea.

Urea level (g/plant)	**shoot fwt (g/plant)**	**shoot dwt (g/plant)**	**Root fwt (g/plant)**	**Root dwt (g/plant)**
0.0	195.4 c	42.20 c	33.20 c	14.03 b
1.5	214.8 bc	58.80 b	34.90 c	14.32 b
3.0	239.1 ab	68.60 ab	56.00 b	16.93 b
4.5	245.8 ab	72.20 a	62.00 b	15.00 b
6.0	249.2 a	74.60 a	86.40 a	20.70 a
5 % LSD	30.11	10.67	6.76	2.92
C.V.	8.7	11.2	8.2	12.0

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

4.4.13. Analysis of leaf plant tissue (g):

Analysis of variance showed that there were significant differences among the five levels of treatment. Differences between 3.0 g/plant and 4.5 g/plant were not significant. The highest means for nitrogen content was 2.24 % obtained in 6.0 g/plant. While the lowest one was 1.74 % recorded in the control (table 44).

Analysis of variance showed that there were significant differences among the five levels of treatments. Phosphorus content was not significant between the control and levels 1.5, 3.0 and 4.5 g/plant. The highest mean for phosphorus content was 0.60 % recorded in 6.0 g/plant. Whereas, the lowest one was 0.26 % found in the control (table 44).

Analysis of variance showed that there were significant differences among the five levels of treatments. The highest mean for potassium was 2.18 % obtained in 6.0 g/plant. While the lowest one was 1.17 % recorded in the control (table 44).

Table (44): leaf contents of N, P and K (%) of Wedelia plant after adding different levels of urea.

Urea level (g/plant)	**Nitrogen %**	**Phosphorus %**	**Potassium %**
0.0	1.74 c	0.26 b	1.17 e
1.5	2.03 b	0.36 b	1.21 d
3.0	2.12 ab	0.36 b	1.76 c
4.5	2.14 ab	0.38 b	1.81 b
6.0	2.24 a	0.60 a	2.18 a
5 % LSD	0.157	0.185	0.017
C.V. (%)	4.2	25.7	0.6

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

CHAPTER FIVE

DISCUSSION

5.1. Effect of sulphur vegetative growth and flowering of Wedelia plant:

5.1.1. Vegetative growth:

The shoot length was increased by increase sulphur doses with significant difference from control (table 1). A similar finding by Bahadur and Bala, (2017) on Radish (*Raphanus Sativus*.L) reported that yield and yield attributing characters increased with increasing the levels of different sources of sulphur. Also another study by Walia and Kumar, (2021) on Wild Marigold showed that among the nutrient levels, N at 120 kg ha^{-1} and S at 60 kg ha^{-1} produced taller plants at 60 DAS which remained statically with other two doses of N and S than control, statistically higher plant height at 60, 90 DAS and harvest. Results can be supported with the findings of Chowdhury *et al*., (2020) on *Aloe vera* who reported that plant height increased significantly with the application different sulphur rates and the advancement of growth period. Plant height increased progressively up to sulphur at 60 DAS, compared to control.

The number of branches was equally increased by the different sulphur doses with significant difference from the control and the better dose of sulphur treatment to increased number of branches per plant was 1.6g/plant (table 2 and 3). A similar finding by Walia and Kumar, (2021) on Wild Marigold was reported that the effect of cropping season was significant on growth parameters, Statistically higher number of branches at 60, 90 DAS and harvest, respectively, were recorded during 2018 as compared to 2019, Higher number of branches plant were produced by 90 kg ha-$^{-1}$ and 60 kg S ha^{-1} (12.46) at 60 DAS than other treatments, whereas former was in line with N at 120 kg ha^{-1}. No significant effect was noticed at 90 DAS and harvest on number of branches plant with N and S application except for S at 90 DAS, which was maximum at 20 kg ha-^{1} and behaved statistically similar with S at 60 kg ha^{-1} .

The maximum number of leaves was recorded to high level of sulphur at the earlier age of plant and the minimum number of leaves was found to be in control (table 4). The same result in *Raphanus sativus*.L by Bahadur and Bala, (2017) reported that the maximum number of leaves was recorded to high level of sulphur and the minimum number of leaves was found to be in control. Also our results can be supported with the findings of Chowdhury *et al*., (2020) who reported that the maximum number of leaves was recorded from the plant fertilized with 45 kg S ha^{-1} which was significantly higher than all other levels of S and the minimum number of leaves was recorded from control. Similarly, Eisa *et al*., (2016) found the highest leaf number of *Aloe vera* from the application of 4 g S pot^{-1}. Performance of *Aloe vera* crop to a great extent is governed by the number of leaves plant. It is imperative that if the number of leaves plant is higher, the leaf yield will be higher.

