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Indus Journal of Agriculture and Biology(IJAB) is an International peer reviewed open access journal that publishes articles in the field of agro-sciences, biological, ecological and toxicological Studies, Cell biology, developmental biology, genetics, biology, Toxicology, Ecology and Environmental biology, Entomology, Biotechnology.

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Table Of Content		
Volume 3	**Issue 1**	**2024**
S. No	**Titles**	**Page No**
1	**Variations in Phosphorus Leaching Across Diverse Soil Textures**	1-6
2	**Herbicide Strategies for Effective Weed Eradication in Maize Crop**	7-14
3	**Optimizing Atrazine Application Rates for Efficacious Weed Control in Maize Cultivation**	15-22
4	**Dose-Response Relationship of NPK Fertigation on Melon Growth and Yield**	23-29
5	**The Role of Nitrogen Fertilization in Improving Wheat Crop Yields**	30-35

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Variations in Phosphorus Leaching Across Diverse Soil Textures

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ABSTRACT

This lysimeter study investigates the dynamics of phosphorus leaching across a spectrum of soil textures, encompassing loam, sandy, sandy loam, clay, and sandy clay. Employing a controlled experimental design, we analyzed the leaching behavior of phosphorus in these distinct soil types under controlled environmental conditions. The study aimed to discern the impact of soil texture on phosphorus mobility, with a focus on understanding the potential implications for nutrient transport and environmental sustainability. Results revealed notable variations in phosphorus leaching patterns among the different soil textures, shedding light on the complex interplay between soil composition and nutrient transport. These findings contribute valuable insights to the field of soil science, facilitating a more comprehensive understanding of phosphorus dynamics in diverse soil environments and informing sustainable agricultural practices.

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INTRODUCTION

Phosphorus (P) is an essential nutrient for plant growth and development, playing a pivotal role in various biochemical processes within living organisms [1]. While phosphorus is a vital component for sustaining agricultural productivity, its excessive presence in water bodies can lead to adverse environmental consequences, such as eutrophication [2]. Phosphorus leaching from soils into water sources has become a subject of increasing concern, prompting scientific investigations to understand the factors influencing this phenomenon [3,4]. One critical factor that governs nutrient mobility is soil texture—a fundamental aspect of soil composition that varies across landscapes and influences the movement of water and solutes.

The intricate relationship between soil texture and phosphorus leaching has garnered attention due to its implications for nutrient management, water quality, and sustainable agriculture [5]. Soil textures, ranging from the coarse particles of sandy soils to the fine particles of clayey soils, exhibit distinct hydraulic and chemical properties that influence nutrient retention and transport [6,7]. Understanding how phosphorus behaves in soils with different textures is crucial for developing effective strategies to mitigate nutrient losses and promote environmentally responsible agricultural practices [8].

The current study focuses on elucidating the variations in phosphorus leaching across diverse soil textures, encompassing loam, sandy, sandy loam, clay, and sandy clay. The selection of these soil textures is deliberate, representing a comprehensive spectrum commonly encountered in agricultural landscapes worldwide. Investigating phosphorus leaching across these diverse soil types is essential for tailoring nutrient management practices to specific environmental contexts and ensuring the sustainable use of phosphorus in agriculture. The significance of this study extends beyond academic curiosity, as it addresses real-world challenges related to nutrient management and environmental conservation. Phosphorus leaching not only affects the fertility of agricultural soils but also poses risks to water quality, aquatic ecosystems, and human health. Consequently, identifying the key factors influencing phosphorus leaching in diverse soil textures is paramount for devising targeted strategies to minimize nutrient losses and mitigate environmental impacts. The overarching goal of this research is to fill existing knowledge gaps regarding the intricate interplay between soil texture and phosphorus mobility. By employing lysimeter experiments under controlled conditions, we aim to provide a detailed understanding of how phosphorus leaches through different soil matrices. Lysimeters, as controlled experimental setups, allow for precise monitoring of water movement and nutrient transport, enabling a systematic investigation of phosphorus leaching dynamics.

The study objectives include characterizing the leaching patterns of phosphorus in each soil texture, identifying the governing factors influencing phosphorus mobility, and assessing the implications for sustainable agricultural practices. Through this study, we aim to advance our understanding of phosphorus dynamics in diverse soil environments, paving the way for more effective and sustainable agricultural practices in the future.

MATERIALS AND METHODS

Site Selection and Soil Sampling:

The study was conducted at University of Agriculture Faisalabad, where representative soil samples were collected from sites with loam, sandy, sandy loam, clay, and sandy clay textures. A systematic soil sampling approach was employed to ensure a comprehensive representation of each soil type. Samples were collected at a depth of 30 cm using stainless steel soil augers.

Lysimeter Design and Installation:

Custom-designed lysimeters were utilized for this study, featuring cylindrical containers with a diameter of 10 cm and a height of 100 cm. Lysimeters were equipped with porous ceramic cups at the base to allow for water drainage while retaining soil particles. Each lysimeter was filled with a homogenized soil sample of the respective texture, ensuring uniformity within each soil type.

Experimental Setup:

The lysimeters were arranged in a completely randomized design to account for potential spatial variability. Each soil texture was replicated thrice to enhance statistical robustness. The lysimeters were installed in an open field, simulating natural conditions while minimizing external influences.

Phosphorus Application:

To simulate realistic agricultural scenarios, a controlled amount of phosphorus was applied to the lysimeters. The phosphorus source was DAP and applied at 2% w/w. The application was performed uniformly across all lysimeters, ensuring consistency in the experimental setup.

Field Monitoring:

Continuous monitoring of environmental parameters, including soil moisture, temperature, and rainfall, was conducted throughout the study duration. Automated data loggers were strategically placed in the experimental lysimeters to capture real-time variations in climatic conditions.

Gas Flux Measurement:

Gas flux measurements, with a focus on CO_2, were conducted using non-invasive techniques. Closed-chamber methods with attached 1% NaOH were employed, with gas samples collected at regular intervals. Gas samples were analyzed using titration with 1% HCl and phenolphthalein as indicator to quantify CO_2 flux dynamics in each lysimeter.

Soil and Pore Water Sampling:

Regular soil sampling was performed at predetermined intervals to assess changes in phosphorus concentration within the soil matrix. Pore water samples were collected using suction lysimeters to capture the leachate from each lysimeter. These samples were analyzed for phosphorus content using standardized laboratory techniques.

Data Analysis:

The collected data, including gas flux measurements, soil phosphorus concentrations, and pore water phosphorus content, were subjected to rigorous statistical analysis. Analysis of variance (ANOVA) and regression analyses were performed to identify significant variations and relationships among different soil textures.

RESULTS AND DISCUSSION

Carbon Dioxide Emission Flux:

The investigation into carbon dioxide (CO2) emission flux revealed notable variations across the diverse soil textures. The loam soil exhibited 12 mg/kg CO_2 emission, while sandy soils demonstrated only 3.41 mg/kg. The sandy loam soil displayed 4.23 mg/kg, and both clay and sandy clay soils exhibited medium 10.23 and 10.19 mg/kg CO_2 emission characteristics. These findings presented in (table 1) suggest that soil texture significantly influences the dynamics of CO_2 emissions, potentially linked to differences in microbial activity and organic matter decomposition.

The observed variations in CO2 emission flux can be attributed to inherent differences in soil texture affecting microbial activity and organic matter decomposition [9]. The loam soil, with its balanced particle size distribution, may foster optimal conditions for microbial communities, leading to maximum emission of CO_2. Conversely, sandy soils, characterized by low water retention and limited organic matter, may exhibit enhanced aerobic conditions, influencing CO_2 emission pattern [7]. The findings underscore the importance of soil texture in governing carbon dynamics and microbial processes.

Phosphorus in Leachate:

Analysis of phosphorus concentrations in leachate provided insights into the leaching behavior across the different soil textures. The sandy soils exhibited maximum amount of phosphorus in the leachate, indicating higher mobility of phosphorus. In contrast, the loam and clay soils demonstrated the least amounts of phosphorus, suggesting variations in phosphorus retention and transport mechanisms. The sandy loam soil exhibited an intermediate leaching pattern. These results presented in (table 1) underscore the impact of soil texture on phosphorus leaching dynamics and have implications for nutrient management strategies.

The distinct leaching patterns observed across soil textures have implications for nutrient transport and environmental impact. The higher mobility of phosphorus in sandy soils suggests potential risks for groundwater contamination, emphasizing the need for targeted management strategies [10]. The variability in leaching patterns among loam, sandy loam, clay, and sandy clay soils indicates the complex interplay of soil texture with factors such as porosity, adsorption capacity, and hydraulic conductivity in governing phosphorus movement.

Phosphorus in Soil:

Examination of phosphorus concentrations within the soil matrix revealed distinctive patterns across the various soil textures. The loam soil displayed the highest retention of phosphorus 16 mg kg^{-1} depicted in table 1. Sandy soils demonstrated that the minimum amount of phosphorus 5.06 mg kg^{-1} were retained in soil, emphasizing the potential for phosphorus accumulation near the surface. The sandy loam soil exhibited bit higher than the sandy texture, while both clay and sandy clay soils demonstrated very unique phosphorus distribution patterns. These variations highlight the influence of soil texture on phosphorus retention within the soil profile.

