Comparative Study on Growth and Yield of Wheat (*Triticum aestivum* L.) under Diverse Fertilizer Applications and Methods

Moyassar Mohammed Aziz

Filed Crops Dept., College of Agriculture and Forestry, University of Mosul, Mosul, Iraq.
Email: moyassar_aziz@uomosul.edu.iq

Abstract

Efficient fertilizer management is an important practice to increase the productivity of wheat (*Triticum aestivum* L.), one of the world's major cereals. In order to investigate wheat growth and yield as affected by different fertilizer sources and application methods in two successive cropping years. Also compared were two main fertilization methods: soil (diammonium phosphate [DAP]) application (T8) and foliar application with seven different nutrient formulas (T1–7) on the basis of R.C.B.D in three replications. Results showed a significantly increase in plant height, spike length and grain yield by foliar application (T6) and (T7) over soil apply with Di Amino Phosphate (DAP). The treatments (T3) (Foliar 100 Complex 25ZM 25 Algham) and (T7) (Foliar NPK) obtained the highest grain yield having statures of 8077.07 kg ha^{-1} and 7653.9 kg ha^{-1}, respectively compared with soil DAP which yielded13355 kg ha^{-1} while The Foliar 100 Complex 25ZM 25 Algham (T3) recorded a height of5860.7 kg ha^{-1}. Foliar nutrition also promoted tiller and spike density, where T3 had the highest spike 713 m^{-2}. This study revealed that foliar application of NPK and Nutigreen with zinc and amino acids was beneficial to nutrient uptake, growth, and grain quality in wheat. Such results may favor integrated nutrient management based on both foliar and soil applications to optimize wheat grains yield and decrease environmental wear. Such findings have important implications for agronomists and policymakers pursuing sustainable wheat production.

Keywords: **Wheat, Fertilizer optimization, Crop growth, Grain yield.**

Introduction

Wheat (Triticum aestivum L.) is considered among the most important cereal crops that are essential for food security globally since it directly provides food to >35% of global population [1] Regardless, increasing agricultural and environmental challenges such as exhausted soil fertility, unpredicted climate variations, and sustainable agriculture demand immediate attention to advance wheat production in productive ways [2]. Fertilization is crucial in promoting wheat growth and yield, with nitrogen (N), phosphorus (P), and potassium (K) as the most important macronutrients [3] [4].

According to the general application of traditional fertilizers such as urea, di-ammonium phosphate (DAP), inefficient utilization leads them to be lost and causing pollution in the environment [5] [6]. Recent improvements of the fertilization process, special organic fertilizers amendments have ability met health basis and biofertilizers also precision applications, including foliar feeding systems indicate potential for improving NUE as well as sustainability [7] [8].

This work was undertaken to assess the relative efficacy of sources and methods of fertilization on yield, growth and nutrient uptake by wheat. It compares the fertilizer use efficiency of soil applied DAP to that of foliar application with seven different types of fertilizer, thus generating knowledge to rationalize wheat nutrient management in the region [9], [10], [11].

Objectives of the Study

1. The objective of this research was to evaluate the effect of different types and application methods of fertilizer on wheat growth and yield.
2. The effects of chemical, organic and biofertilizers on wheat growth criteria such as height, number of tillers, and leaf area were studied.
3. The effect of two fertilization types, namely soil application, and foliar spraying on grain yield components (grain number, grain weight and harvest index) was determined.
4. Regardless of the treatments (granules and foliar fertilizers) used for all studied traits, seeding rates of 140 and 200 kg ha-1 were compared.

Finally, we conclude with some suggestions to improve fertilizer use in wheat cultivation for increasing productivity and maintaining sustainability.

Materials and Methods

Experimental location:

A field experiment was conducted in 2023 – 2024 growing season at the district of Al-Hamdania, Nineveh Governorate, Iraq (36.27° N, 43.35° E). Average annual rainfall reached around 500 mm in the region and with a temperate climate, the growing period temperature varies from 7°C~33°C.

***Experimental Design*:**

The experiment was carried out in RCBD design, with three replications to evaluate the influence of fertilizer application methods on growth and yield of wheat. A total of seven types of fertilizers were applied as foliar and diammonium phosphate (DAP) was used for the soil treatments.