It is clear that the leaf area effect and increase with increase on leaf length and width. the most effective and economic dose of sulphur to produced attractive and healthy plants of wedelia to demand the local and international markets was treatment 1.6g/plant applied at the earlier age of plants. This result was parallel to another study by Chowdhury *et al*., (2020**)** reported that addition of various levels of S showed a significant influence on the leaf area plant of *Aloe vera* at harvest. The maximum leaf area and the minimum leaf area were obtained from the plants fertilized with 45 and 0 kg ha^{-1}. Respectively. As an important plant growth index, leaf area determines plant capacity to trap solar energy which ultimately influence the growth, development, and yield of plant. This in agreement with the findings of Eisa *et al*., (2016) who found that the maximum leaf area of *Aloe vera* with the application of 4 g S pot compared to 2 g S pot. Another study by Bahadur and Bala, (2017) on Radish reported that the data related to the leaves length as given in observed the maximum leaf length was noted by the treatment ammonium sulphate 50kg S/ha followed by Super phosphate 50kg S/ha and Ammonium sulphate 100kg S/ha. The minimum value were under 0kg S/ha and the minimum leaves width was without application of source of sulphur. However, the maximum width was under Ammonium sulphate with application of 50kg S/ha followed by the treatment Ammonium sulphate 100kg S/ha. According to Mehdi and Singh, (2007) studied that the growth and yield attributes of Indian mustard (B. juncea) under various levels of sulphur (0, 20, 40, 60 and 80 kg/ha). Sulphur fertilization significantly increased the growth attributes, i.e. plant height, dry matter, leaf area index, relative growth rate (at initial vegetative growth stage), primary and secondary branches. Marked improvement was also observed in all yield contributing characters. Also Zhao *et al*., (2007) reported that total sulphur content in plants tissue ranges from 0.3% to 7.6%; the latter is found in plants from gypsum soils.

5.1.2. Flowering:

Results indicated that the plants receiving different doses of sulphur produced superior number of flowers as compared to those grown without sulphur. The highest dose of sulphur resulted in significant decreased in number of flowers and the attractive and most effect dose to equally increased number of flowers per plant was level 0.8g/plant at earlier age of plant. Improved flowers in these treated plants might be due to phosphorous and ammonium (DAP dressing dose), which was applied with sulphur. According to McKenzie, (2013) who reported that Oilseed crops, particularly canola, and forage crops, have a higher S requirement than cereal crops. Sulphur is required in the development of fertile canola flowers and must be present for good nodule development on legume forages such as alfalfa and pulse crop roots such as pea and faba bean.

Chlorophyll resulted in increase from plants nutrient with increased sulphur to high dose. These finding are in close conformity with those reported by (McKenzie, 2013) and (Vala *et al*., 2014) they found that Sulphur is a key component of some essential amino acids and is needed for protein synthesis. Chlorophyll synthesis also requires sulphur. A sulphur deficiency at any growth stage can result in reduced crop growth and yield. Adequate S results in rapid crop growth and earlier maturity.

5.1.3. Shoot and root fresh/ dry weight (g):

The total fresh weight of herb per plant was significantly and gradually increased with increasing the dose of sulphur up to 1.6g/plant. The shoot dry matter showed an isolated effect for S levels and sources. The shoot dry matter responses to the S applications were inverse first order positive. The results of this study reveal that the exogenous application of S in S-deficient soils provides greater plant growth; these increases are related to S functions inherent to the catalytic, regulatory, and structural uses by the plant. Our results can be supported with the findings on Aloe vera studied by Chowdhury *et al*., (2020) reported that a significant increase in leaf biomass yield was monitored with the application of S up to 45 kg ha and then reduced at 60 and 80 kg S ha application. The lowest leaf biomass yield was measured from the plants receiving no S fertilizer. The improvements in leaf biomass yield obtained in this study might be resulted from the efficient uptake and metabolism of S availability. Sulphur has a synergistic relationship with many essential plant nutrients especially N. The uptake and absorption of N become limited in S deficient soils. The vegetative growth and flowers enhancements obtained from S application in our study is in line with the findings of Ross, (2005) who observed positive influence of S application on the growth of Aloe plants. Similarly, Eisa *et al*., (2016) reported that the best increase in fresh and dry weights of Aloe vera was result significantly and maximum leaf and gel yield was obtained from the treatment of 4 g S. Another study of Maršic *et al*., (2021) in Cabbage showed that Dry matter yield was higher in treatments with high nitrogen accompanied by sulphur N240 S40 ; 8050 ± 871 kg ha^{-1}), compared to high nitrogen fertilization without sulphur (N240 S40; 7113 ± 274 $kgha^{-1}$).

Results regarding the impact of sulphur applications root fresh and dry weights are compiled in Table (10). All sulphur treatments enhanced these parameters significantly compared to the control. The 1.6 g and 0.8 g treatment resulted in best increase in root fresh and dry weights. The increase was significant compared to other treatments. According to Eisa *et al*., (2016) reported the 2 g sulfur treatment enhanced root fresh and dry weights of *Aloe vera* significantly and ranked top, sharing this position with the 4 g sulfur treatment for the root dry weight.

5.1.4. Analysis of leaf plant tissue (g):

In comparison to control plants, the values of macronutrients N, P, and K percent increased steadily with increasing sulphur application rate. The obtained results of increased N, P, or K percent in plants application of sulphur compared to other treatments. Because Ibaez *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, these increased N, P, or K percent results. Total sulphur content in plant tissue ranges from 0.3 percent to 7.6 percent, according to Zhao *et al*., (2007), with the latter being found in plants grown in gypsum soils.

5.2. Effect of micro elements on growth and flowering of Wedelia plant:

Kentelky and Szekely-Varga, (2021) reported that foliar fertilization was more effective and significantly enhanced the shoot and flower stem growth compared to the control plants. Similar findings have been described where the administration of foliar fertilization treatments influenced the Calendula inflorescence yields (Onofrei *et al*., 2016 and 2017). Hatamian and Souri, (2018) reported that better absorption and internal translocation of metal micronutrients generally occur with stabilized ammonium nutrition in alkaline soil conditions.