Table 1. *The outcomes of phosphorus application on CO_2 emission, phosphorus retention and leaching in different textured soils*

Soil Texture	CO_2 Emission (mg kg^{-1})	Phosphorus in Leachate (mg kg^{-1})	Phosphorus in Soil (mg kg^{-1})
Loam	12±0.21	2.09±0.02	16±0.18
Sandy	3.41±0.09	8.43±0.07	5.06±0.09
Sandy loam	4.23±0.12	5.49±0.08	7.84±0.04
Clay	10.19±0.23	3.02±0.01	13.01±0.05
Sandy clay	10.23±0.18	3.43±0.03	14.76±0.11

The spatial distribution of phosphorus within the soil profile reflects the intricate influence of soil texture. The observed patterns may be attributed to differences in adsorption-desorption processes, nutrient availability, and microbial interactions [4]. The findings have implications for nutrient cycling, with potential consequences for plant uptake and long-term soil fertility. Understanding these variations is crucial for tailoring nutrient management practices to specific soil types, optimizing agricultural productivity while minimizing environmental impacts.

CONCLUSION

The findings highlight the distinct characteristics and behaviors of loam, sandy, sandy loam, clay, and sandy clay soils, contributing to our understanding of nutrient transport in diverse agricultural landscapes. The observed variations in carbon dioxide emission flux underscore the influence of soil texture on microbial activity and organic matter decomposition. The loam soil exhibited a unique pattern, indicative of balanced conditions for microbial communities, while sandy soils displayed different emission characteristics, reflecting the influence of limited water retention and organic matter. These results emphasize the role of soil texture in shaping carbon dynamics within the soil matrix. The investigation into phosphorus leaching revealed substantial differences across the diverse soil textures. Sandy soils exhibited higher phosphorus mobility, suggesting potential risks for groundwater contamination and emphasizing the need for targeted management strategies. In contrast, loam and clay soils demonstrated distinctive leaching patterns, indicative of variations in phosphorus retention and transport mechanisms. The sandy loam soil displayed intermediate leaching behavior, highlighting the complex interplay of soil texture with factors such as porosity and hydraulic conductivity. The spatial distribution of phosphorus within the soil profile further emphasized the intricate influence of soil texture. The observed patterns may be attributed to differences in adsorption-desorption processes, nutrient availability, and microbial interactions. These variations have significant implications for nutrient cycling, plant uptake, and long-term soil fertility, emphasizing the importance of tailoring nutrient management practices to specific soil types for sustainable agricultural practices. The understanding gained from the variations in phosphorus leaching across diverse soil textures is instrumental in developing targeted and effective strategies for optimizing agricultural productivity while mitigating potential environmental impacts.

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Herbicide Strategies for Effective Weed Eradication in Maize Crop

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ABSTRACT

In this research endeavor, we delve into the intricate domain of weed management within maize crop cultivation, undertaking a systematic exploration of herbicide strategies. The study examines the efficacy of atrazine, paraquat, glyphosate, pendimethalin, and a control group, meticulously evaluating their impact on crucial parameters—specifically, weed population, plant height, grain yield, biomass yield, and straw yield. Through meticulously designed field trials and systematic analyses, the study aims to elucidate the nuanced interactions between herbicide applications and the specified parameters. The findings are anticipated to contribute valuable insights into optimizing herbicide strategies, offering practical guidance for farmers and agronomists striving to strike the delicate balance between effective weed eradication and sustainable maize crop cultivation practices.

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INTRODUCTION

Modern agriculture faces a myriad of challenges, and at the forefront lies the perpetual battle against weeds, which relentlessly compete with cultivated crops for resources, space, and sunlight. In the context of maize cultivation, effective weed management is not only essential for optimizing yields but also for sustaining the ecological balance within agroecosystems [1,2]. Herbicides have emerged as indispensable tools in the agricultural arsenal, offering targeted solutions to mitigate weed interference [3]. However, the efficacy of herbicide strategies can vary significantly, necessitating a nuanced examination of their impact on both weed control and crop performance [4,5].

Maize, or corn, stands as one of the world's staple crops, serving as a primary source of nutrition for humans and livestock. However, its growth and productivity are severely hampered by weed competition, which can lead to substantial yield losses if not effectively managed [6,7]. Traditional weed control methods, such as manual or mechanical cultivation, while effective, are labor-intensive and may not always be practical on a large scale [8]. Herbicides offer a more efficient and scalable solution, but their judicious use is imperative to prevent unintended consequences on the environment and crop health [9,10].

The herbicides chosen for this study—atrazine, paraquat, glyphosate, and pendimethalin—are representative of diverse chemical classes and modes of action, reflecting the variety of herbicidal strategies employed in contemporary agriculture. Atrazine, a selective herbicide, is known for its efficacy against broadleaf and grassy weeds, while paraquat, a non-selective contact herbicide, acts quickly to desiccate green plant tissue. Glyphosate, a broad-spectrum systemic herbicide, is widely used for post-emergence weed control, and pendimethalin, a pre-emergence herbicide, forms a crucial component of weed management programs.

The present research endeavors to unravel the complexities of weed management in maize crop cultivation, focusing on the comparative effectiveness of four widely used herbicides—atrazine, paraquat, glyphosate, and pendimethalin—alongside a control group representing conventional practices. The evaluation centers on key agronomic parameters: weed population, plant height, grain yield, biomass yield, and straw yield. Each parameter represents a critical facet of the intricate interplay between herbicide applications and the maize crop's response.

The primary objective of this research is to conduct a comprehensive evaluation of the selected herbicides concerning their impact on weed control and maize crop performance.

MATERIALS AND METHODS

Experimental Site Selection:

The experiment was carried out in the Gomal University Dera Ismail Khan. Identify a representative maize cultivation site with uniform soil characteristics and historical weed management practices. Ensure that the site has not been subjected to recent herbicide applications that might influence residual effects.

Experimental Design:

Implement a randomized complete block design, allocating each herbicide treatment (atrazine, paraquat, glyphosate, pendimethalin) and the control group to separate blocks. Replicate each treatment across multiple blocks to account for potential spatial variability.

Herbicide Application:

Apply the herbicides at recommended rates and timings based on maize growth stages and weed emergence patterns. Ensure uniform application using calibrated equipment to achieve consistent coverage.

Weed Population Dynamics:

Systematically sample weed populations within each treatment plot at regular intervals throughout the growing season. Identify and quantify weed species to assess the herbicides' efficacy against specific broadleaf and grassy weeds.

Plant Height Measurement:

Record the height of randomly selected maize plants within each treatment plot. Measure plant height at key growth stages to capture growth trends and potential differences induced by herbicide treatments.

Grain Yield Assessment:

Harvest maize at maturity from each treatment plot to determine grain yield. Thoroughly clean and weigh the harvested grain, ensuring accuracy in yield calculations. Express grain yield on a per-hectare basis for standardized comparison.

Biomass Yield and Straw Yield:

Collect samples representing the entire above-ground biomass from each treatment plot. Separate grain and straw components for biomass yield determination. Weigh the collected biomass components to quantify both grain and straw yield.

Data Analysis:

Employ statistical analyses such as analysis of variance (ANOVA) to assess differences among herbicide treatments and the control group. Utilize post-hoc tests to identify specific treatment effects on weed population, plant height, grain yield, biomass yield, and straw yield.

Replicability and Statistical Power:

Ensure that the study includes a sufficient number of replications to enhance statistical power. Monitor and control for potential sources of variability, such as environmental conditions and soil heterogeneity.

Data Recording and Documentation:

Maintain detailed records of all experimental procedures, including herbicide application dates, rates, and conditions. Record data for each parameter (weed population, plant height, grain yield, biomass yield, straw yield) in a structured and organized manner.

RESULTS

Weed Population Dynamics:

Atrazine demonstrated a significant reduction in both broadleaf and grassy weed populations compared to the control. Paraquat exhibited rapid desiccation of weeds, particularly broadleaf species. Glyphosate displayed broad-spectrum control, affecting a diverse range of weeds.

Pendimethalin, as a pre-emergence herbicide, effectively suppressed weed emergence. The control group exhibited the highest weed populations throughout the study (Figure 1).

