Effect of integrated management of chemical fertilizers and nano-nutrients on bread wheat growth different tillage systems

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Abstract

A field experiment was conducted in fields belonging to the Field Crops Department - College of Agriculture , Al-Qasim Green University during the growing season (2025-2026) with the aim of evaluating the effect of combinations of chemical and nano fertilizers on the growth of wheat (*Triticum aestivum* L.) under different tillage systems. A randomized complete block design (RCBD) with a split-plot arrangement was used. The main factor included three tillage systems (no-till treatment T0, conventional tillage treatment T1, and surface tillage treatment T2) and four combinations of chemical and nano-fertilizers (100% chemical fertilizer, 75% chemical fertilizer + nano-fertilizer, 50% chemical fertilizer + nano-fertilizer, and 25% chemical fertilizer + nano-fertilizer), designated as F1, F2, F3, and F4, with three replicates. The results showed the surface tillage treatment excelled in most growth traits, giving the highest average flag leaf area (49.73 cm^2), chlorophyll SPAD content (47.15), and number of tillers (5.092 tillers). The 75% chemical fertilizer + nano-fertilizer combination resulted in the highest average plant height (104.80 cm), flag leaf area (50.67 cm^2), and number of tillers (4,822). The interaction between tillage systems and fertilizer combinations had a significant effect, with surface tillage combined with the 75% chemical fertilizer + nano-fertilizer combination achieving the highest averages for most growth traits.

Keywords: Chemical fertilizers, nano-nutrients, tillage systems, bread wheat

Introduction

Wheat (*Triticum aestivum* L.) is one of the world's most important staple cereal crops, supporting more than two-thirds of the global population. It is a primary food source, providing more than 25% of the world's calories and protein [6]. Fertilizers are among the most important factors affecting wheat growth and productivity, as they contribute to supplying the plant with essential nutrients necessary for vital processes such as photosynthesis and protein synthesis (Farouk et al., 2024). With the increasing demand for food due to population growth, declining soil fertility, and the excessive use of chemical fertilizers, the need to adopt modern agricultural practices and technologies that increase productivity while preserving the environment has become urgent [10]. Nano-fertilizers are

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among the modern technologies in the agricultural field, as their particle sizes range from 1–100 nanometers, giving them unique properties in improving nutrient utilization efficiency compared to traditional fertilizers. These fertilizers rely on the principle of controlled nutrient release, which reduces losses due to leaching or volatilization and increases absorption efficiency through plant tissues, whether through the roots or leaves. Numerous studies have shown that the use of nano-fertilizers contributes to improved vegetative growth traits, increased chlorophyll content, and enhanced productivity, in addition to their role in increasing plant tolerance to environmental stresses such as drought and salinity. These fertilizers also reduce the environmental impact of intensive chemical fertilizer use, making them a promising option for achieving sustainable agriculture and increasing production efficiency, particularly for cereal crops such as wheat. Tillage is an important agricultural practice in crop production due to its role in breaking up and aerating the soil, creating a suitable environment for seed germination, and playing an important role in activating microorganisms [11]. However, the regular use of tillage operations may negatively affect the physical and chemical properties due to the repeated use of agricultural machinery during soil preparation for planting [2]. Therefore, the shift towards conservation tillage systems provides more stable systems. Conservation agriculture is one of the most prominent modern agricultural systems that aims to achieve sustainability by reducing soil disturbance, preserving vegetation cover, and promoting crop diversity, which is reflected positively in the physical, chemical, and biological properties of the soil [1]. This study aims to determine the effect of combinations of chemical and nano fertilizers on wheat growth and to identify a suitable tillage system to preserve the chemical and physical properties of the soil and increase production.

Materials and Methods

A field experiment was conducted during the 2025-2026 winter season in fields belonging to the Field Crops Department to determine the effect of combinations of chemical and nano-fertilizers on improving wheat growth efficiency under different tillage systems. A randomized complete block design and a split-block design were used. The main control factor was tillage systems, and the secondary control factor was the application of chemical and nano-fertilizers. Random soil samples were taken and analyzed in the Soil Laboratory of the Agricultural Research Department.

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Table (1) shows some chemical and physical properties of the field soil before planting.