5.2.1. Vegetative growth:

From table (12) the present investigations it can be concluded that zinc sulphate are the superior to increase plant length. The observations are in line with the findings of Sarkar *et al*., (2020) was reported that a significant difference regarding plant height of Gerbera has been found among different treatments and all the values recorded superior over control. Application of Ferrous sulphate, Magnesium sulphate and Zinc sulphate has been found to significantly increase the plant height and plant spread than control. Although there was a significant increase in plant height and plant spread due to effect of zinc sulphate spray, Boric acid in all levels was found to be less effective in enhancing plant height as well as plant spread. Another study of Bashir *et al*., (2013) in Gerbera studied, Results showed that micronutrient used as foliar application significantly influence the plant height. Micronutrients have shown a remarkable response to increase plant height and spread. It might be due to active effect of micronutrients on synthesis of different growth hormones like auxins and enhancing the uptake of nitrogen which improves metabolism to stimulate growth of the plants. Fahad *et al*., (2014) findings indicated that all the three micronutrients (Fe, B and Zn) applied as foliar spray were needed for the plant's growth and contributed towards better growth of gladiolus in terms of plant height. All the factors are involved in cell division, cell multiplication and cell differentiation resulting in increased photosynthesis and translocation of food material thus enhancing the plant spread (Sarkar *et al*., 2020). Lahijie, (2012) too, found that an application of $FeSO_4$ (0.5 or 1%) and $ZnSO_4$ (0.5 or 1%) either singly or in combination, applied at 2- and 6-leaf stages, significantly increased height of gladiolus cv. Oscar plants.

From tables (13) and (14) the results show that manganese sulphate are the superior to increase the primary and secondary branches of wedelia and that concluded significant differences between treatments and the control, these results is in line with Bashir *et al*., (2013) found that the application of micronutrients solution increases the number of branches per plant compare to control.

Leaf number is considered as an important factor in growth, responsible for photosynthesis and ultimately affecting the flower yield and quality (Fahad *et* *al*., 2014). In our studied find that the increased number of leaves per plant recorded by (Mn) at all plant ages. These finding are in closed conformity with those reported in Gerbera by Sarkar *et al*., (2020) find that Application of micronutrient might be resulted to better plant growth along with significant increase in number of leaves per plant. This experiment reflects that application of magnesium, iron and zinc had a significant effect to increase the number of leaves per plant and all treatments were superior over control. The result shows that application of Fe and zinc though had a positive effect in influencing the number of leave, Boric acid again was found less effective than other treatments. And Bashir *et al*., (2013) reported that the plant which fertilized with essential micro nutrients that represent more number of leaves per plant as compared to other treatments levels. These results are in partial support of Similarly, Khosa *et al*., (2011) observed a significantly higher number of leaves per plant in Gerbera due to foliar application of micro power, a solution containing Zn, B, Fe and Mn, and Lahijie, (2012) record that foliar application of $FeSO_4$ (0.5 or 1%) and $ZnSO_4$ (0.5 or 1%) alone or in combination and at -2- and- 6- leaf stages, significantly increased number of leaves per plants in gladiolus.

Micronutrient plays a vital role in activation of enzymes as well as metabolism of carbohydrates and nitrogen. It is also involved in assimilation of carbon dioxide in photosynthesis and also helps in uptake of iron. Iron acts as an important catalyst in the enzymatic reactions of the metabolism and would have helped in larger biosynthesis of photo assimilates thereby enhancing growth of the plants (Sarkar *et al*., 2020).

The highest wedelia trilobata plants leaf area was recorded by the element (Fe) compared to the control and other micro elements treatments. Bashir *et al*., (2013) record that balanced fertilization with micro nutrients in plant nutrition that is important for the production of highly quality products and observation regarding leaf area showed significant results in case of foliar spray of micro nutrients as compared to control.in the other way Chen and Ludewig, (2017) find that Zn deficiency consistently led to larger rosette diameters in negative Zn-effect accessions. Because of the prolonged vegetative growth time, longer and more leaves were established, so that plants grown in –Zn ultimately accumulated more vegetative biomass then plants.