Treatments and Fertilizer Application

For soil application, DAP (di-amino-phosphate) (18 – 46 – 0) was incorporated into the soil as granules at a rate of 50 kg on the seeding date. Additionally, urea (46% N) was applied as granules on two separate occasions: 21 days after seeding and at the onset of tillering [12].

For foliar application, seven distinct fertilizers, DISPER Bloom, DISPER Complex GS, DISPER ZM, DISPER Alghum GS, DISPER Chlorophyll GS, Nuti-green AD51, and Liquid DAP 18-46-00, were applied individually and in different combinations. Tables (1 and 2) detail the quantities of foliar fertilizer sprayed twice at both the tillering and elongation stages and outline the specific fertilizer treatments used in the experiment.

Soil-applied DAP (18-46-0) was applied as granules at a rate of 50 kg ha^{-1} at sowing. Urea (46% N) was supplemented in two split applications, 21 days after seeding and at tillering onset [12].

Foliar fertilizers consisted of seven distinct formulations: DISPER Bloom, DISPER Complex GS, DISPER ZM, DISPER Alghum GS, DISPER Chlorophyll GS, Nuti-green AD51, and Liquid DAP 18-46-0. The application rates and timings are listed in Tables 1 and 2, respectively. Foliar sprays were applied twice, at the tillering and elongation stages of growth.

ISSN 2072-3857

Table (1): Foliar Fertilizers, Origins, Substances, Amounts, and Spray Times.

Foliar Fertilizers	Fertilizer Origin	Fertilizer Substances	Sprayed Amounts	Sprayed Time
DISPER Bloom	Spain	Seaweeds 26.3%, Free amino acids 8%, Vitamins 0.3%, Polysaccharides 5.5%.	24 g L^{-1}	@ tillers and elongation stages
DISPER Complex GS	Spain	Iron 5%, Manganese 4%, Magnesium 2%, Zinc 0.4%, Boron 0.6%, Molybdenum 0.2%, EDTA, EDDHSA	50 g L^{-1}	@ tillers and elongation stages
DISPER ZM	Spain	total Zinc 8.2% total, Magnesium 8.1%	25 g L^{-1}	@ tillers and elongation stages
DISPER Alghum GS	Spain	Humic Acids 60%, Fulvic Acids15%, Seaweed Extracts 5%, Potassium (K_2O) 20%	25 g L^{-1}	@ tillers and elongation stages
DISPER Chlorophyll GS	Spain	Free Amino Acids 60%, Vitamins 22%, Molybdenum 2%	25 g L^{-1}	@ tillers and elongation stages
Nuti-green AD51	Italy	Amino Acids 50%	2.5 L ha^{-1}	@ tillers and elongation stages
Liquid DAP	Jordan	18 N, 46 P, 0 K.	2 L ha^{-1}	@ tillers and elongation stages

ISSN 2072-3857

Table (2) Form of (Foliar, and Granule) Fertilizers that used in experiment

Treatment No.	Foliar Fertilizers Treatments	Granules Fertilizer
T1	DISPER Bloom (50%), DISPER Complex GS (50%), DISPER ZM (25%), DISPER Alghum GS (25%)	-
T2	DISPER Bloom (75%), DISPER Complex GS (75%)	-
T3	DISPER Bloom (100%), DISPER ZM (25%), DISPER Alghum GS (25%)	-
T4	DISPER Complex GS (100%), DISPER ZM (25%), DISPER Alghum GS (25%)	-
T5	DISPER Chlorophyll GS	-
T6	Nuti-green AD51	-
T7	Liquid DAP 18-46-00.	-
T8	-	DAP 18 – 46 – 0

Crop Management

The wheat cultivar ‘IPA-99’ was sown November 15, 2023 in rows with a mechanical seed drill, by depositing of 200 kg ha^{-1} (for the granular fertilizer), and 140 kg ha^{-1} for foliar treatments. The plant beds were 10 m × 50 m in size, and the distance between the rows was 20 cm. Common agronomic management practices such as irrigation, weed control, and pest control were conducted synchronously along the crop growth period.

Data Collection

Plant height, tiller number/m^2, spike number and spike length were recorded as growth traits. Grain yield components based on grains/spike, 1000- grain weight, grains/m^2, straw weight, biological and grain yields (t/ha $^{-1}$) were recorded at physiological maturity.

