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Developing Nutrient Management Practices on Growth, Yield, And Nutrient up Take by Hybrid Wheat

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ABSTRACT

Hybrid wheat (Triticum aestivum L.) production represents a vital frontiersman opportunity for breaking the stagnant yield barriers in modern global agriculture. However, exploiting the genetic potential of hybrid wheat demands highly precise, synchronized, and balanced nutrient management strategies. A comprehensive field investigation was carried out over two consecutive agricultural cycles to systematically evaluate the impact of variednutrient management protocols—integrating distinct levels of chemical fertilizers (NPK) with micro-nutrients (Zn, Fe) and organic bio-fertilizers—on the vegetative growth, structural yield attributes, economics, and macro-micronutrient uptake kinetics of hybrid wheat crops. The research highlights that the adoption of an Integrated Nutrient Management (INM) strategy, specifically combining 150% of the Recommended Dose of Fertilizers (RDF) with 5 tonnes of Farmyard Manure (FYM) per hectare and zinc sulphate application, achieves a paradigm shift in performance. This formulation generated the highest plant heights, maximum tillering intensity, superior dry matter accumulation, and optimized Leaf Area Index. Concurrently, physiologicalyield matrices including spikes per unit area, grain count per spike, and test weight reached maximum dimensions, translating to a substantial grain yield accretion over standard conventional regimes. Nutrient uptake profiling demonstrated an elevated concentration of Nitrogen, Phosphorus, and Potassium within both grain and straw matrices, paired with superior protein capitalization. The findings underscore that structured nutrient calibration is imperative for sustaining hybrid wheat performance, optimizing soil environmental chemistry, and fulfilling food security obligations.

KEYWORDS

Hybrid Wheat, Integrated Nutrient Management, Yield Attributing Characters, Nutrient Uptake, Nitrogen Dynamics, Zinc Fortification, Sustainable Agriculture, Economic Returns, Dry Matter Accumulation, Soil Fertility.

INTRODUCTION

Wheat (Triticum aestivum L.) serves as an indispensable dietary cornerstone globally, providing approx imatelytwenty percent of the overall caloric and protein consumption for the human population. In the contemporary era, the overarching challenge of global agricultural systems lies in expanding production to satisfy the food requirements of a burgeoning population under severe constraints of shrinking arable land resources, unpredictable climate shifts, and declining multi-nutrient status in soil profiles. While the Green Revolution catalyzed massive yield spikes via semi-dwarf high-yielding varieties, genetic gains in conventional wheat lineages have reached a visible plateau over recent decades. Tocircumvent this production stagnation, the commercial exploitation of heterosisvia the development of hybrid wheat has emerged as a scientifically sound, high-potential intervention. Hybrid wheat varieties exhibit extensive root architectures, greater vegetative vigor, enhanced physiological source-to-sink transmission efficiency, and a inherently higher capacity to adapt to diverse abiotic stresses.

Despite these outstanding genetic attributes, the real-world manifestation of the yield advantages of hybridwheatis heavily reliant on the management of it sagronomic environment, among which nutrient provision remains the single most decisive factor. Because of their accelerated growth dynamics, dense tillering patterns, and larger grain-bearing capacities, hybrid wheat plants require a larger and more continuous flux of essential plant nutrients throughout their life cycle compared to traditional inbred varieties. Imbalanced or inadequate fertilization not only truncates the physiological expression of heterosis but also leads to severe economic losses for cultivators and causes the degradation of long-term soil health metrics.

Historically, agronomic recommendations have relied deeply on unilateral, high-input chemical nitrogenous, phosphatic, and potassic fertilizers. While chemical inputs provide rapid elemental release, their intensive and exclusive usage has induced widespread micronutrient deficiencies—particularly of zinc and iron—and compromised the physical, chemical, and biological stability of soil systems. Therefore, developing dynamic, responsive nutrient management practices that fuse optimal macro-element ratios with essential micro-elements and organic soil conditioners is critically necessary. Integrated Nutrient Management (INM) presents a viable framework to synchronize nutrient availability with the exact crop uptake demands of hybrid cultivars. Understanding how these structural nutrient paradigms regulate physiological growth variables, structural yield mechanics, and chemical nutrient uptake partitions within hybrid wheat holds significant scientific and practical importance. This research investigation was designed to systematically evaluate and establish a robust, economically viable nutrient management strategy tailored specifically for hybrid wheat in the region.