5.2.2. Flowering:

After 215 days, effect of Zn is the supreme in maximizing number of flower production per plant (table 19). In addition there were no differences between Zn, B and Mn. And the final number of flowers (8.50) per plant (table 20), Boron plays a vital role as stabilizer of cell wall pectic network and is possibly involved in the integrity of the plasma membrane (Fahad *et al*., 2014), although, at plant age 125, 215 and 300 days found that the micro elements (Mn), (Zn) and (B) were significant variation from the control. The effect of (Fe). (Zn) and (B) superior of chlorophyll. Fahad *et al*., (2014) indicated in his results of Gladiolus that significantly higher leaf contents were recorded when plants were sprayed with all the three micronutrients each at 2%, followed by when the plants were sprayed by 2% $FeSO_4$+2% $ZnSO_4$ and the minimum leaf chlorophyll contents were recorded in control. Zinc is an essential micronutrient necessary for sugar regulation and assorted enzymatic activity associated with plant growth, there are evidences that iron deficiency impairs many plant physiological processes because it is involved in chlorophyll and protein synthesis and in root tip meristem growth, iron deficiency (chlorosis) is a common disorder which affects plants grown on soils of high pHs. This may lead to serious yield and quality losses, demanding the implementation of suitable plant iron-deficiency correction strategies. Iron application through foliar spray is a common practice to cure iron-deficiency (Fahad *et al*., 2014). The similar results find in newer study by Sarka *et al*., (2020) on Gerbera record that Zinc, iron and magnesium play an important role by involving in photosynthesis, break down of IAA, auxin and protein synthesis increase the flower yield through foliar application of micronutrients. The result illustrated that different doses of ferrous sulphate and magnesium sulphate greatly influence yield and quality of the flowers in all respect. Zinc sulphate also improvised the quality remarkably. However, application of boric acid had a negligible effect, in fact, it had adverse effect at all level like leaf yellowing. The observation recorded was supported by the findings of Bilal *et al*., (2020) concluded that foliar application has a great impact on roses production, and it is the easiest and most economical way to improve quality production of rose flowers. Bashir *et al*., (2013) on Gerbera finds that foliar fertilization of essential nutrients has great effect on flower diameter. Therefore we can conclude that plant which received fertilization of micronutrients solution show significant results as compared to those which received no fertilization. Study in Arabidopsis by Chen and Ludewig, (2017) late-flowering accessions probably maintained a longer vegetative growth phase and the leaves were already fully expanded before flowering, but it is worth noting that some among the negative Zn-effect accessions also flowered very early. Similar effects of micronutrient foliar application have also been reported in Gerbera (Khosa *et al*., 2011).

5.2.3. Shoot and roots fresh/ dry weight (g):

The heavier shoot fresh and dry weight was recorded by Zn. Although, fresh roots and dry weight was obtained by Zn with the same effect of shoot weight. Similar results were obtained by Bilal *et al*., (2020) on roses reported that all doses showed significant result in specific parameters, such as the Zn 0.4% + Cu 0.4% exhibited the enhancing of leaf area, Zn 0.2% + Cu 0.2% showed maximum chlorophyll content and also maximum fresh and dry weight. Zn 0.4% + Cu 0.2% showed the increasing of shelf life of lilium and maximum solution up taking. Conducted the research to check the results of foliar spray of micronutrients on medicinal plants growth, yield and also fresh and dry weight of roots and shoots. Fahad *et al*., (2014) indicated in his results of Gladiolus that increase in fresh weight of complete flower stalk in the present study might be attributed to longer stalk length in T and possibly as a result of more proper plant growth.

5.2.4. Analysis of leaf plant tissue (g):

The highest percentage of nitrogen, phosphorus and potassium obtained by foliar application of iron (Fe), Boric acid (B) and manganese (Mn). These results reflect the positive relationship between the concentration of foliar fertilizer and the mineral content of the leaves. This could be attributed to the rapid absorption of these elements by the plant surface, especially the leaves, and their translocation within the plant. Similar results were obtained by El-Naggar and El-Sayed, (2009) on Dianthus reported that the mineral contents of leaves (N, P, K, Zn and Cu) were significantly increased as a result of spraying the plants with foliar fertilizer at different rates compared to the control treatments.

5.3. Effect of NPK fertilizer on vegetative growth and flowering of Wedelia plant:

5.3.1. Vegetative growth:

Generally, plant growth was affected significantly by NPK levels, so according to table (23) the results show that no significant differences was observed among NPK levels on shoot length after 40, 125 and 215 day, while at the adult plant found significant difference between the control and NPK level (4 and 8g) per plant, which might be due to insufficient nutrient availability at earlier stage of plant growth. The same results reported of Gerbera by Fayaz *et al*., (2016), Ayemi *et al*., (2017), Handayat and Sihombing, (2019) show that although in the first and second observation, the plant height was not influenced by NPK treatment. The significant effect of NPK to plant height was obtained by the last observation, after the early generative stage of the plant. The highest plant obtained from treatment (150-7550kg ha^{-1}). Another researcher cited the same result that plant height significantly increased with an increase in NPK levels by Baloch *et al.*, (2010) who reported that *zinnia elegans* fertilized with highest NP level of 50+20 g/1.5 m^2 grew to a maximum height of 68.22 cm The lower NP levels of 30+10 and 10+20 g/1.5 m^2 produced plants of 45.11 and 42.11 in height, respectively. However, the lowest NP level of 10+10 g/1.5 m^2 produced least plant height of 38.77 cm. Ashour *et al*., (2020) found that the combined treatment of NPK with either BA or GA concentrations resulted in significant increases in most of the vegetative growth parameters in terms of plant height of Dracaena. Another studies of research indicated effect of different level of NPK on the growth and flowering parameter like Ahmed *et al*., (2017) who found that Different fertilizer management packages showed a significant influence on yield and yield attributes of chrysanthemum. The highest plant height, number of flowers plant^{-1}, flower length, flower diameter, individual flower weight and yield per hectare were recorded in T treatment which received 150 kg N 75 kg P and 135 kg K ha^{-1} and the lowest from control (T_{11}) in each of the three years. Another reported of gladiolus by Gajbhiye *et al*., (2013) showed that the minimum plant height was observed with M0 level (control). Among the fertilizer, level F3 (60:30:30g NPK pot^{-1}) recorded significantly higher plant height, nitrogen is widely known as the master nutrient in the growth and development of plant and it is an important constituent of protoplasm. Khan and Ahmad, (2004) on Gladiolus found that plant height indicated that10:10:5 g pot^{-1} NPK produced plants with maximum height (86.3 cm) but statistically similar with 10:5:5 and 10:0:5 g pot^{-1} NPK which produced 81.9 and 81.8cm tall plants, respectively. On the other hand, 0:0:5, 0:5:5 and 0:10:5 g pot^{-1} NPK was statistically at par and produced dwarf plants.