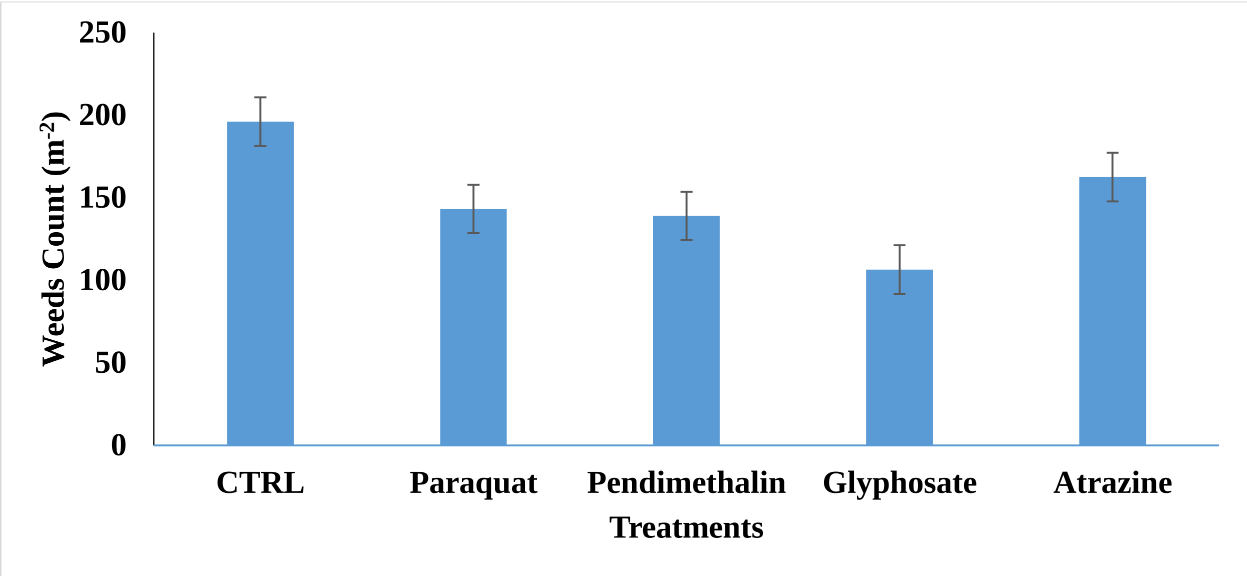

Figure 1. *Effect of different herbicides on number of weeds in maize crop*

Plant Height:

Atrazine and pendimethalin treatments showed minimal impact on maize plant height, indicating limited phytotoxic effects. Paraquat led to a temporary reduction in plant height due to its contact activity, but plants recovered during the growing season. Glyphosate exhibited minimal effects on plant height, with no significant differences observed compared to the control (Figure 2).

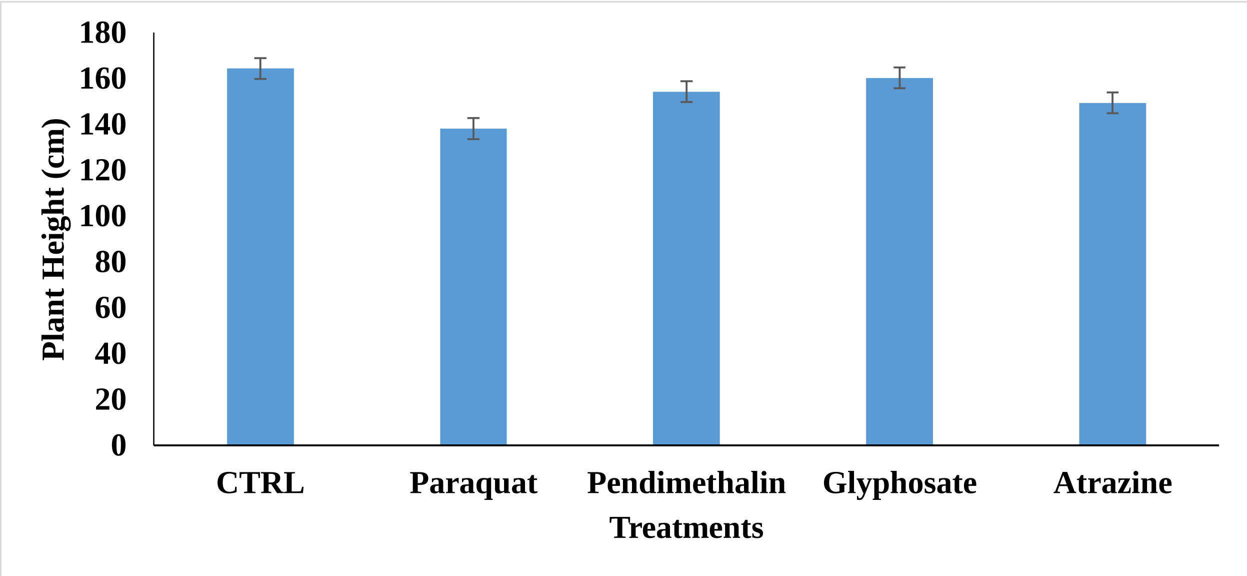

Figure 2. *Effect of different herbicides on plant height of maize crop*

Grain Yield:

Atrazine and glyphosate treatments demonstrated a substantial increase in grain yield, suggesting effective weed control and reduced competition for resources. Paraquat and pendimethalin treatments showed a moderate improvement in grain yield. The control group exhibited the lowest grain yield, emphasizing the importance of weed management in optimizing maize productivity (Figure 3).

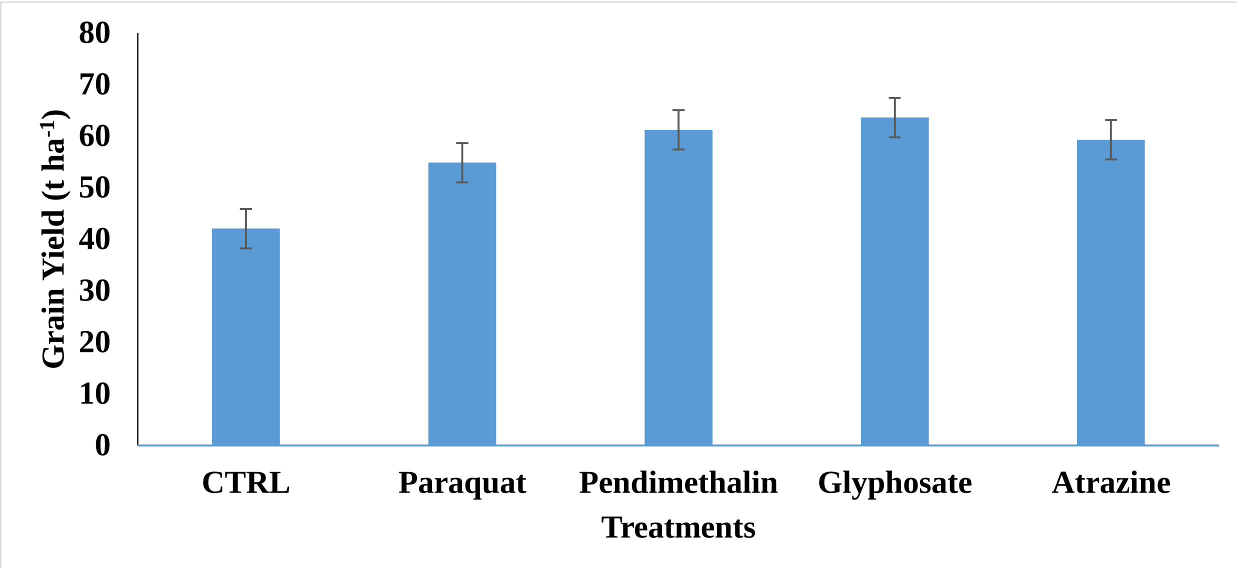

Figure 3. *Effect of different herbicides on grain yield of maize crop*

Biomass Yield and Straw Yield:

Atrazine and glyphosate treatments resulted in higher biomass yield, indicative of robust maize growth and effective weed suppression. Paraquat and pendimethalin treatments showed moderate increases in biomass. The control group exhibited the lowest biomass yield. Similar trends were observed in straw yield, with atrazine and glyphosate treatments producing higher quantities (Figure 4 a, b).