Statistical Analysis

The data were subjected to analysis of variance (ANOVA) using the GenStat v21 software. Treatment means were compared using the least significant difference (LSD) test at a 5% significance level[13].

Results and Discussion

Plant Height

Plant height varied significantly among the different treatments (Table 3). The tallest plants were recorded in the foliar Nutigreen treatment (T6) at 93.33 cm, followed by the foliar NPK (T7) at 88.00 cm and foliar Complex with zinc and Algham (T3) at 86.67 cm. The lowest plant height was observed with soil-applied DAP (T8) at 54.67 cm. This indicates the superior effects of foliar fertilization on vegetative growth compared to soil fertilization, possibly due

ISSN 2072-3857

to rapid nutrient uptake through the foliage, especially (amino acids in T6, and rapid absorption of NPK in T7, also micronutrients in T2,T3, and T4) comparing with T8 [14].**Figure 1** illustrates that a seeding rate of 140 kg/ha resulted in the highest average plant height of 83.524 cm. This significantly surpassed the height achieved at a seeding rate of 200 kg ha^{-1} (54.667 cm). This difference was primarily attributed to the reduced competition for essential nutrients among plants at the lower seeding rate, in contrast to the denser planting at 200 kg ha^{-1}.

Tillers Number / m^2

The largest number of tillers was produced in the "foliar complex fertilizer" (T3) treatment at 713 tillers/m^2, followed by "foliar amino acid" (T5) at 594.667 tillers/m^2 and "foliar NPK"(T7) with 454.33 tillers/m^2. The lowest tiller was observed in T8 (383.667) which had less soil DAP. It is assumed that the presence of micronutrients, i.e., Zn and amino acids might help to maintain a hormonal balance in improving nutrient uptake and tiller development [8]. In **Figure 2** an increase in the tiller number is observed for rice culture with 140 kg ha^{-1}, reaching 506.19 m^{-2} which was higher than the one obtained with 200.000 seeds of rice (383.667 m^{-2}). This discrepancy was due to the reduced impact of the plant hormone "auxin" at 100 kg seed ha^{-1}, in turn its effect was more apparent when applied with a higher rate (200 kg ha^{-1}).

Spikes Number per Square Meter

The pattern of spikes per square meter reflected the trend seen in the tiller count (Table 3). T3 (Foliar 100 Complex 25 ZM 25Algham) had the highest spike count at 672.333, followed by T7 (Foliar NPK) with 455.333, and T5 (Foliar 2 Amino Acids) with 455. In contrast, T8 (Soil DAP) recorded the lowest spike count at 325.533. This suggests a positive relationship between treatments that enhance tiller formation and the subsequent development of spikes. As shown in **Figure 3**, the number of spikes was higher at the seeding rate of 140 kg ha^{-1}, reaching an average of 463.952 spikes m^{-2} at this seeding rate. In contrast, the seeding rate of 200 kg ha^{-1} resulted in 325.533 spikes m^{-2} of the latter. This superiority was due to the increased number of tillers per unit area observed at the 140 kg ha^{-1} seeding rate.

ISSN 2072-3857

Table (3): Response of plant height, tiller number, and spike number for treatments.

No	Treatments	Plant Hight (cm)	Tillers No. tillers m^{-2}	Spikes No. spike m^{-2}
T1	Foliar 50B 50Complex 25 ZM 25 Algham	73.00 c	439.00 cd	453.00 bc
T2	Foliar 75 B 75Complex	84.667 abc	390.33 d	332.667 d
T3	Foliar 100 Complex 25 ZM 25 Algham	86.667 ab	713.00 a	672.333 a
T4	Foliar 100B 25 ZM 25 Algham	81.667 abc	452.00 cd	389.333 cd
T5	Foliar 2 Amino Acids	77.333 bc	594.667 b	455.00 bc
T6	Foliar 2.5 Nutigreen	93.333 a	500.00 c	490.00 b
T7	Foliar NPK	88.000 ab	454.33 cd	455.33 bc
T8	Soil DAP	54.667 d	383.667 d	325.533 d
lsd		**12.010**	**77.230**	**80.470**