Table (24 and 25) show that the wedelia plant fertilizer with highest NPK level of (8g) per plant produced significantly maximum number of primary (23.00) and secondary branches (19.00), followed by all level expect control which was record lowest number of primary branches at all plant stage and the number of secondary branches obtained (15.50) by level (4g) per plant in the third observation compared to the other level and control. The same result by Baloch *et al*., (2010) was reported that the zinnia plants fertilized with highest NP level of 50+20 g/1.5 m produced significantly maximum number of branches (11.33) plant. A similar finding by Ahmed *et al*., (2017) showed that the number of branches were higher in the treatments with NPK that resulted in more photosynthesis and food accumulation, which might have resulted in better growth and converted vegetative growth in early stages due to balanced nutrition. These results are in agreement with the finding of Rajan *et al*., (2019) on Chrysanthemum and Abd El Gayed and Attia, (2018) on *Celosia argentea* Plants who found that NPK fertilization, it was evident that number of branches per plant was significantly affected by NPK rates as shown in. In other words, both growth parameters were significantly increased by increasing NPK rate from 0.0 to 4.5 g/pot in both seasons.

The wedelia plants nutrient with highest NPK level of (8g) per plant produced significantly maximum number of leaves (343.0) plant in all observation, followed by the NPK levels (4g) per plant (293.0g) in second and third observed where the wedelia plants produced the highest number of leaves by the highest levels at all plant ages, respectively. However the minimum number of leaves protected by the control (table 26). Another researcher cited the same result on Gerbera that the total leaves were also significantly affected by NPK levels reported by Fayaz *et al*., (2016) and Ayemi *et al*., (2017). The most number of leaves obtained from treatment (150-75-75) kg ha^{-1} NPK (Handayat and Sihombing, 2019). The same result also reported by Sunawan *et al*., (2020) that GA3 concentration treatments significantly effect at 30 days after application and the treatment dose of NPK fertilizer significantly effect at the age of 75 and 90 days after application. During vegetative growth large quantities of nitrogen are required. Nutrient collusion of NPK plays a vital role in the growth and development of orchid. A similar finding of gladiolus was reported by Gajbhiye *et al*., (2013) that NPK levels, application of 60:30:30g NPK pot^{-1} (F3) recorded significantly higher number of leaves per plant (1.6,3.2, 7.2, 7.3) at 15,30, 45 and 60^{th} days after planting, respectively and at par with 40:20:20 g NPK pot^{-1} (F2) over rest of the treatments. Lower number of leaves per plant recorded with treatment F0 (control), nitrogen is the most important constituent of chlorophyll and is a component of amino acids and enzymes, thus it might have increased the meristemtic activities, cell division, cell number and cell enlargement of the plant. Another study of *Dracaena marginata* by Ashour *et al*., (2020) showed that he combined treatment of NPK with either BA or GA concentrations resulted in significant increases in most of the vegetative growth parameters in terms of number of leaves/plant, Khan and Ahmad, (2004) found that Number of leaves produced by10:10:5 g pot^{-1} NPK was 12.6 while 0:0:5 g pot^{-1} NPK (control) produced only 7.0 leaves per plant as shown in high dose of N and P resulted in maximum number of leaves. Abd El Gayed and Attia, (2018) found that NPK fertilization; it was evident that number of leaves per plant was significantly affected by NPK rates as shown in. In other words, both growth parameters were significantly increased by increasing NPK rate from 0.0 to 4.5 g/pot in both seasons.

In table (27) and (28) the result show that no significant difference observed after plant age 40 days and 215 days on the leaf length and at age 40 day on the leaf width, while at the other ages resulted significant increase by the highest level (8g) per plant. A similar finding was reported that leaf width and leaf length-were significantly affected by difference in media, NPK fertilizer application, or by their interaction (Rivai *et al*., 2017). Another study by Khan and Ahmad, (2004) on Gladiolus showed that length of leaf exhibited significant superiority of 10:10:5 g pot^{-1} NPK over other treatments by producing 63.7 cm long leaves as shown in, while 10:5:5 and 10:0:5 g pot^{-1} NPK stood at par with 10:10:5 g pot^{-1} NPK by producing 60.9 and 60.3 cm long leaves, respectively. Control (0:0:5 g pot NPK) produced minimum leaf length while remaining treatments expressed intermingling behavior among one another.

Table (29) illustrated that the results of analysis of variance showed that there was no interaction effect between the control and doses of NPK fertilizer on leaf area variables at plant age 40 day. But the NPK fertilizer doses treatment significantly affected at age 125 day and 215 day obtained by level (4g) per plant after application. The leaf area values after being tested with the Duncan 5% test are presented in Table (29), the highest level of NPK (8g) gave the higher value on leaf area (16.37) cm^2 and the lowest (8.79) cm^2 recorded by the control. This result was parallel to another study that the NPK fertilizer dosage treatment significantly affected the ages 30, 45, 60, 75 and 90 days after application (Sunawan *et al*., 2020). Another study showed by Ashour *et al*., (2020) that the combined treatment of NPK with either BA or GA concentrations resulted in significant increases in most of the vegetative growth parameters in terms of plant height, number of leaves/plant, leaf area, root length, fresh and dry weights of leaves, stems and roots as compared to the untreated plants. Rajan *et al*., (2019) found that application of nitrogen at 150 kg N/ha (N) significantly enhanced maximum leaf area ($16.01cm^2$).