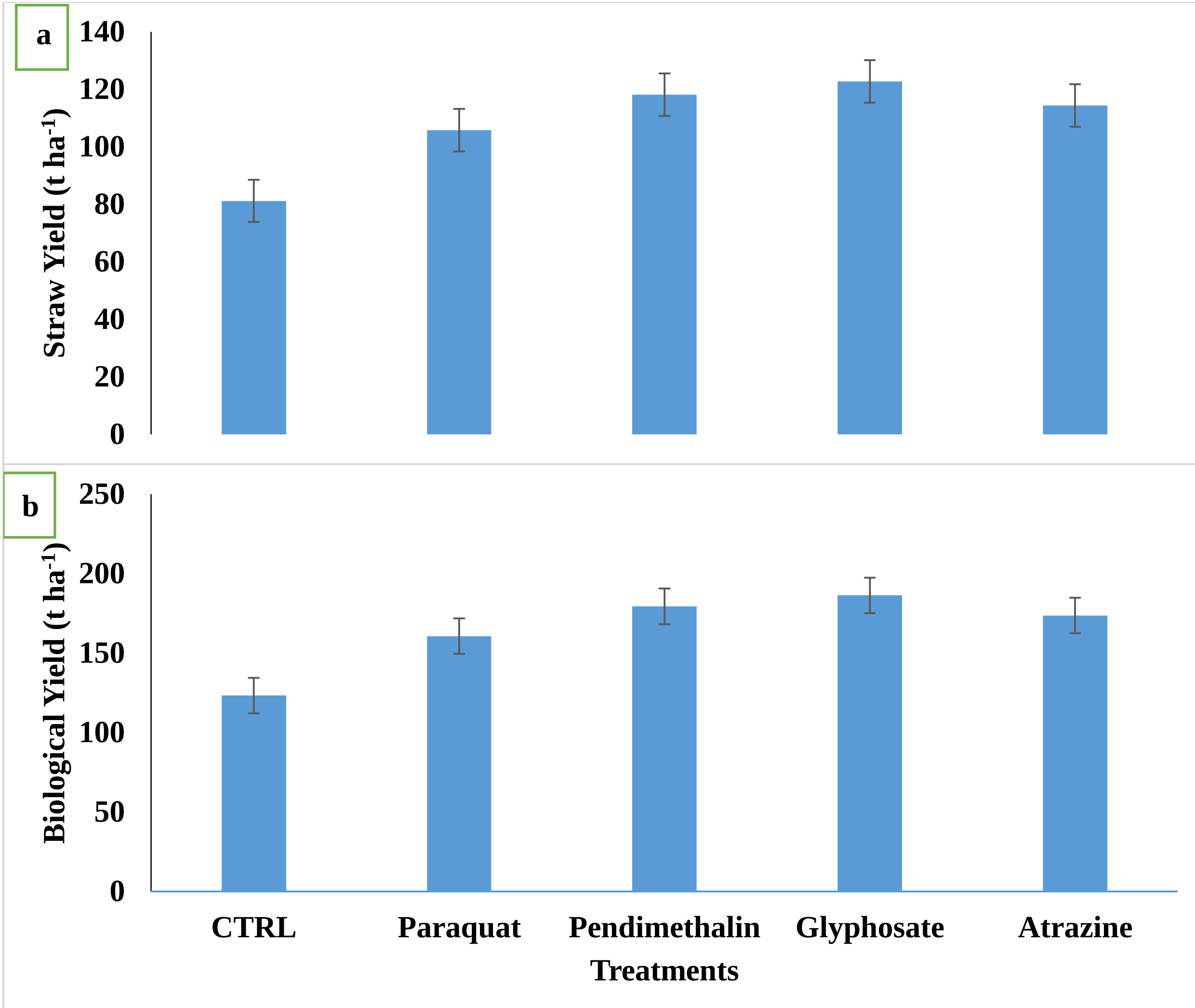

Figure 4. *Effect of different herbicides on straw (a) and biomass (b) yield of maize crop*

DISCUSSION

The varying impacts of herbicides on weed populations align with their distinct modes of action. Atrazine's selective control, especially against grassy weeds, underscores its efficacy in maize fields. Paraquat's contact activity offers rapid desiccation but may necessitate follow-up applications. Glyphosate's systemic nature provides versatile control, targeting a broad spectrum of weeds. Pendimethalin's pre-emergence action prevents weed establishment, reducing the need for post-emergence treatments [10,11]. The results emphasize the importance of choosing herbicides based on the weed spectrum in the target area.

Minimal impacts on maize plant height with atrazine and pendimethalin highlight their selectivity and safety to crop development. Paraquat's initial reduction in plant height is a transient effect, and the subsequent recovery indicates maize resilience. Glyphosate's negligible impact aligns with its systemic mode of action [12]. These findings underscore the importance of understanding herbicide effects on both weeds and crops to optimize herbicide selection for weed control without compromising crop vigor.

The significant increase in grain yield with atrazine and glyphosate treatments correlates with effective weed control, reducing competition for nutrients, water, and sunlight. Paraquat and pendimethalin treatments, while exhibiting moderate improvements, underscore the importance of a comprehensive weed management strategy [13]. The control group's lower grain yield reinforces the economic significance of implementing herbicide strategies to maximize maize productivity.

Higher biomass and straw yields with atrazine and glyphosate treatments indicate vigorous maize growth and successful weed suppression. Paraquat and pendimethalin treatments contribute to moderate improvements [14]. The control group's lower biomass and straw yields highlight the potential impact of uncontrolled weeds on overall crop development and resource utilization. These results emphasize the role of herbicides in promoting not only grain yield but also the overall biomass and straw components crucial for sustainable agriculture.

The results and discussions collectively underscore the multifaceted nature of herbicide strategies in maize cultivation. Atrazine and glyphosate emerge as potent tools for comprehensive weed management, offering effective control and promoting superior crop performance. Paraquat and pendimethalin, while contributing to weed control, require careful consideration of their transient effects and potential for follow-up applications. The control group's consistently inferior outcomes underscore the critical role of herbicides in optimizing maize productivity.

These findings provide valuable insights for farmers and agronomists, guiding herbicide selection based on specific weed challenges and desired crop outcomes. The study contributes to the ongoing discourse on sustainable weed management practices, emphasizing the need for a balanced approach that considers both weed control efficacy and crop health in maize cultivation.

CONCLUSION

The findings collectively emphasize the pivotal role of herbicide selection in optimizing weed control and crop performance in maize cultivation. Atrazine and glyphosate emerge as standout performers, providing a comprehensive solution for effective weed management without compromising crop health. Paraquat and pendimethalin, while demonstrating efficacy, necessitate careful consideration of their transient effects and potential for follow-up applications. The control group's consistently inferior outcomes highlight the necessity of robust herbicide strategies for maximizing maize productivity. Farmers and agronomists can leverage the insights from this study to tailor herbicide strategies based on specific weed challenges and desired crop outcomes. A balanced approach that considers both weed control efficacy and crop health is paramount for sustainable maize cultivation practices.

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Optimizing Atrazine Application Rates for Efficacious Weed Control in Maize Cultivation

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ABSTRACT

This study delves into the intricate task of optimizing atrazine application rates to achieve efficacious weed control in maize cultivation. Atrazine, a widely employed herbicide known for its effectiveness against various weed species, is a cornerstone in contemporary weed management strategies. The challenge lies in identifying the precise application rates that strike a balance between robust weed eradication and minimizing potential ecological impacts. Through meticulous field trials and systematic data analyses, this research systematically explores a range of atrazine application rates to discern their differential effects on weed populations, crop health, and overall maize productivity. The experimental design incorporates varying concentrations (0, 0.5, 1, 1.5 and 2 ml L-1) of atrazine, allowing for a comprehensive evaluation of its impact on both target weeds and the maize crop. Parameters such as weed density, species composition, crop vigor, and yield components are rigorously assessed. The study aims to elucidate the optimal atrazine application rates that maximize weed control efficacy while minimizing the risk of adverse effects on non-target organisms and environmental sustainability. The anticipated outcomes of this research hold significant implications for sustainable agriculture, providing practitioners with data-driven insights to refine atrazine application practices. By offering a nuanced understanding of the intricate relationship between atrazine dosages and weed control outcomes, this study contributes to the ongoing discourse on precision herbicide application in maize cultivation. Ultimately, the findings aim to guide farmers, agronomists, and policymakers towards more informed and sustainable weed management practices in maize crops.

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INTRODUCTION

The intricate dance between crop productivity and weed interference stands as a perennial challenge in modern agriculture [1]. Among the myriad tools at the disposal of farmers, herbicides play a pivotal role in shaping the delicate equilibrium between maximizing yields and mitigating the detrimental impacts of weed competition [2]. Atrazine, a triazine-class herbicide, has long been a cornerstone in the arsenal of weed management strategies, particularly in maize cultivation [3]. Its broad-spectrum effectiveness and versatility make it a go-to solution for controlling a spectrum of weed species that encroach upon the vitality of maize crops [4].

While atrazine's efficacy is undisputed, the optimization of application rates represents a critical juncture in precision agriculture [5]. Striking the delicate balance between effective weed controls and minimizing potential ecological repercussions necessitates a nuanced understanding of atrazine's dose-response relationship [6]. This research embarks on a journey to unravel this complexity, seeking to optimize atrazine application rates for efficacious weed control in maize cultivation.

Maize, or corn (*Zea mays*), stands as one of the world's primary staple crops, sustaining both human and livestock populations. Its significance in global food security underscores the imperative of optimizing cultivation practices to ensure robust yields. Weeds, however, pose a perennial threat, competing for essential resources and hampering the growth and productivity of maize crops. In this context, herbicides have emerged as indispensable tools, offering a targeted and efficient means of weed control [7,8].

Atrazine, a chlorotriazine herbicide, has been a linchpin in the realm of weed management for decades. Its mode of action involves inhibiting photosynthesis in susceptible plants, rendering it effective against a broad spectrum of grasses and broadleaf weeds. Its residual activity further extends its effectiveness, providing a prolonged shield against weed resurgence [9]. Despite its efficacy, the environmental impact of atrazine has sparked debates, necessitating a nuanced approach to its application.

The optimization of atrazine application rates becomes particularly crucial for several reasons. First, excessive application may lead to environmental contamination, affecting non-target plants and organisms, and potentially leaching into water sources. Second, economic considerations prompt the need for judicious herbicide use, ensuring cost-effectiveness for farmers while maintaining efficacy. Third, evolving weed populations may exhibit varying degrees of susceptibility, demanding a tailored approach to dosage.

The substantial significance for agricultural practitioners, researchers, and policymakers alike. By unraveling the intricate relationship between atrazine application rates and weed control efficacy, the study contributes to the development of more sustainable and precise weed management practices in maize cultivation. The findings hold the potential to inform agronomic decisions, guiding farmers towards optimized herbicide use that aligns with both economic and environmental considerations.

As agriculture navigates the complex terrain of feeding a growing global population while minimizing environmental impacts, the optimization of herbicide application rates emerges as a crucial strategy.

This research endeavors to systematically assess the impact of varying atrazine application rates on weed populations (weed density and species composition) and growth and yield of maize.