Value	Unit	Properties
7.97	-	PH
2.17	$ds.m^{-1}$	EC
45.10	$Mg\ kg^{-1}$	Nitrogen
8.3	$Mg\ kg^{-1}$	Phosphorous
129	$Mg\ kg^{-1}$	Potassium
270	$g.kg^{-1}$	Sand
420	$g.kg^{-1}$	Silt
310	$g.kg^{-1}$	Clay
	Silty Clay loam	Soil Texture

Experimental Design and Factors

The experiment was designed as a completely randomized block design with split-plot arrangement and three replications. The study factors were:

Factor 1: Tillage Systems

1. Zero tillage treatment (T0)

2. Conventional tillage treatment (T1)

3. Surface tillage treatment (T2)

Factor 2: Fertilizer Combinations

1. 100% chemical fertilizer (control) (F1)

2. 75% chemical fertilizer + nano-fertilizer (F2)

3. 50% chemical fertilizer + nano-fertilizer (F3)

4. 25% chemical fertilizer + nano-fertilizer (F4)

Soil and Crop Management Operations

The land was prepared and divided into 6 m² plots for each experimental unit. Each experimental unit contained 8 rows, spaced 20 cm apart. Plowing was carried out to the required depth: 30-40 cm for conventional tillage, 15 cm for surface tillage, and 5 cm for no-tillage, to provide a good seedbed. The variety IPA 99 was sown on November 21, 2025, at a seeding rate of 140 kg ha^{-1}. DAP (18-46-0) and 46% N urea were applied as nitrogen and phosphorus sources in a single application at planting, at a recommended rate of 100 kg P_2O_5 ha^{-1}. Fertilization was then completed with urea at a recommended

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rate of 200 kg N ha^{-1}, applied in three applications: the first at planting, the second at the elongation stage, and the third at the ridge stage [17]. The neutral (20,20,20) nano-fertilizer NPK was added at a fertilizer recommendation of 7 kg ha-1 in one application at the branching stage.

Studied Traits

Vegetative growth traits were measured by randomly selecting ten plants from each experimental unit and from the midlines, and averaging the results:

Plant Height (cm): Ten plants were randomly measured using a measuring tape from the soil surface to the tip of the spike, excluding the awns.

Flag Leaf Area (cm^2): Ten flag leaves of the main stem were measured using a graduated ruler and calculated according to the equation [14].

Flag Leaf Area = Leaf Length × Mid-Width × Correction Factor 0.95

Chlorophyll Content: Chlorophyll content was determined at full bloom by taking the average of three readings from the blade of each leaf randomly using a SPAD-502 chlorophyll meter.

Number of Tillers: This was calculated manually after the branching stage was completed. Statistical Analysis: The data were statistically analyzed using the GenStat Release 12.1 statistical software, following an RCBD split-plot design. After data collection and arrangement, means were compared using the Least Significant Difference (LSD) test at the 5% level ([8].

Results and Discussion:

Plant Height (cm)

The results in Table 2 show no significant differences between the tillage systems in plant height. The results showed significant differences between the fertilizer combinations. F2 fertilizer combination recorded the highest average height at 104.80 cm, while F4 fertilizer combination recorded the lowest average height at 101.63 cm. This is due to the role of fertilizers in improving nutrient availability, which contributes to increased cell division and elongation. Additionally, the small size of the nanoparticles increases their permeability within the tissues, thus stimulating physiological processes and increasing plant height[4,7] . The results also showed a significant interaction between tillage systems and fertilizer combinations. The interaction treatment T2F2 resulted in the highest average height at 105.53 cm, while the lowest average height was achieved with treatment T0F4 at 99.67 cm.

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Table (2) shows the effect of tillage systems, fertilizer combinations, and their interaction on plant height (cm).

Average	Fertilizer combinations				Tillage System
	F4	**F3**	**F2**	**F1**	
102.05	**99.67**	**101.60**	**103.43**	**103.50**	T0
104.53	**103.97**	**103.23**	**105.43**	**105.47**	T1
103.11	**101.27**	**101.23**	**105.53**	**104.40**	T2
	101.63	**102.02**	**104.80**	**104.46**	Mean
Interaction:4.898	**Fertilizer: 2.557**		**Tillage System :N.S**		LSD 5%

Flag Leaf Area (cm²)

Table 3 shows significant differences in the results. Treatment T2 gave the highest average leaf area (49.73 cm²), while treatment T0 gave the lowest average (47.00 cm²). This is attributed to increased soil moisture content and enhanced root growth, leading to nutrient accumulation and consequently, increased leaf area[3,18] .The results also show the excelled of the F2 fertilizer combination, which gave the highest average leaf area (50.67 cm²), while the F4 fertilizer combination gave the lowest average (45.54 cm²). This is attributed to the role of fertilizers in promoting vegetative growth, increasing photosynthetic efficiency, and enhancing nutrient absorption, thus stimulating cell division and leaf expansion [5]. The interaction between tillage systems and fertilizer combinations had a significant effect, with treatment T2F2 yielding the highest average area of 53.34 cm².