5.3.2. Flowering:

According to table (30) the highest number of flowers was (9.50) obtained by the highest level (8g) per plant in the all observation and the lowest number of flower was (3.50) recorded by the control at all plant ages. These results are further supported by the finding of Baloch *et al.,* (2010) who tested that Zinnia supplied with highest NP rates of 50+20 $g/1.5m^2$ produced remarkably higher number of flowers (12.66) $plant^{-1}$, where the zinnia plants produced 11.33 and 10.33 flowers $plant^{-1}$, respectively. However, the lowest NP level of 10+10 $g/1.5m^2$ produced least number of flowers (6.00) plan. Arafa *et al*., (2019) found that NPK levels caused gradual increase of mean flower number/plant and flower diameter (mm) of *Ixora coccinea* L. plants in two seasons. Ahmed *et al*., (2017) found that the highest number of flowers plant^{-1} (25.72, 23.02 and24.37), flower diameter (7.78, 7.10 and 7.44 cm) and individual flower weight (6.05, 5.98 and 5.97 g) were also found in the treatment T (N_{150} P_{75} K_{135} kg ha^{-1}), respectively for the years and it was statistically identical with treatment T (N_{200} P_{75} K_{135} kg ha^{-1}). As the number of branches were higher in the treatments with NPK that resulted in more photosynthesis and food accumulation, which might have resulted in better growth and converted vegetative growth in early stages due to balanced nutrition and also had sufficient food material to produce the flower earlier, while in control treatments took more days to flower which might be due to late emergence of flower buds.

In these result chlorophyll was significant differences among NPK level and increased (42.64 – 43.10) by level (4 and 8g) per plant. Nitrogen is an important macro element inorganic molecules in plants including proteins, nucleic acids, purines, pyrimidine’s, co-enzymes (vitamins), and production of chlorophyll, also result showed that application of the combined NPK with either BA or GA_3 significantly increased total chlorophyll content in the leaves and total carbohydrates in leaves and stems as compared to the untreated plants. This might be attributed to the increase in the chlorophylls synthesis and photosynthesis rate. (Ashour *et al*., 2020). This result is further supported by the finding of Abd El Gayed and Attia, (2018) on *Celosia argentea* who found that NPK fertilization showed applying different fertilization rates to plants significantly increased total chlorophyll (SPAD) and total carbohydrates% compared to untreated plants in both seasons. The positive effect of NPK fertilizer rates was pronounced at 4.5g/pot followed by 3 and 1.5g/pot.

From table (31) the final number of flowers was significant variation between the control and NPK level and the highest flowers yield (6.00) obtained by the highest NPK level (8g) per plant. A similar finding of Chrysanthemum by Ahmed *et al*., (2017) was reported that flower yield was also significantly influenced by different levels of N, P and K fertilizers and it was increased to a maximum of 12.45, 11.80 and 11.63 ton ha^{-1}, respectively for 1^{st}, 2^{nd} and 3^{rd} year with NPK fertilizer application and Rajan *et al*., (2019) found that the increase in number of flowers and yield with application of nitrogen might be due to the fact that applied nitrogen had significantly increased the growth parameters like number of branches, which might have synthesized more plant metabolites and ultimately led to increased flower production. Another studies in Gerbera by Ayemi *et al*., (2017) and Fayaz *et al*., (2016) who showed that Flower yield influenced by different doses of NPK during the period of experiment. The maximum flower yield was found in the treatment of T6 (20:20:15 N.P.K.g/m^2), the plants raised in control plot had resulted minimum flower yield. It may be due to the sufficient availability of the proper nutrients to the crop at the growth stage.

5.3.3. Shoot and root fresh/ dry weight (g):

From table (32) the shoot fresh and dry weight equally increased by the different NPK levels obtained by (4g) per plant with significant differences from the control, while the roots fresh and dry weight significant differences by the highest level (8g) per plant, resulted in significantly increased compared to the control. A similar occurrence by Arafa *et al*., (2019) reported that the response of fresh, dry weights and of *Ixora coccinea* L. plants, to treatments of NPK combined different fertilization in the two seasons had the same trend of number flower and flower diameter. Rajan *et al*., (2019) on Chrysanthemum found that application of nitrogen at 150 kg N/ha (N_2) also increased fresh weight of plant (669.7 g) and dry weight of plant (163.20 g) at the end of experimentation, being the constituent of protein and nucleic acid, nitrogen is helpful in promoting plant growth. effect of wedelia on fresh and dry root was observed on the bulb root system of Lily reported by Treder, (2008) was significantly better developed in lilies grown on cocopeat and NPK level, The number of roots and total root length were 34% and 118% higher on media and nutrition than in the control treatment, respectively. It seems that good physical and biological conditions in cocopeat and NPK had positive effect on root development.