This study, focused on atrazine in maize cultivation, aims to carve a path towards a more nuanced, efficient, and sustainable approach to weed management, thereby contributing to the broader discourse on precision agriculture and responsible herbicide use.

MATERIALS AND METHODS

Experimental Design:

The study employed a randomized complete block design (RCBD) to account for potential spatial variability in the experimental field. A total of six treatment levels were established, representing atrazine application rates of 0, 0.5, 1, 1.5, and 2 ml per liter of herbicide solution.

Field Site Selection:

A representative maize cultivation site was selected based on uniform soil characteristics and historical weed management practices. The site had not been subjected to recent herbicide applications to avoid residual effects.

Herbicide Application:

Atrazine, a chlorotriazine herbicide, was used as the primary weed control agent. A range of application rates, including 0, 0.5, 1, 1.5 and 2 ml per liter, were prepared to encompass a spectrum of dosage levels. Herbicide application was carried out during the early stages of maize growth, corresponding to the recommended timing for effective weed control.

Plot Preparation:

Experimental plots were demarcated with suitable spacing to prevent herbicide drift and facilitate proper replication. Each treatment level was replicated across multiple plots to ensure robust statistical analyses.

Weed Density Assessment:

Weed density was assessed by systematically sampling a predetermined area within each plot. Weed species, density, and diversity were recorded to evaluate the herbicide's efficacy against different weed types.

Maize Growth Parameters:

Maize growth parameters, including plant height and chlorophyll content, were measured at regular intervals throughout the growing season. Plant height provided insights into crop vigor, while chlorophyll content served as an indicator of overall plant health.

Grain Yield Measurement:

Maize grain yield was determined by harvesting mature maize cobs from each plot. Harvested grain was thoroughly cleaned, weighed, and expressed on a per-hectare basis for standardized comparison.

Biomass and Straw Yield:

Above-ground biomass, comprising both grain and vegetative plant components, was collected from each plot at the time of harvest. Separation of grain and straw components facilitated the quantification of biomass and straw yield.

Statistical Analysis:

Statistical analyses, including analysis of variance (ANOVA), were employed to discern significant differences among the atrazine application rates for each parameter. Post-hoc tests were conducted where necessary to identify specific treatment effects.

Replicability and Randomization:

The experimental design incorporated a sufficient number of replications for each treatment to enhance statistical power. Randomization of treatment application and data collection points minimized bias and increased the robustness of the study.

Data Recording and Documentation:

All experimental procedures, including herbicide preparation, application, and data collection, were meticulously recorded. The documentation included dates, weather conditions, and any unforeseen events that could influence study outcomes.

Safety Precautions:

Adherence to safety protocols during herbicide handling and application was paramount to minimize risks to researchers, the environment, and neighboring ecosystems. Herbicide containers and waste were disposed of in accordance with environmental safety guidelines.

Environmental Monitoring:

Throughout the study, environmental conditions such as soil moisture, temperature, and weather patterns were monitored. These variables were considered in data interpretation to contextualize the herbicide's effects on both weed and crop responses.

RESULTS

Weed Population Dynamics:

Atrazine application exhibited a dose-dependent response in weed density. The control group (0 ml/L) had the highest weed density, while increasing atrazine rates correlated with a significant reduction in weed populations. At 2 ml/L, weed density reached its lowest point, indicating the efficacy of atrazine in suppressing weed growth. Atrazine demonstrated selectivity in weed control, influencing different weed species to varying extents. Broadleaf weeds showed higher susceptibility to atrazine, with a noticeable decline in their representation as herbicide rates increased. Grass species also exhibited reduced density with higher atrazine doses, highlighting the herbicide's effectiveness against both weed categories (Figure 1).

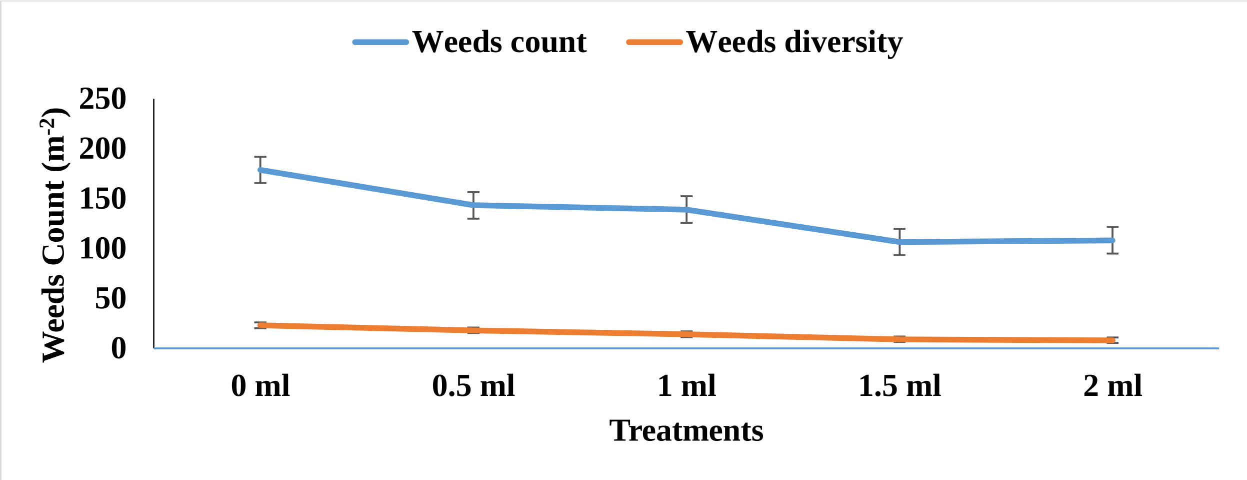


Figure 1. *Effect of different rates of atrazine on number and diversity of weeds in maize crop*

Plant Height and Chlorophyl:

The inverse relationship between atrazine application rates and weed density aligns with the herbicide's mode of action, inhibiting photosynthesis and impeding weed growth. The selectivity observed in weed species composition emphasizes atrazine's differential impact on broadleaf and grassy weeds. Such selectivity is crucial in maintaining crop integrity while efficiently managing weed populations. The positive correlation between atrazine application rates and maize grain yield underscores the herbicide's pivotal role in optimizing crop productivity. Higher atrazine doses effectively reduced weed competition, allowing maize plants to allocate resources more efficiently toward grain production (Figure 2).

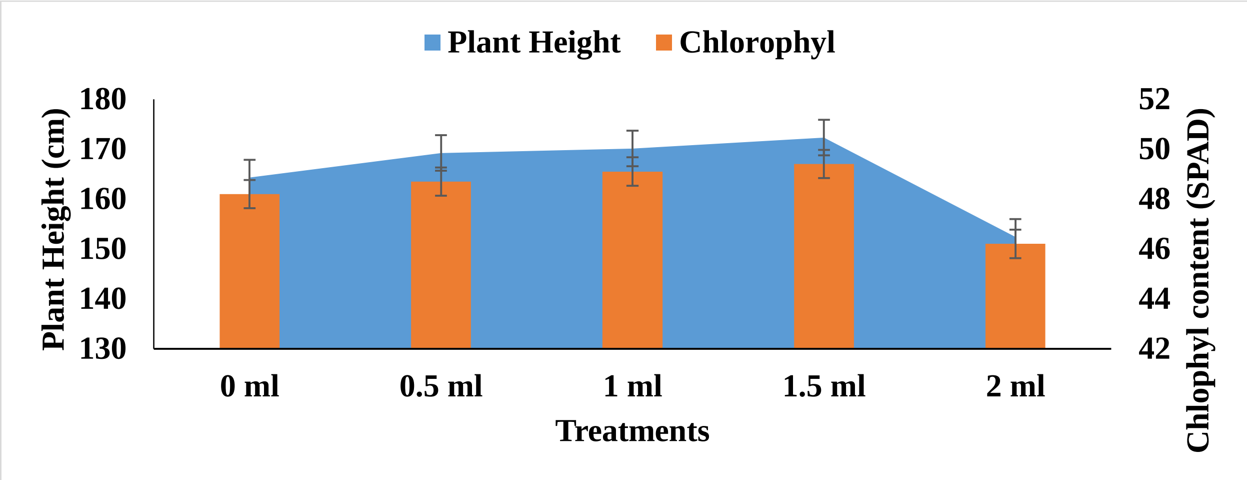


Figure 2. *Effect of different herbicides on plant height of maize crop*

Grain Yield:

Maize grain yield demonstrated a clear positive correlation with atrazine application rates. The control group exhibited the lowest grain yield, while incremental increases in atrazine dosage resulted in a significant improvement in maize productivity. At 1.5 ml/L, maize grain yield reached its peak, emphasizing the potential for optimizing atrazine application rates to maximize crop output (Figure 3).