1. RESEARCH SCOPE

Review of Literature

Agronomic literature from the past decade consistently indicates that hybrid geno types require a higher level of nutrient availability to express their fullyield potential. Researcher shave observed that the nitrogen metabolism of hybrid wheat operates at a higher kinetic threshold, necessitating synchronized top-dressings to prevent early canopy senescence. Previous field trials indicate that hybrid varieties demonstrate a 15–20% higher nitrogen utilization efficiency when nutrient distribution matches the critical growth stages of jointing and anthesis. Furthermore, the incorporation of organic matrices like Farmyard Manure (FYM) or vermicompost has been shown to improve the physical architecture of the soil, enhance moisture retention capacities, and sustain a steady release of localized ions, preventing leachinglossesofchemicalnitrogenandthefixationofphosphorusinthesoilcomplex.Recentstudieso n micronutrients emphasize that zinc acts as a core structural component for several key enzymes and plays an essential role in tryptophan synthesis, which directly influences auxin production and subsequent cell elongation in hybrid cultivars.

Research Gap

Although the macro-level responses of conventional wheat to standard fertilizer rates have been extensively documented across various agro-ecological zones, there is a distinct lack of systematic scientific data regarding the specific nutritional requirements of newly introduced hybrid wheat cultivars. Most regional recommendations rely on blanket fertilizer guidelines developed originally for inbred varieties, failing to account for the unique vegetative vigor and nutrient extraction dynamics of hybrids. Furthermore, the interactions between intensive macro-fertilization and micro-nutrient mobilization within the rhizosphere of hybrid wheat remain poorly understood, creating a critical gap in our ability to design sustainable, high-yield production packages

Hypothesis

It is hypothesized that hybrid wheat varieties, due to their higher genetic yield potential and broader root systems, will respond positively to higher levels of targeted fertilization. Additionally, the integration of organic manures with balanced inorganic chemical fertilizers and critical micronutrients (such as Zinc) will create a synergetic agronomic environment. This approach is expected to significantly improve crop growth indicators, maximize yield attributes, and enhance nutrient uptake efficiency compared to the standard application of chemical NPK alone.

Objectives

The primary objectives of this field investigation were define das follows:

- To evaluate the specific impact of diverse nutrient management systems on the vegetative growth kinetics and physiological attributes of hybrid wheat.
- To quantify the changes instructuralyield components and ultimate grain productivity undervaried nutritional treatments.
- To measure the directional uptake of macro (N, P, K) and micro (Zn) nutrients within the grain and straw profiles of the hybrid crop.
- To determine the financial profit ability and economic dynamics of implementing alternative nutrient management schedules for hybrid wheat cultivation.

2. METHODOLOGY

The field experiment was conducted during two successive rabi seasons at the Crop Research Center. The experimental field plot was characterized by a typical deep texturized soil, exhibiting an alkaline pH of 7.6, low baseline organic carbon content (0.42%), medium available nitrogen (215 kg/ha), medium available phosphorus (16.8 kg/ha), and high available potassium (310 kg/ha). The experiments were arranged in a Randomized Block Design (RBD) featuring three replications. The test crop chosen for the study was a high-yielding hybrid wheat variety sown at a standard row spacing of 22.5 cm using a uniform seeding rate of 100 kg/ha. The experimental setup tested eight distinct nutrient management formulations, which are detailed
below:

- **T1:**Absolute Control (No fertilizer application)
- **T2:**100% Recommended Dose of Fertilizers (RDF) via chemical sources (120:60:40 kg N: P2O5: K2O per hectare)
- **T3:**125% Recommended Dose of Fertilizers (RDF)
- **T4:**150%Recommended Dose of Fertilizers (RDF)
- **T5:**100% RDF+ 5 tonnes of Farmyard Manure (FYM) per hectare
- **T6:**125% RDF+ 5 tonnes of FYM perhectare
- **T7:**150% RDF+5 tonnes of FYM perhectare
- **T8:**150% RDF+ 5 tonnes of FYM/ha +Zinc Sulphate (ZnSO4) @25 kg/ha

Full doses of phosphorus and potassium, along with the specified organic components and micro nutrients, were applied as a basal layer at the time of sowing. Nitrogen was applied in three split applications: 50% asabasal dose, 25% at the crown rootinitiation (CRI) phase, and theremaining 25% at the boot stage. Standard agronomic interventions, including uniform irrigations and weed control measures, were applied across all treatments. Growth variables such as plant height, dry matter accumulation, and Leaf Area Index (LAI) were systematically recorde datperiodicintervals. Atharvest, yield parameters including the number of effective spikes per square meter, grain count per spike, and 1000-grain test weight were measured. Plant samples were dried, ground, and analyzed using standard laboratory procedures: the micro-Kjeldahl method for total nitrogen determination, the vanadomolybdo-phosphoric yellow color method for phosphorus analysis, and flame photometry for potassium evaluation.

1. DISCUSSION

Structural Growth Attributes

The systematic analysis of growth indicators clearly demonstrated that hybrid wheat responds significantly to enhanced and balanced nutrient availability. The treatment receiving the highest nutrient input, **T8** (150% RDF + 5 t FYM/ha + ZnSO4), recorded the highest plant height (104.5 cm) and dry matter accumulation (14,250 kg/ha) at maturity, which was significantly superior to the control (T1) and standard chemical-only applications (T2). This enhancement in growth dynamics can be attributed to the continuous supply of primary nutrients through the joint action of quickly available inorganic fertilizers and slowly decomposing organic matter. This steady nutrient availability encouraged active cell division, internode elongation, and chlorophyll synthesis, resulting in a higher Leaf Area Index (LAI). This expanded canopy allowed for enhanced interception of photosynthetically active radiation, which fueled greater dry matter accumulation throughout the vegetative phase.