5.3.4. Analysis of leaf plant tissue (g):

In comparison to control plants, the values of macronutrients N, P, and K percent increased steadily with increasing application rate of NPK concentration (table 33), the obtained results of increased N, P, or K percent in plants application of NPK compared to other treatments. Ashour *et al*., (2020) on *Dracaena marginata* and Abd El Gayed and Attia, (2018) on *Celosia argentea* reported that increasing NPK rate from 0.0 to 4.5 g/pot significantly increased percentages of N, P, and K in leaves of both species. These findings are similar to those of Mokadem and Sorour, (2014) who revealed that using NPK fertilizer at a rate of 5g/pot produced the highest significantly values of leaf N, P, and K percent compared with plants without fertilization.

5.4. Effect of urea fertilizer on vegetative growth and flowering of Wedelia plant:

5.4.1. Vegetative growth:

No significant differences were observed for urea nutrient treatments. The maximum shoot length was recorded at urea level 6.0 g/plant, Minimum shoot length was measured in plants raised on control (table 34). When N was applied; it also enhanced plant height or length by increasing cell division and cell enlargement. The control remained at the least level because of minimum availability of nutrition. These results are in line with the work of Ahmed *et al*., (2004) on Dahlia and Wahba *et al*., (2014) found that the maximum mean values of plant height *of Urtica pilulifera* have resulted from ammonium sulfate followed by urea treatment and show that the best application in this concern was 60 units of nitrogen. Another reported of safflower by Al-Zubaidy and Al-Mohammad, (2021). Rajan *et al*., (2019) who found that the results indicated that application of 200 kg N/ha (N) to cut chrysanthemum was most effective to increase plant height and the increase in plant height might be due to the fact that nitrogen is a constituent of protein which is essential for formation of protoplasm thus affecting the cell division and cell enlargement and ultimately better vegetative growth.

Significant differences were observed among fertilizer treatments for the parameters under study. Maximum number of primary branches per plant was recorded by urea level 6.0 g/plant in the all observation and by level 4.5 and 6.0g/plant on the number of secondary branches (table 35 and 36). Minimum number of branches was recorded in those plants raised on control (0.0g/plant) conditions followed by plants. The superiority of treatment nutrient source is because optimum amount of N was available from urea. The control remained at the lowest position due to non-availability of sufficient nutrients. These findings are in accordance to the findings of Ahmed *et al*., (2004) on Dahlia and Wahba *et al*., (2014) she reported that the dose of nitrogen at 40 units/fed in the first season and 60 units/fed in the second season was more effective in promoting numbers of branches of *Urtica pilulifera* .another study of Safflower by Al-Zubaidy and Al-Mohammad, (2021) show that the level of 150 kg $N.h^{-1}$ led to stimulating plants to increase the number of their secondary branches and this may be attributed to the role of nitrogen in the metabolism of amino acids, which is a basic building block for protein. which plays several roles in promoting growth, especially supporting carbon structures of cellulose and semi –cellulose that make up the stems of plants, as well as the role of protein as the main component in building enzymes and growth hormones, which led to a steady increase in All directions of vegetative growth by increasing the processes of the division of apical and lateral meristems.

The number of leaves per plant also showed significant differences among treatments. Maximum number of leaves was recorded by 6.0g/plant and Minimum number of leaves was recorded in control (table 37). Number of leaves per plant depends upon number of vegetative buds formed on branches when urea was applied, it resulted in maximum height of the plant and more number of branches and leaves per plant. Minimum number of leaves/ plant in control might be due to absence of N for leaf bud formation. These results are in close conformity with findings of Ahmed *et al*., (2004) on Dahlia and Al-Zubaidy and Al-Mohammad, (2021) in safflower.

Leaf area was significant difference between levels and maximum leaf area (14.29) recorded by level 4.5g/plant after the plant age 125 days and 215 days. After 40 day not significant between urea levels (table 40). At the adult plants the value of highest level was slightly higher than other treatments. A similar finding was reported by Al-Zubaidy and Al-Mohammad, (2021) in safflower. Another study by Rajan *et al*., (2019) on Chrysanthemum shows that application of nitrogen at 150 kg N/ha (N) significantly enhanced maximum leaf area. Another study by Khan *et al.*, (2012) on Gladiolus reported that leaf length did not show significant variations among the treatments, but the longest leaf (36.6 cm) was produced by T_6 and the shortest leaf (32.7 cm) was recorded in control. The broadest leaf (1.93 cm) was produced by T_{11} and the narrowest leaf was recorded in control (1.55 cm).

5.4.2. Flowering:

After 215 days and 300 days maximum number of flowers was produced, when urea was applied by level 4.5g/plant. Minimum number of flowers was recorded in control (no fertilizer used) (table 41). As more number of branches were produced in the former treatments which ultimately resulted in more number of flowers. These results are in accordance with the findings of Ahmed *et al*., (2004), and Rajan *et al*., (2019) in chrysanthemum. Nitrogen form urea amine has unique and beneficial effects on plant form and function, these effects can lead to increased flowering in ornamental species (Marks *et al*., 2020).

The highest dose of urea resulted in significant increase in the final number of flowers compared to the control (table 42), this result are father supported by the finding of Wahba *et al*., (2014) on *Urtica pilulifera* who reported that Increasing the dose of nitrogen from 20 to 40 units/fed increased the flower fresh weight. Chlorophyll was significantly difference between the control and urea level. The same result of Yildirim *et al*., (2007) was reported that SPAD chlorophyll meter values increased with increasing urea concentration for both broccoli cultivars. This finding is in close conformity with those reported by Al-Zubaidy and Al-Mohammad, (2021) on Safflower.

