

Effect of Tillage Systems and Levels of Nano-Micronutrients on Vegetative Growth of Sunflower (*Helianthus annuus* L.)

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I. Abstract

The experiment was carried out on a field in Al-Muthanna Governorate, Iraq, during the spring growing season of 2024, precisely in March. The region exhibits semi-arid climatic conditions, characterized by progressively rising temperatures during the growing season. This study sought to examine the impact of various tillage strategies and micronutrient concentrations on the vegetative growth of sunflower plants in Al-Muthanna Governorate during the spring growing season of 2024. The experiment utilized a randomized complete block design (RCBD) featuring a split-plot arrangement and three replications. The findings indicated the subsequent: The zero tillage system (T3) markedly surpassed the majority of vegetative growth parameters, including plant height, leaf count, and stem diameter, achieving measurements of 133.17 cm, 21.08 leaves, and 21.45 mm, respectively. The second level (M2) markedly surpassed the others, yielding the highest average plant height, leaf count, and stem diameter, measuring 132.74 cm, 20.17 leaves, and 20.17 mm, respectively. The findings indicated that the no-tillage approach markedly enhanced vegetative growth characteristics in comparison to medium and deep tillage. The moderate concentration of micronutrients (45) produced the optimal plant response. This is due to conservation agricultural practices, particularly no-tillage, which enhance plant development and promote greater height. Plants cultivated using the no-till system exhibited greater height, owing to enhanced soil moisture and improved physical characteristics that facilitate vegetative growth. The research determined that implementing a conservation agriculture system with balanced fertilizing effectively enhances sunflower productivity in semi-arid regions.

II. Introduction

The sunflower (*Helianthus annuus* L.) is a significant oilseed crop globally, noted for its high production and nutritional value, including substantial amounts of proteins, vital minerals, and vitamins. It is utilized across multiple industries, including oil production, as it serves as the principal source of vegetable oils worldwide. It is additionally utilized in the pharmaceutical sector (Sher et al., 2016). This crop is grown extensively across diverse environmental and agricultural conditions because to its substantial economic benefits for farmers. Moreover, it enhances soil fertility when integrated with zero tillage, as it mitigates soil erosion and conserves moisture and organic matter. Tillage



systems are essential for enhancing the physical and chemical characteristics of soil, influencing soil aeration, water permeability, and root development. These systems encompass zero tillage, medium tillage, and deep tillage, each varying in their effects on soil structure and nutrient absorption efficiency.

Micronutrients including iron, zinc, and boron are vital for plant growth, as they participate in enzyme synthesis and several physiological functions. The researcher stated in his study that including these elements at optimal levels enhances vegetative growth and improves plant traits, whereas excessive quantities adversely affect vegetative growth features and ultimately yield (Lal, 2015). Sher et al. (2018) shown in their study on sunflower crops that zero tillage technologies considerably enhance plant height, surpassing that of typical tillage methods. This is probably attributable to enhanced efficiency in water and nutrient absorption caused by less soil friction.

Raliya et al. (2015) discovered that the use of zinc oxide nanoparticles resulted in a notable enhancement in plant height and stem diameter. Plants subjected to nanoparticle treatment demonstrated enhanced vegetative growth, attributable to zinc's pivotal function in enzyme activation, hence promoting photosynthesis. Researcher Kolenčik et al. (2020) investigated the application of nanonutrients to sunflower crops and discovered that it enhanced vegetative traits, such as plant height and leaf count, due to improved nutrient absorption efficiency, which stimulated the plant's physiological processes.

III. Materials and methods

The experiment was conducted in a field in Al-Muthanna Governorate, Iraq, during the spring growing season of 2024, in March.

A randomized complete block design (RCBD) with a split plot design was used, with three replicates per treatment.

Table : Soil analysis before planting

Items	value	unit
ECE (1:1)	5.20	dsm-1
PH	5.11	—
Available nitrogen	15.60	mg kg-1
Available phosphorus	0.70	mg kg-1
Sand	500.00	gm kg-1soil
Clay	250.00	gm kg-1soil
silt	127.00	gm kg-1soil
Soil texture	Sandy clay loam	

First treatment Main Plot Factor: Tillage Systems

T1: Deep tillage

T2: Minimum tillage

T3: No-tillage

Second treatment Sub Plot Factor: Micronutrients

M1: 35

M2: 45

M3: 75

Third treatment Tillage Method (Conservation Agriculture)

No-tillage (T3): No tillage was performed; the soil was planted directly in the crop residue, and small furrows were created for seed placement only.