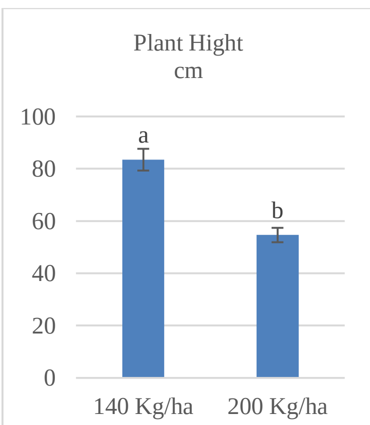

Figure (1): effect of seeding rates on Plant Hight

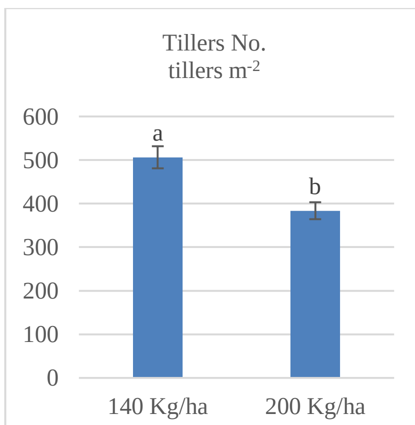

Figure (2): effect of seeding rates on Tillers number

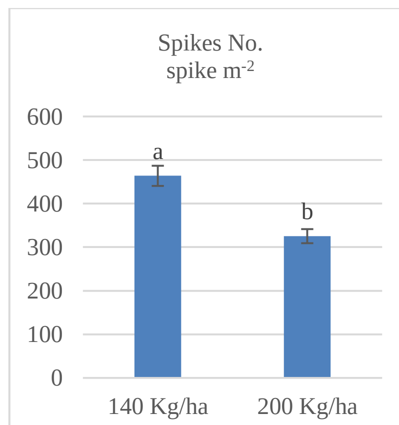

Figure (3): effect of seeding rates on Spikes number

ISSN 2072-3857

Spike Length

According to Table (4), the longest spike length was found in T2 and T7 (Foliar 75 B 75 Complex and Foliar NPK), measuring both of them were 8.3 cm. This was followed by T6 (Foliar 2.5 Nutigreen) at 7.5 cm, and T3 (Foliar 100 Complex 25 Zn 25 Algham) at 7.1 cm. On the other hand, the shortest spike length, at 6 cm, was noted in T4 (Foliar 100B 25 Zn 25 Algham). The outstanding results of T7 and T6 can likely be attributed to the balanced nutrient mix of NPK and Nutigreen, which may have facilitated spike growth and grain development. **Figure 4** shows that there were no significant differences in spike lengths between the seeding rates of 140 and 200 kg ha^{-1}, with average spike lengths of 7.6 cm and 7.93 cm, respectively.

Grains Number per Spike

In terms of the number of grains per spike among the foliar sprayed plants (Table 4) T7 (Foliar NPK), T2, Foliar 75 B 75 Complex had the highest with mean value of at 47.966 followed by T6 (Foliar 2.5 Nutigreen) with and T5 (Foliar 2 Amino acids) were116 on par but numerically higher at 35.041 disjointed from them statistically by10grains per spike). On the other hand, the lowest number of grains were achieved by T4 (Foliar 100B 25ZM 25 Algham) with a value of 26.311. The results indicate that foliar application of NPK, and Nutigreen significantly improved grain yield which could be a result of increasing nutrient availability during the reproductive periods. Number of grains per spike A higher number of grains per spike (39.3) was reported at the 200 kg ha^{-1} seeding rate, but did not differ significantly from that recorded at 140 kg ha^{-1}, which was 37.49 grains per spike (**Figure 5**).

1000-Grain Weight

Table (4) exhibited no significant between all treatments, though T5 (Foliar 2 Amino Acids) had a better effect of heading up the 1000-grain weight at 35.167 g succeeded by T3 (34.87 g), and then by T8 (32.85 g); followed by T7 recorded the lowest grain weight at the concentration of 32.722 g. The findings revealed that amino acids are necessary to enhance weighting of grail through protein synthesis and transport improvement systems. As illustrated in **Figure 6**, the 1000-grain weight was on a rise at the seeding rate of 140 kg ha^{-1} and arrived at to 33.516 g; this amount was, however not significantly different from that achieved in the same treatments with 200 kg ha^{-1} (32.89 g).