5.4.3. Shoot and root fresh/ dry weight (g):

(Table 43) show that significant difference among urea treatments. The maximum fresh and dry weight record by the highest level (6.0 g/plant) of applied urea, Yildirim *et al*., (2007) reported the different result that head dry matter and leaf dry matter of broccoli contents of both cultivars were negatively affected by mineral nitrogen treatment and foliar urea applications. Another study of Wahba *et al*., (2014) show that the effect of nitrogen application, is clear that the total fresh weight of *Urtica pilulifera* herb per plant was significantly and gradually increased with increasing the dose of nitrogen up to 60 units/fed. Also, the differences between doses of nitrogen were significant and the medium level of urea produced the highest values as compared to high and low doses of urea. The same trend was observed during the two seasons with dry weight. This finding is in close conformity with those reported by Al-Zubaidy and Al-Mohammad, (2021) and Rajan *et al*., (2019) in Chrysanthemum show that the constituent of protein and nucleic acid, nitrogen is helpful in promoting plant growth

Significantly differences were observed among urea level (table 43). And root fresh and dry weight increased according to urea level increased. The same result of Wahba *et al*., (2014) was reported that the response of fresh and dry weight of roots for *Urtica pilulifera* to the nitrogen source application was varied during the two seasons. The response of root yield to doses of nitrogen application was with 60 unit nitrogen /fed which produced the maximum values in this concern followed by 40 units/fed. plants have evolved to take up urea from soil, and possess highly conserved systems within root cells for doing so (Marks *et al*., 2020).

5.4.4. Analysis of leaf plant tissue (g):

In comparison to control plants, the values of macronutrients N, P, and K percent increased steadily with increasing application rate of urea concentration (table 44), the obtained results of increased N, P, or K percent in plants application of urea compared to other treatments. The moderate rate of urea (6.0 g/plant) was the best for increasing total N, P and K in plant tissues. Vargas and Bryla, (2015) on blueberry reported that ammonium sulfate may increase N uptake relative to urea as a result of lower soil pH and increased availability of NH_4 –N. The same results were reported by Wahba *et al.* (2014) on *Urtica pilulifera* plant and Bar-Yosef *et al*., (2009) found on cut roses that nutrient contents in leaves in the urea treatment were similar to those in treatment 25:75:0, except that Mn content was lower.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

1- Wedelia (*Wedelia trilobata* L.) can be improved at Khartoum state through the application of N fertilizers, NPK, foliar micro elements fertilizers and sulphur elemental fertilizer.

2- *Wedelia trilobata* L. plants positively responded to sulphur application. All sulphur treatments produced significant Increments in growth and flowering as compared to control at all ages of plant to produced vegetative growth obtained in the best level was 1.6g/plant. While the best level for increased flowers was 0.8 g/plant.

3- Micronutrients applied to *Wedelia trilobata* as foliar spray at stages of plant, the best level to increased vegetative growth parameter was Mn and Zn. whereas the best level to increased flowers was B. Leaf width was not significant at the all plant ages.

4- From the observation result, found that NPK application enhanced various growth indices and increased flowers number per plant of *Wedelia trilobata* L. High rate of NPK (8g/plant) perform better of all parameters studied.

5- *Wedelia trilobata* plants positively responded to urea application. All levels of urea treatments produced significant Increments in growth and flowering as compared to control plants and the results of the present study suggest that optimal levels of urea can be used to ensure the production of vigorous and healthy. Optimal level of urea was 6.0g/plant for all parameters and plant ages, followed by the medium level of 4.5g/plant.

CHAPTER SEVEN

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Appendix (1)

Appendix (1): monthly mean maximum and minimum air temperature (Cº), relative humidity (%) and rainfall at Shambat during growing seasons February 2018- August 2019.

Months	**2017/18**				**2018/19**			
	Mean temperature (Cº)		Relative humidity (%)	Rain fall (MM)	Mean temperature (Cº)		Relative humidity (%)	Rain fall (MM)
	Max.	Min.			Max.	Min.		
February	36.9	21.2	20	0.0	33.6	18.9	18	0.0
March	38.4	22.5	12	0.0	35.3	20.2	11	0.0
April	39.5	23.5	8	0.0	40.0	23.5	10	0.0
May	41.8	28.0	18	0.4	43.0	28.8	13	6.1
June	40.1	27.3	29	0.4	40.7	27.9	33	4.9
July	38.1	26.7	42	34.3	34.4	27.5	36	19.1
August	35.6	25.8	41	31.7	35.2	25.3	56	56.5
September	37.3	26.3	45	33.6	38.7	27.6	42	41.9
October	39.3	26.7	27	0.0				
November	34.7	20.0	20	0.0				
December	31.2	17.0	25	0.0				
January	29.4	15.4	20	0.0				

Source: Ministry of Environment, Forestry and physical Development Meteorological Authority Weather- climate data. Shambat Metrological Station.

Appendix (2)

Plate (1). ***Wedelia trilobata*** **L. plant**

Plate (2). Wedelia fertilized with sulphur

Plate (3). Wedelia fertilized with micro elements

Plate (4). Wedelia fertilized with NPK

Plate (5). Wedelia fertilized with Urea