Minimum tillage (T2): Shallow tillage to a depth of 10–15 cm. Deep Plowing (T1)

Plowing to a depth of 25–30 cm using a disc and moldboard plow.

Sunflower (*Helianthus annuus* L.) cultivar Lilo was sown in March 2024.

The row planting method was used with regular spacing between plants.

Micronutrients were added in solution form:

Foliar spraying was performed. Levels (35, 45, 75) were applied in two stages:

First: Early vegetative growth stage, Second: Pre-flowering stage.

Irrigation was carried out as needed using surface irrigation. Weed control was performed manually when necessary. The same conditions were maintained for all treatments.

Tested Traits

Plant Height (cm): Measured from the soil surface to the base of the disc (Sahoki et al., 1996).

Number of Leaves (leaf-plant): Based on the total number of leaves per plant, from the first green leaf to the last leaf (Hunt, 1982). Stem diameter (mm): Measured at the midpoint of the plant stem using a Vernier caliper.

Data were analyzed using analysis of variance (ANOVA) according to an RCBD design. Significance of differences between means was tested using the least significant difference (LSD) test at a probability level of 0.05.

IV. Results and Discussion

Table (1) of the effect of tillage systems and different levels of nanonutrients on plant height (cm)

average	M	average	T
132.36	M1	127.50	T1
132.74	M2	129.42	T2
124.98	M3	133.17	T3
1.810	L.S.D(0.05)	1.753	L.s.D(0.05)

Table (2) of the effect of tillage systems and different levels of nanonutrients on stem diameter (mm)

average	M	average	T
19.09	M1	17.73	T1
20.70	M2	19.04	T2
18.44	M3	21.45	T3
0.838	L.S.D(0.05)	0.811	L.S.D(0.05)

Table (3) of the effect of tillage systems and different levels of nanonutrients on the number of plant leaves (plant leaf - 1)

average	M	average	T
18.53	M1	17.67	T1
20.17	M2	17.83	T2
17.88	M3	21.08	T3
1.084	L.S.D(0.05)	1.049	L.S.D(0.05)

The results indicated substantial variations in vegetative development characteristics (plant height, stem diameter, and leaf count) among the treatments. The findings also demonstrated the superiority of treatment M2T3 (zero tillage + level 45) across all examined attributes.

This is ascribed to the enhancement of soil physical qualities due to zero tillage, which facilitated increased root growth and improved nutrient absorption. Moreover, the moderate concentration of micronutrients established an appropriate nutritional equilibrium for the plant, avoiding toxicity.

Plant height has considerable variability influenced by tillage regimes and varying micronutrient levels, owing to its significant correlation with lodging and light interception efficiency. The findings demonstrated the superiority of zero tillage (T3), which produced the maximum plant height of 133.17 cm.

Zero tillage conserves crop leftovers, resulting in diminished moisture loss, enhanced organic matter, improved microbial activity, and decreased soil structure degradation, so creating a more favorable root environment. An increase in stem diameter significantly enhances plant output by augmenting vascular bundles and nutrient transport vessels due to the thickening of the phloem, xylem, and pith layers, which leads to improved nutrient uptake by the roots. This enhances nutrient availability by improving efficiency and offers increased potential for seeds, the final product, to develop and absorb nutrients. This is substantiated by the affirmative link between the two. An increase in stem diameter is likely attributable to enhanced carbohydrate availability, resulting in improved root growth and greater absorption of minerals such as zinc and iron. This produces a more robust stem with enhanced structural support. The maximum value at level T3 was 21.45 mm, while the maximum value at level M2 was 20.70 mm. This results from zero tillage techniques, which enhance soil structure and augment organic matter, hence facilitating root growth and enhancing nutrient delivery to the stem, finally resulting in an increase in stem diameter. The augmented leaf count due to less environmental stress, along with a consistent nutrition supply, enhances enzyme activity, hence promoting vegetative branching and expanding the photosynthetic surface area. The augmented leaf count with zero tillage is ascribed to enhanced environmental conditions in the root zone, peaking at T3 with 21.08 leaves per plant. The addition of micronutrient M2 enhanced photosynthetic efficiency and promoted leaf development, leading to an optimal nutritional equilibrium. The mean micronutrient concentration (45) yielded a peak leaf count of 20.17 leaves per plant, establishing a balanced and conducive nutritional milieu that promoted physiological activities. The elevated concentration (75) resulted in harmful effects, perhaps due to the buildup of components in plant tissues without their use.

The results align with the findings of Lal (2015) and Hobbs et al. (2008) concerning the significance of conservation tillage systems in enhancing soil characteristics and augmenting production efficiency and photosynthetic activities.



V. References

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