ISSN 2072-3857

Table (4): Response of Spike length, number of grains per spike, and 1000 grains weight for treatments.

No	Treatments	Spike length cm	Grains No. per Spike	1000 grains weight
T1	Foliar 50 B 50 Complex 25 ZM 25 Algham	7.80 [ab]	33.020 [c]	33.419 [a]
T2	Foliar 75 B 75 Complex	8.30 [a]	46.848 [a]	34.870 [a]
T3	Foliar 100 Complex 25 ZM 25 Algham	7.10 [bc]	32.488 [c]	31.867 [a]
T4	Foliar 100 B 25 ZM 25 Algham	6.70 [c]	26.113 [d]	34.509 [a]
T5	Foliar 2 Amino Acids	7.50 [abc]	35.041 [c]	35.167 [a]
T6	Foliar 2.5 Nutigreen	7.50 [abc]	40.952 [b]	33.412 [a]
T7	Foliar NPK	8.30 [a]	47.966 [a]	32.722 [a]
T8	Soil DAP	7.93 [ab]	39.300 [b]	32.890 [a]
lsd		**1.007**	**3.404**	**10.57 (N.S)**

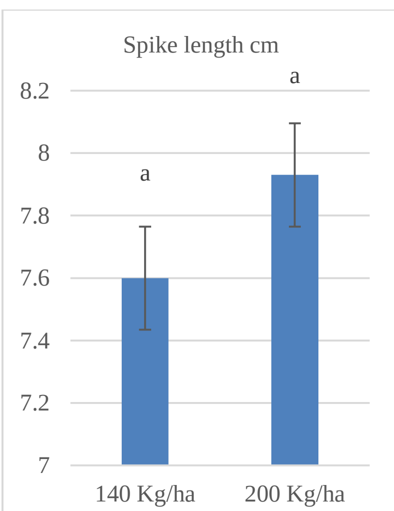

Figure (4): effect of seeding rates on Spikes length

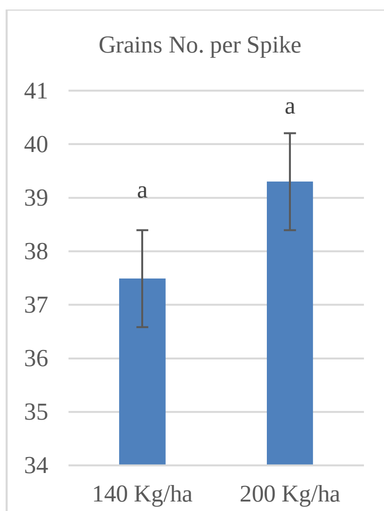

Figure (5): effect of seeding rates on Grains number per spike

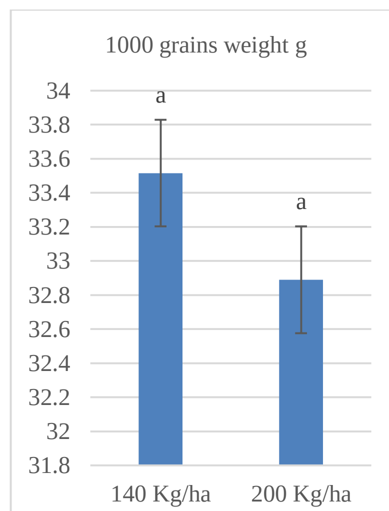

Figure (6): effect of seeding rates on 1000 grains weight

Grains Number per Square Meter

Results in Table 5 show that the highest number of grains/m2 was achieved by T3 (Foliar 100 Complex 25ZM 25Algham) being equal to 21,840.7 followed by T7 (Foliar NPK) at the value of 21,857.3 and by T5 (foliar_2Amino Acids) with a mean

ISSN 2072-3857

value of 15,980.00 grains/m^2. Meanwhile, the least grain number 10,166.3 belonged to T4 (Foliar_100B_25ZM_25Alghum). These findings indicated that the foliar NPK had significantly increased the grain yield per unit area. The seeding rate of 200 kg ha^{-1} had a better performance in terms of grain number per m^2 registering, on average, 19,020.7 grains m-2 (**Figure 7**), and it was superior to that at the dose of 140 kg ha^{-1} which presented an average value of 16,235.414 grains m^{-2}. This response is attributed to the higher number of plants per unit area when grown at 200 kg ha^{-1}, which positively affected grain number per m^2.