Yield Dynamics and Productivity Components

Yield components, which determine final crop productivity, were significantly influenced by the various nutrient treatments. Treatment **T8** produced the highest number of effective spikes per square meter (412.3) and the largest number of grains per spike (52.6), as outlined in Table 1. The test weight (1000-grain weight) also reached its highest level (43.8 grams) under this treatment. The balanced supply of essential elements during the transition from vegetative tre productive grow thstagesen sured effective fertilization and minimized floret abortion, maximizing grain setting.

Consequently, the highest overall grain yield (62.5 quintals per hectare) was achieved with treatment T8, representing a 54.3% increase over the standard 100% RDF treatment (T2). This confirms that hybrid wheat requires nutrient inputs beyond standard regional recommendations to express its full genetic yield advantage. The integration of zinc played a critical role in optimizing carbohydrate metabolism and facilitating the smooth translocation of photosandates from source leaves directly into the developing grains, resulting in fuller, heavier kernels.

Table1: Influence of Nutrient Management Practiceson Yield Attributes and Productivity of Hybrid Wheat

Treatment Code	Effective Spikes (per m²)	Grains per Spike	1000 - Grain Weight (g)	Grain Yield (q/ha)	StrawYield (q/ha)
T1 (Control)	210.4	28.2	34.1	22.4	31.2
T2 (100% RDF)	325.6	40.5	39.5	40.5	54.8
T3 (125% RDF)	348.1	42.3	40.2	44.2	58.6
T4 (150% RDF)	362.8	45.1	41.0	48.1	62.4
T5 (100% RD F+ FYM)	355.2	43.8	40.8	46.3	60.1

Treatment Code	Effective Spikes (per m²)	Grainsper Spike	1000-Grain Weight (g)	Grain Yield (q/ha)	Straw Yield (q/ha)
T6 (125% RDF + FYM)	378.4	47.2	41.9	51.8	66.5
T7 (150% RDF + FYM)	395.7	50.1	42.7	57.4	72.9
T8 (T7 + ZnSO4)	412.3	52.6	43.8	62.5	78.3

Nutrient Up take Patterns and Quality Aspects

Nutrient removal profiling revealed that the total uptake of Nitrogen, Phosphorus, and Potassium followed the total dry matter production trends across treatments. The highest total nutrient uptake (148. 5 kg N/ha, 28.4 kg P/ha, and 132.6 kg K/ha) was recorded in treatment **T8**. The application of organic manure improves root proliferation by enhancing soil structure and porosity, allowing the roots to accessa larger volume of soil and absorb nutrients more efficiently. The inclusion of zinc sulphate further accelerated the enzymatic pathways responsible for nutrient assimilation within the plant tissue. Grain protein content also increased significantly under balanced nutrition, as a steady nitrogen supply during late-stage grain development supports the synthesis of amino acids and storage proteins within the endosperm.

EconomicViabilityAnalysis

Evaluating the economic returns of alternative nutrient management protocols is essential for determining their suitability for widespread adoption by farming communities. Economic analysis demonstrated that while treatment **T8** incurred the highest production cost due to the addition of organic manure and micronutrient inputs, it also generated the highest gross returns and net financial profit. This performance was driven by the substantial yield premium achieved over chemical-only treatments. The benefit-cost ratio (B:C ratio) reached an optimal value of 2.34 under this treatment, demonstrating that investment in balanced, integrated inputs is highly profitable for hybrid wheat cultivation.

3. CONCLUSION

This investigation demonstrates that the genetic potential of hybrid wheat can be fully expressed through targeted, comprehensive nutrient management. Relying solely on standard chemicalinputs (100% RDF) is insufficient to support the high vegetative growth and reproductive demands of hybrid cultivars. The implementation of an Integrated Nutrient

Management framework—specifically combining 150% Recommended Dose of Fertilizers with 5 tonnes of FYM per hectare and 25 kg of Zinc Sulphate (Treatment T8)—consistently achieved the highest values across all critical growth indicators, yield attributes, and ultimate grain output. It also significantly enhanced nutrient absorption and improved the overall quality profile of the harvest. Financially, this approach proved highly sustainable, delivering superior net economic returns and an optimal benefit-cost ratio. Based on these findings, this integrated fertilizer regime is highly recommended for adoption by hybrid wheat growers in the region to maximize productivity while maintaining long-term soil fertility. Future research should focus on exploring thelong-term impacts of these treatments on the deep soil microbiome and tracing the movement of micronutrients within the soil-plant system over extended crop rotations.

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