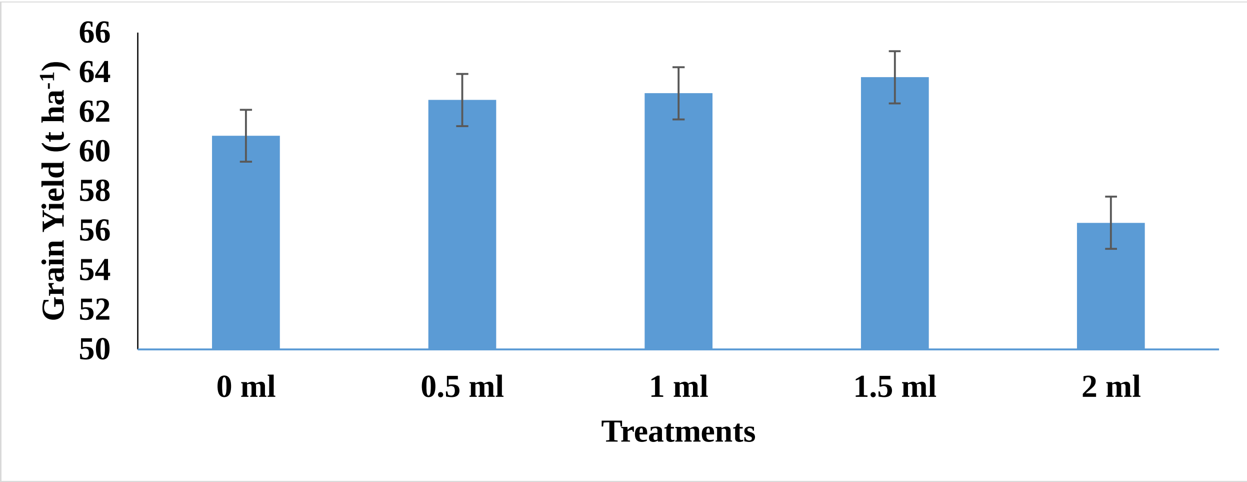
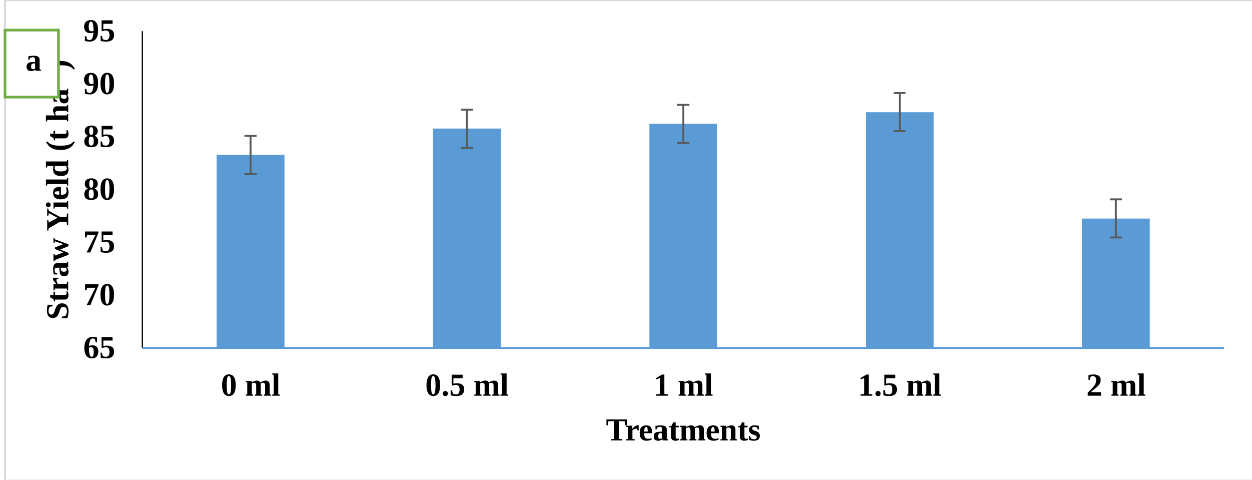


Figure 3. *Effect of different herbicides on grain yield of maize crop*

Biomass Yield and Straw Yield:

Atrazine application influenced both biomass and straw yield, reflecting the herbicide's impact on overall maize development. Biomass yield increased steadily with atrazine dosage, indicating robust crop growth and effective weed suppression. Straw yield followed a similar trend, demonstrating the herbicide's ability to enhance not only grain yield but also vegetative plant components. (Figure 4 a, b).



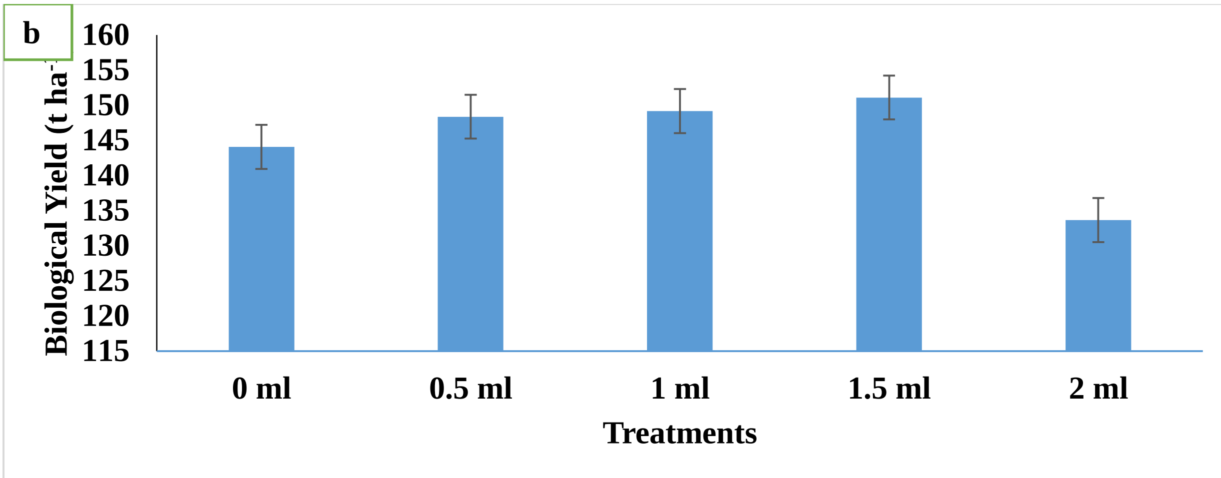


Figure 4. *Effect of different rates of atrazine on straw (a) and biomass (b) yield of maize crop*

DISCUSSION

The inverse relationship between atrazine application rates and weed density aligns with the herbicide's mode of action, inhibiting photosynthesis and impeding weed growth. The selectivity observed in weed species composition emphasizes atrazine's differential impact on broadleaf and grassy weeds [10]. Such selectivity is crucial in maintaining crop integrity while efficiently managing weed populations.

The observed reduction in maize plant height with increasing atrazine application rates aligns with the herbicide's mode of action, which inhibits photosynthesis in susceptible plants. The dose-dependent phytotoxic effect on plant height underscores the importance of careful consideration when optimizing atrazine application rates to balance weed control efficacy with potential impacts on crop development [10].

Chlorophyll content serves as a critical indicator of plant health and photosynthetic activity. The decline in chlorophyll content with higher atrazine rates suggests a potential interference with the photosynthetic process [11]. While the reduction in chlorophyll content may be associated with the herbicide's impact on weeds, the study highlights the need for a nuanced approach to atrazine application to minimize adverse effects on maize crops.

The positive correlation between atrazine application rates and maize grain yield underscores the herbicide's pivotal role in optimizing crop productivity. Higher atrazine doses effectively reduced weed competition, allowing maize plants to allocate resources more efficiently toward grain production.

The increase in biomass and straw yield with higher atrazine rates indicates the herbicide's comprehensive influence on overall crop development [12]. Enhanced biomass reflects not only improved grain yield but also increased vegetative plant components, contributing to the resilience and vitality of the maize crop.

The study identifies an optimal range for atrazine application rates, balancing effective weed control with considerations of economic efficiency and environmental impact. The dosage of 1.5

ml/L emerged as the point of maximum efficacy, achieving substantial weed suppression without compromising maize health.

CONCLUSION

The optimization of atrazine application rates represents a delicate dance between weed control efficacy and potential impacts on maize crops. This study contributes valuable insights to the ongoing discourse on responsible herbicide use, urging a nuanced and context-specific approach in the pursuit of sustainable and efficient maize cultivation practices. As agriculture evolves, precision-based weed management strategies become paramount, and these findings contribute to the collective knowledge guiding farmers, agronomists, and policymakers toward more informed decision-making in herbicide application for maize crops.

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Dose-Response Relationship of NPK Fertigation on Melon Growth and Yield

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ABSTRACT

The goal of the study was to determine how different NPK fertigation levels affected the watermelon (Citrullus lanatus L.) growth and yield in Pakistan's Khyber Pakhtunkhwa (KP) ecological zone. Using three replications and a Randomized Complete Block Design (RCBD) with five NPK levels (0%, 25%, 50%, 75%, and 100% of the advised 150:120:90 kg/ha), the experiment was carried out at the Arid Zone Research Centre during the rainy season of 2021. Plant height, leaf count, number of male and female flowers, days to 50% flowering, fruit count, and fruit weight at harvest were among the parameters that were measured. Results showed that raising NPK levels, especially at 75% of the prescribed dose, significantly increased plant height, leaf count, and flower count. At 100% NPK, the plants reached their maximum height (119.68 cm at 6 weeks and 227.16 cm at 10 weeks) and leaf count (41 leaves at 6 weeks and 79 leaves at 10 weeks), with 75% NPK coming in close second. At 75% NPK (18 flowers) and 100% NPK (17 flowers), the largest number of blooms per plant was observed. Significant progress was also shown in the fruit weight, with the highest average fruit weight (6.43 kg) being produced by 75% NPK. According to the study's findings, NPK fertigation at 75% of the suggested dosage greatly increases watermelon growth and yield; as a result, farmers in the area are advised to use this technique to increase productivity and profitability.