Straw Weight

The straw weight was the highest in T3 (Foliar 100 Complex 25 ZM 25 Algham) of 499.3 kg ha-1 (Table 5), followed by T8 (Soil DAP) of 466.7 kg ha-1 and T7 (Foliar NPK) of302.3 kg ha-1 respectively. On the contrary, the minimum of straw weight (201 kg ha-1) was recorded in T4 (Foliar 100B × 25 ZM × 25 Algham). This response pattern indicates a relationship between the treatments, which promote vegetative growth, and straw yield. The straw yield between the seeding rate of 200 kg ha-1 was significantly higher than that at 140 kg ha-1 (Fig.8). This increase was explained by an enhanced crop density due to the increased scarring rate.

Biological Yield per Hectare

Table (5) also shows that the highest biological yield was obtained from T3 (Foliar 100 Complex 25ZM 25 Algham) of 12,071.73 kg ha^{-1}. and T8 (Soil DAP) yielding 10,860.27 kg ha-1. The lowest biological yield (5,550.4 kg ha^{-1}) was also recorded with T4 (Foliar 100 B 25 ZM 25 Algham). These results indicate that the foliar application of a complex containing zinc and Algham increased total biomass production. As shown in **Figure 9**, the biological yield was maximized at the seeding rate of 200 kg ha-1 (10,860.27 kg ha^{-1}) compared to that obtained with 140 kg ha-1 (8,594.78 kg ha^{-1}). This rise was probably caused by the more plants per m^2 as a resultant of the higher seeding rate.

Grain Yield per Hectare

Table 5 shows that maximum grain yield was observed for T3 and T7 (Foliar 100 Complex 25 Zn 25 Algham) which were 8077.07, and even the lowest dose of Foliar NPK was considered in this study to produce a highest grain yield (7653.87 kg ha^{-1}). This was succeeded by T8 (Soil DAP) of 7,126.93 kg ha^{-1} yield, while the least grain yield was observed for T4 (Foliar 100 B 25 ZM 25 Algham) which gave a whole yield of the order of 3,942.40 kg ha^{-1}. These observations indicate that NPK foliar application should be considered as the best approach for optimizing grain yield, because of its balanced nutrient supply and efficient uptake. Due to its overwhelming performance in straw yield and biological yield, the target seeding rate of 200 kg ha^{-1} performed best in terms of total grain yield volume (7,126.93 kg ha^{-1}) (**Figure 10**); by contrast, at the 140 kg ha^{-1} rate it achieved a significantly lower grain yield of 5,894.78 kg ha^{-1}).

ISSN 2072-3857

Table (5): Response of grain number, straw weight, biological yield, and grain yield for treatments.

No	Treatments	Grains No grain m^{-2}	Straw weight kg ha^{-1}	Biological Yield kg ha-1	Grain Yield kg ha-1
T1	Foliar 50 B 50 Complex 25 Zn 25 Algham	14958.0 c	307.3 c	8258.13 d	5799.47 cd
T2	Foliar 75 B 75 Complex	15584.3 c	298.3 c	7794.67 de	5408.00 d
T3	Foliar 100 Complex 25 Zn 25 Algham	21840.7 a	499.3 a	12071.73 a	8077.07 a
T4	Foliar 100 B 25 Zn 25 Algham	10166.3 d	201.0 d	5550.40 f	3942.40 e
T5	Foliar 2 Amino Acids	15940.0 c	401.3 b	9749.07 bc	6538.40 bc
T6	Foliar 2.5 Nutigreen	13321.3 c	203.3 d	6666.93 ef	5040.27 d
T7	Foliar NPK	21837.3 a	302.3 c	10072.53 bc	7653.87 a
T8	Soil DAP	19020.7 b	466.7 a	10860.27 ab	7126.93 ab
lsd		**2639.7**	**43.37**	**1221.3**	**1057.9**