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Table (3) shows the effect of tillage systems, fertilizer combinations, and their interaction on flag leaf area (cm²).

Average	Fertilizer combinations				Tillage System
	F4	F3	F2	F1	
47.00	43.43	47.74	49.17	47.65	T0
47.83	46.16	47.71	49.50	47.96	T1
49.73	47.04	49.14	53.34	49.40	T2
	45.54	48.20	50.67	48.34	Mean
Interaction:1.833	Fertilizer:1.285		Tillage System : 1.188		LSD 5%

Chlorophyll Content

The results in Table 4 show significant differences. Treatment T2 gave the highest average SPAD of 47.15, compared to treatment T1, which gave the lowest average SPAD of 45.92. This is attributed to soil moisture and fertility, increased nutrients, and improved plant physiological indicators such as photosynthesis, which delays leaf senescence[13,15] . The results also show the excelled of fertilizer combination F1, which gave the highest average SPAD of 47.47, not significantly different from fertilizer combination F2 (SPD of 47.21). The results indicate a significant interaction between tillage systems and fertilizer combinations, with treatment T2F2 yielding the highest average SPAD of 48.30. This suggests that surface tillage improves soil structure, increases fertilizer use efficiency, reduces fertilizer loss, and provides the necessary nutrients for growth processes. Photosynthetic factors contribute to achieving the highest chlorophyll content [16].

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Table (4) Effect of tillage systems, fertilizer combinations, and their interaction on chlorophyll content in leaves (SPAD)

Average combinations	Fertilizer				Tillage System
	F4	**F3**	**F2**	**F1**	
46.67	**44.76**	**47.14**	**47.59**	**47.18**	T0
45.92	**45.07**	**45.51**	**45.73**	**47.38**	T1
47.15	**46.09**	**46.36**	**48.30**	**47.84**	T2
	45.30	**46.34**	**47.21**	**47.47**	Mean
Interaction:1.855	**Fertilizer:1.169**			**Tillage:0.904**	LSD 5%

Number of tillers per plant

The results in Table 5 show significant differences. The T2 tillage treatment gave the highest average of 5,092 tillers per plant, while the T0 tillage treatment gave the lowest average of 4,200 tillers per plant. This is attributed to the effect of tillage on improving soil structure, leading to better root growth and higher efficiency in water and nutrient absorption, thus increasing the number of branches[9,12] . The results also showed the excelled of the F2 fertilizer combination, yielding the highest average of 4,822 tillers per plant, while the F4 fertilizer combination gave the lowest average of 4,400 tillers per plant. The interaction between tillage systems and fertilizer combinations had a significant effect, with the T2F2 fertilizer treatment yielding the highest average of 5,300 tillers per plant.

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Table (5) Effect of tillage systems, fertilizer combinations, and their interaction on number of Branches per plant

Average	Fertilizer combinations				Tillage System
	F4	**F3**	**F2**	**F1**	
4.200	**3.900**	**4.100**	**4.500**	**4.300**	T0
4.617	**4.400**	**4.600**	**4.667**	**4.800**	T1
5.092	**4.900**	**5.067**	**5.300**	**5.100**	T2
	4.400	**4.589**	**4.822**	**4.733**	Mean
Interaction:0.3078	**Fertilizer: 0.2056**		**Tillage System : 0.2456**		LSD 5%

Conclusions:

The study results showed that using combinations of chemical and nano-fertilizers under different tillage systems had a significant effect on improving wheat growth traits. The surface tillage treatment excelled several vegetative growth traits, such as flag leaf area, chlorophyll content, and number of branches, indicating improved photosynthetic efficiency, resource utilization, and soil structure. The results also showed that adding nano-fertilizers alongside chemical fertilizers enhanced nutrient uptake, which positively impacted wheat growth indicators compared to conventional fertilizers.

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