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INTRODUCTION

Watermelon, scientifically known as *Citrullus lanatus* L., is a member of the Cucurbitaceae family. It falls under the kingdom Plantae and order Cucurbitales [1]. This plant is quite versatile, with a growth habit that resembles that of a vine. It is well-known for producing the highly sought-after watermelon fruit [2]. Watermelons have a rich history, tracing back to their origins in Africa, particularly the Kalahari and Sahara deserts, many centuries ago. Over time, they have expanded their reach from Africa to Asia, Europe, and North America, making their way to Asia and the Middle East between 900 and 1000 A.D., and to Europe between 1300 and 1400 A.D. [3]. The term "watermelon" was first recorded in an English dictionary in 1615.

China took the lead in watermelon production with a whopping 69,576,643 tonnes. Iran, Turkey, Brazil, and the United States also made significant contributions to the global production, resulting in a total of 104,472,354 tons [4].

Watermelons have a multitude of health benefits, as stated by Ijaz et al. [5]. These foods are packed with vitamin B, which helps with energy production, and beta-carotene, which enhances the immune system and fights against age-related vision problems. Watermelons have a high water content, which helps prevent dehydration. They are a popular choice for those watching their calorie intake because they are low in calories. Watermelons contain potassium, which can contribute to reducing blood pressure and protecting against kidney stones, strokes, and heart diseases. In addition, watermelons are rich in antioxidants that help combat free radicals, which can lower the risk of cancer and heart diseases. Additionally, their diuretic properties can be advantageous for maintaining kidney and bladder health, while their juice has been known to help reduce skin blemishes [6,7].

Watermelons thrive in warm climates and prefer well-drained soils that are rich in organic matter [8]. The seeds are high in fat and protein, commonly consumed as snacks, incorporated into various dishes, or utilized for their oil content. Watermelon is packed with beneficial nutrients like lycopene, phenolic antioxidants, cucurbitacin E, and citrulline, which contribute to its significant nutritional value [9].

Watermelon production is influenced by the climate and farming methods. Factors such as poor cultivation practices, inadequate spacing, and improper fertilizer application contribute to low yields. Fertilization is crucial for achieving optimal growth in regions with less fertile soils. This is particularly important in areas with savannah soils. Fertilizer application has a significant impact on the growth of watermelons, particularly when it comes to the role of nitrogen [10].

This study seeks to investigate the impact of NPK fertigation on watermelon growth and yield. The main focus is to find the best fertilizer rates to enhance sustainable yield improvement.

MATERIALS AND METHODS

The experiment was carried out in the Arid Zone Research Centre through the course of the rainy season in the year 2022. The location is located in the Khyber Pakhtunkhwa (KP) ecological zone of Pakistan, at an elevation of 173 meters above sea level, at a latitude of 31 degrees 49 minutes north and a longitude of 70 degrees 55 minutes east. In this particular region, the climate is distinguished by the presence of distinct dry and rainy seasons. According to Rahmani et al. [11]

the soil at the experimental location is predominantly composed of clay-loam and has a diminished cation exchange capacity (CEC).

"Sugar Baby" watermelon variety was utilized for the experiment. This particular variety matures early and is ready for harvesting within seventy to seventy-five days. There were five different amounts of NPK fertilizer that were used in the experimental design. These levels were 0%, 25%, 50%, 75%, and 100% of the prescribed 150:120:90 kg/ha NPK. There were a total of fifteen experimental units, which was achieved by performing three separate replications of each treatment level.

The experimental design was a Randomized Complete Block Design (RCBD), and there were three replications of the experiment to guarantee that the results were reliable and representative of the whole. Two to three weeks following planting, application of fertilizer treatments was carried out in order to guarantee adequate nutrient uptake during crucial periods of plant development. Plant height, the number of leaves, the number of male and female flowers, the number of days until fifty percent of the flowers have bloomed, the number of fruits, and the weight of the fruits during harvest were the parameters that were measured.

In order to obtain comprehensive information regarding growth and yield, data gathering was carried out with great care at a number of different stages of progression. In order to establish the statistical significance of the treatment effects, the data that were collected were analyzed using the technique known as Analysis of Variance (ANOVA). The Least Significant Difference (LSD) test, which was described by Gomez and Gomez [12], was utilized in order to assess the mean differences that existed between the various treatments. The dependability and precision of the experimental data were ensured by this meticulous analytical technique, which also provided useful insights into the ideal quantities of NPK fertilizer for watermelon production under the conditions that were present.

RESULTS AND DISCUSSION

Plant Height

The impact of different NPK fertilizer levels on plant height at various stages of watermelon growth was analyzed, and the results are summarized in Table 1. At 2 weeks after sowing (WAS), there was no significant difference in plant height across the different treatments. However, by 6 WAS and 10 WAS, significant differences were observed. At 6 WAS, the application of 100% recommended NPK (150:120:90 kg/ha) resulted in the highest plant height (119.68 cm), followed by 75% NPK (103.45 cm), 50% NPK (83.64 cm), 25% NPK (72.41 cm), and the control (52.73 cm). At 10 WAS, the highest plant heights were recorded for 100% NPK (227.16 cm) and 75% NPK (224.34 cm), with 50% NPK (213.18 cm) and 25% NPK (197.42 cm) also showing significant increases compared to the control (154.67 cm).

The Least Significant Difference (LSD) test confirmed the significance of these differences at 6 and 10 WAS, indicating that higher doses of NPK fertilizer positively influence the plant height of watermelon, with the 100% and 75% NPK levels being particularly effective.

Number of Leaves

The number of leaves also showed significant variation among the treatments at different stages of growth (Table 1). At 2 WAS, there was no significant difference in the number of leaves across the treatments. By 6 WAS, the 75% NPK treatment resulted in the highest number of leaves (41), followed closely by 100% NPK (39). The 50% NPK (35) and 25% NPK (31) treatments also showed significant increases compared to the control (16). At 10 WAS, the highest number of leaves was recorded for 75% NPK (79), with 100% NPK (75), 50% NPK (74), and 25% NPK (63) showing significant increases compared to the control (45).

The Least Significant Difference (LSD) test verified the significance of these differences at 6 and 10 WAS. This indicates that larger dosages of NPK fertilizer have a favorable influence on the number of leaves that watermelon produces, with the levels of 100% and 75% NPK being particularly effective.

Table 1. *Effect of different fertigation concentrations on plant height and leaves count of water melon*

Fertigation Treatments	Plant Height (cm)			Number of Leaves		
	Weeks After Sowing (WAS)					
	2	6	10	2	6	10
0	2.71	52.73 e	154.67 d	4	16 c	45 c
25%	3.11	72.41 d	197.42 c	3	31 b	63 b
50%	3.19	83.64 c	213.18 b	3	35 ab	74 a
75%	3.21	103.45 b	224.34 a	5	41 a	79 a
100%	3.14	119.68 a	227.16 a	4	39 a	75 a
LS	NS	*	*	NS	*	*
LSD		5.67	7.86		6.41	5.93

Flower Count per Plant

The study evaluated the impact of various NPK fertigation treatments on the flower count per plant and the results are presented in Table 2. The flower count per plant varied significantly across the different NPK fertigation treatments. The highest flower counts were observed in the 75% NPK treatment (18 flowers per plant) and the 100% NPK treatment (17 flowers per plant), both of which were statistically similar and significantly higher than the other treatments. The 50% NPK treatment also showed a notable increase in flower count (13 flowers per plant), while the 25% NPK treatment had a moderate increase (10 flowers per plant). The control treatment, with no NPK application, had the lowest flower count (4 flowers per plant).

The Least Significant Difference (LSD) test confirmed the statistical significance of these differences, with an LSD of 2.08 for flower count, indicating that the differences among treatments were significant at the 5% probability level.

Fruit Weight

Fruit weight also exhibited significant differences among the treatments described in Table 2. The 75% NPK treatment resulted in the highest fruit weight (6.43 kg), followed closely by the 100% NPK treatment (6.36 kg). Both treatments significantly outperformed the other fertigation levels. The 50% NPK treatment achieved a fruit weight of 4.01 kg, while the 25% NPK treatment resulted in a fruit weight of 3.23 kg. The control treatment produced the lowest fruit weight (2.78 kg).

The statistical significance of these differences was validated by the Least Significant Difference (LSD) test, which yielded a value of 1.21 for fruit weight. This value indicates that the differences between treatments were significant at the 5% probability level.