ISSN 2072-3857

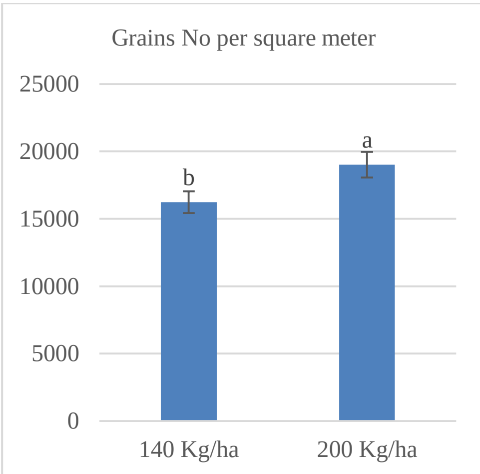

Figure (7): effect of seeding rates on Grains number per m^2

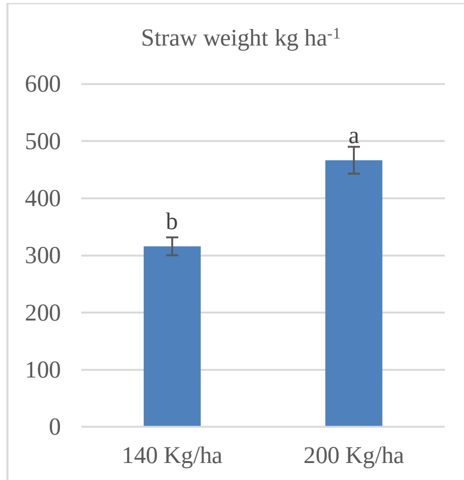

Figure (8): effect of seeding rates on Straw weight

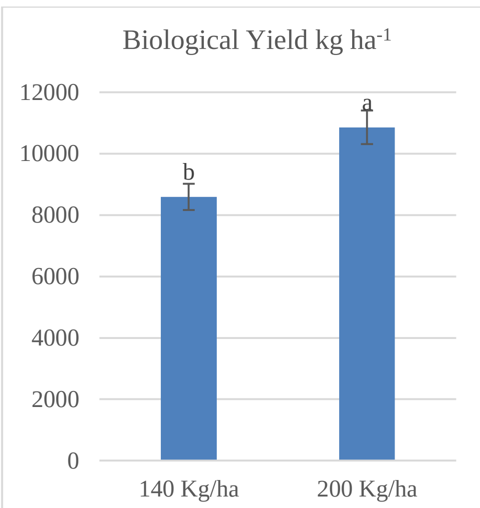

Figure (9): effect of seeding rates on biological yield

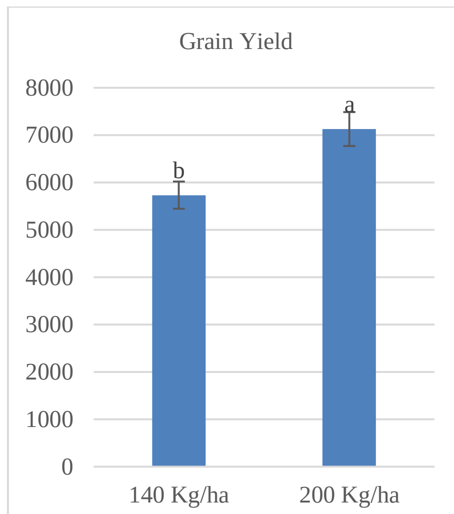

Figure (10): effect of seeding rates on Grain yield .

Integrated Discussion

This study confirmed that the foliar application of fertilizers, particularly NPK and formulations enriched with zinc and amino acids, significantly improved wheat growth and yield metrics compared with conventional soil-applied diammonium phosphate. Rapid leaf absorption allows plants to assimilate nutrients more efficiently, leading to improved tillering, spike development, and grain filling.

Micronutrients, such as zinc, and bioactive compounds, such as amino acids, in foliar treatments play a crucial role in hormonal modulation and stress resistance, contributing to enhanced vegetative and reproductive growth. These findings align with those of previous studies that support foliar fertilization as a sustainable and efficient nutrient management strategy [15], [5].

Integrated nutrient management, combining soil and foliar fertilization, may thus optimize wheat productivity while minimizing environmental impacts by reducing nutrient losses. From an economic perspective, the costs associated with the adoption of the treatments utilized in the experiment are anticipated to be approximately 75% lower than those of the traditional method involving the application of granular DAP fertilizer. Consequently, it is recommended to implement treatments T3 and T7, as they resulted in the highest grain yield, which is the primary objective pursued by farmers.

References

[1]*The State of Food and Agriculture 2021*. FAO, 2021. doi: 10.4060/cb4476en.

[2]S. Gautam *et al.*, "Field evaluation of slow-release nitrogen fertilizers and real-time nitrogen management tools to improve grain yield and nitrogen use efficiency of spring maize in Nepal," *Heliyon*, vol. 8, no. 6, p. e09566, Jun. 2022, doi: 10.1016/J.HELIYON.2022.E09566.

[3]D. Shahwar *et al.*, "Role of microbial inoculants as bio fertilizers for improving crop productivity: A review," *Heliyon*, vol. 9, no. 6, p. e16134, Jun. 2023, doi: 10.1016/J.HELIYON.2023.E16134.

[4]E. Liu *et al.*, "Long-term effect of chemical fertilizer, straw, and manure on soil chemical and biological properties in northwest China," *Geoderma*, vol. 158, no. 3–4, pp. 173–180, Sep. 2010, doi: 10.1016/J.GEODERMA.2010.04.029.

[5]X. Zhang, E. A. Davidson, D. L. Mauzerall, T. D. Searchinger, P. Dumas, and Y. Shen, "Managing nitrogen for sustainable development," *Nature 2015 528:7580*, vol. 528, no. 7580, pp. 51–59, Nov. 2015, doi: 10.1038/nature15743.

[6]R. S. Meena *et al.*, "Impact of Agrochemicals on Soil Microbiota and Management: A Review," *Land 2020, Vol. 9, Page 34*, vol. 9, no. 2, p. 34, Jan. 2020, doi: 10.3390/LAND9020034.

[7]C. Mani, P. Kumar, and C. Mehta, "Impacts of Foliar Feeding of Zinc and Polyamine on The Productivity of Wheat" 2019, Accessed: Dec. 07, 2025. [Online]. Available: www.jetir.org

[8]N. K. Fageria, V. C. Baligar, and C. A. Jones, "Growth and mineral nutrition of field crops, third edition," *Growth and*

Mineral Nutrition of Field Crops, Third Edition, pp. 1–550, Jan. 2010, doi: 10.1201/B10160/GROWTH-MINERAL-NUTRITION-FIELD-CROPS-NAND-KUMAR-FAGERIA-VIRUPAX-BALIGAR-CHARLES-ALLAN-JONES/RIGHTS-AND-PERMISSIONS.

[9]G. R. Khan *et al.*, “Split Nitrogen Application Rates for Wheat (Triticum aestivum L.) Yield and Grain N Using the CSM-CERES-Wheat Model,” *Agronomy 2022, Vol. 12, Page 1766*,

.vol. 12, no. 8, p. 1766, Jul. 2022, doi: 10.3390/AGRONOMY12081766

A. BHAKAR, Y. V. SINGH, K. [10] SHEKHAWAT, R. SINGH, V. K. SHARMA, and ABHISHEK, "Assessment of wheat (Triticum aestivum) growth, yield and economics under varying nutrient and weed management options," Indian Journal of Agronomy, vol. 69, no. 4, pp. 370–383, Dec. .2024, doi: 10.59797/IJA.V69I4.5539

K. Sultonov et al., "Effect of integrative [11] NPK soil and foliar nutrition on winter wheat (Triticum aestivum L.) productivity in irrigated arid lands," Front Sustain Food Syst, vol. 8, p. 1508913, Jan. 2024, doi: .10.3389/FSUFS.2024.1508913/BIBTEX

R. Lal, Soil and Fertilizers, 1st Edition. [12] CRC Press, 2020. doi: 10.1201/9780429471049/SOIL-.FERTILIZERS-RATTAN-LAL

Roger Payne, "Genstat ® Multivariate [13] analysis A Guide to Multivariate Analysis in Genstat ® (21 st Edition)," 2020, Accessed: Dec. 11, 2025. [Online]. Available: /www.vsni.co.ukhttp://www.genstat.co.uk

P. Marschner, "Marschner's Mineral [14] Nutrition of Higher Plants: Third Edition," Marschner's Mineral Nutrition of Higher Plants: Third Edition, pp. 1–651, 2011, doi: .10.1016/C2009-0-63043-9