Table 2: *Impact of various NPK fertigation treatments on the flower count per plant and fruit weight of watermelon*

Fertigation Treatments	Flower Count per plant	Fruit Weight (Kg)
0	4 d	2.78 c
25%	10 c	3.23 bc
50%	13 b	4.01 b
75%	18 a	6.43 a
100%	17 a	6.36 a
LS	*	*
LSD	2.08	1.21

DISCUSSION

A considerable increase in watermelon growth and yield can be achieved with the application of NPK fertigation, according to the findings of the study. There was a significant rise in the height of the plant as the amount of NPK fertilizer increased, reaching up to 75% of the required dose. The findings of this study are consistent with the findings of Kacha et al. [13] and Aitbayeva et al. [14], who showed that greater fertilizer treatment resulted in improved growth and yield components of watermelon. In addition, Kacha et al. [13] observed that an enhanced nutrient supply to cucumbers results in improved carbon utilization, which in turn leads to the subsequent production of assimilates and other compounds.

At both six and ten weeks after sowing (WAS), the administration of fertilizer resulted in a considerable increase in the quantity of leaves. All of the treatments were much more effective than the control, despite the fact that the differences between the different doses of fertilizer were not statistically significant. According to Ndereyimana et al. [15] and Fernandez et al. [16], who showed increased vine length and leaf number in watermelon with higher nitrogen application, this data lends credence to the conclusions of those researchers.

In addition, the research showed that the use of fertilizer had a favorable impact on the quantity of blooms that were produced by each kind of plant. The increased flower count can be linked to the higher vegetative development that occurred as a result of the increased availability of different nutrients. The findings of Yakimova et al. [17], who indicated that the blossoming of watermelon responds to the application of fertilizer, are in agreement with these findings.

CONCLUSION

According to the findings of the study, the application of NPK fertigation at a dose that is 75% of the prescribed dosage had a substantial impact on the plant's height, the number of leaves, the number of flowers produced by each plant, and the ultimate weight of the watermelon fruit. Taking into consideration these findings, it is suggested that farmers in the area under investigation implement this degree of fertigation in order to increase the profitability of their watermelon output. In addition to contributing to improved economic outcomes for farmers, this method has the potential to result in increased growth and yields over time.

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The Role of Nitrogen Fertilization in Improving Wheat Crop Yields

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ABSTRACT

A field study was conducted during the 2021-22 growing season to evaluate the effects of different nitrogen levels (0, 40, 80, and 120 kg N ha⁻¹) on the performance of two wheat genotypes, Galaxyand AZRC-Dera. The study meticulously gathered detailed data on various growth and yield parameters, which were then rigorously analyzed. The findings revealed that AZRC-Dera consistently outperformed Galaxyacross several key metrics. Throughout the crop growth cycle, AZRC-Dera produced notably taller plants, a trend that was significantly enhanced by incremental nitrogen application. The application of nitrogen at 120 kg ha⁻¹ was particularly effective, resulting in substantial increases in both the number of tillers and fertile tillers per plant in AZRC-Dera. Furthermore, the grain yield of AZRC-Dera was markedly higher compared to Galaxy, underscoring the genotype's superior responsiveness to nitrogen fertilization. The study conclusively demonstrated that each incremental addition of nitrogen fertilizer had a positive impact on the growth and productivity of the wheat cultivars under investigation. AZRC-Dera, in particular, exhibited notable superiority in several growth and yield parameters, making it a promising candidate for achieving higher wheat productivity through optimized nitrogen management. The research highlights the critical role of nitrogen fertilization in enhancing wheat growth and yield, with AZRC-Dera showing significant advantages in terms of plant height, tiller production, and grain yield. These findings provide valuable insights for agronomic practices aimed at maximizing wheat productivity.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is a crucial global cereal crop, ranking third in significance after maize and rice, and contributes approximately 30% to the world's total cereal production, highlighting its essential role in global food security [1]. In Pakistan, wheat is a staple food, occupying about 37% of the total cultivated land area and significantly contributing to agriculture with nearly a 14% share. Despite its importance, there is a notable yield gap, particularly evident during the 2022-23 period when wheat was cultivated on 11 million hectares, yielding 26.767 million tons [2]. Bridging this yield gap is crucial for enhancing productivity per unit area.

Intensive agriculture and the introduction of new, more productive wheat genotypes have led to significant nitrogen depletion in the soil. However, crops show a positive response to added nitrogen, underscoring its critical role [3]. Nitrogen is vital for plant metabolism, particularly in protein synthesis and chlorophyll production. Adequate nitrogen supply boosts photosynthetic activity, promotes strong vegetative growth, and imparts a deep green color, influencing carbohydrate utilization.

Recent studies highlight the benefits of nitrogen application at specific growth stages for cereals such as maize, wheat, sorghum, and barley. Fertilization with nitrogen, especially after silking or grain filling, is crucial for maximizing grain yields [4]. High-yielding varieties generally exhibit increased yield components with elevated nitrogen levels [5]. Therefore, the judicious use of nitrogenous fertilizers is essential for achieving farm profitability while minimizing environmental pollution.

This study aims to address the discrepancy between the beneficial effects of fertilizer usage on wheat and the variable responses of different wheat types to fertilizers. Conducted in the agro-ecological settings of DI Khan, the primary objective is to determine the optimal nitrogen fertilizer dosage for wheat growth under these specific conditions. By exploring the intricate relationship between nitrogen, wheat cultivars, and agro-ecological dynamics, this study seeks to provide insights that enhance wheat productivity and promote sustainable agricultural resource management. The subsequent sections will detail the methodology, results, and discussions to unravel the complexities of nitrogen application in optimizing wheat yield in the unique context of DI Khan.

MATERIALS AND METHODS

Experimental Setup

This investigation was conducted at the Research Area of the Arid Zone Research Center, DI Khan, aiming to examine the impact of varying nitrogen levels (0, 40, 80, and 120 kg ha^{-1}) on two wheat genotypes: Galaxyand AZRC-Dera. The soil in the experimental field was well-prepared, featuring 0.45% organic matter (OM), 0.029% nitrogen, 9 ppm available phosphorus, and 120 ppm exchangeable potassium, creating a conducive environment for wheat growth.

The experimental design followed a Randomized Complete Block (RCB) Design with a factorial arrangement and four replications. Each treatment was assigned to plots measuring 1.4 m by 4 m. Sowing was carried out using single-row hand drills, with a row spacing of 30 cm. A basal application of 60 kg ha^{-1} P_2O_5 and 50 kg ha^{-1} K_2O, along with one-third of the nitrogen dose, was done at sowing. The remaining nitrogen was split into two equal parts: one-third was applied at the first irrigation, and the rest at the second irrigation. This method ensured a steady supply of nitrogen throughout the critical growth stages of the wheat plants.

Data Collection and Analysis

Comprehensive data were meticulously recorded for various parameters, including the number of plants, tillers, fertile tillers per unit area, straw yield, and grain yield per hectare. The statistical analysis was performed using the "Statistix 8.1" software. Differences among treatment means were evaluated using the Least Significant Difference (LSD) test at a 5% probability level, following the methodology outlined by Lee *et al*. [6].

Soil Preparation

The soil preparation involved several steps to ensure optimal growing conditions. Initially, the field was plowed to a depth of 15-20 cm, followed by harrowing to break down soil clumps. The final step was leveling to ensure uniformity across the experimental plots.

Sowing Procedure

The sowing was performed using a precise single-row hand drill method to maintain consistent row spacing. The seeding rate was adjusted to ensure optimal plant density, enhancing the reliability of the growth and yield measurements.

Nutrient Management

The application of a basal dose of phosphorus (P_2O_5) and potassium (K_2O) was done to meet the initial nutrient requirements of the wheat plants. The nitrogen application strategy, divided into three stages, aimed to match the nitrogen availability with the plant's growth stages, maximizing nutrient uptake efficiency and promoting healthy development.

Irrigation Management

Irrigation scheduling was based on the critical growth stages of wheat, ensuring adequate moisture availability. The timing and quantity of water applied were carefully monitored to avoid water stress and ensure uniform growth across all plots.

Pest and Weed Control

Integrated pest management practices were employed to control pests and diseases. Regular monitoring was conducted to identify and manage pest infestations promptly. Weed control was achieved through a combination of mechanical weeding and the application of pre-emergence herbicides.

Statistical Analysis

The experimental data were analyzed using the "Statistix 8.1" software. Analysis of variance (ANOVA) was conducted to determine the significance of the treatments. The LSD test at a 5% probability level was used to compare the means of different treatments. This rigorous statistical approach ensured that the observed differences in growth and yield parameters were attributable to the varying nitrogen levels and not to random variation.

RESULTS AND DISCUSSION

The primary objective of this study is to maximize wheat yields through genomic and ecological manipulations. Germination, a critical indicator of plant growth, plays a pivotal role in achieving this goal. This study focuses on the wheat cultivars Galaxy and AZRC-Dera, evaluating their response to different nitrogen levels.

Germination and Stand Establishment

Cultivar AZRC-Dera exhibited significantly higher germination rates throughout the crop growth period, underscoring its genetic superiority. The observed differences in sprouting counts among the cultivars can be attributed to heritable variations. These findings are consistent with Ju *et al*. [7], who highlighted the differential response of wheat varieties to nitrogen levels. Notably, nitrogen application at rates of 40, 80 and 120 kg ha^{-1} resulted in significantly more plants compared to the zero nitrogen treatment. The highest nitrogen rate (120 kg ha^{-1}) consistently produced the greatest number of plants, indicating the positive impact of nitrogen on germination and early crop establishment.

Table 1. *Quantity of plants m^{-2} as influenced by the fertilization of N at various dates*

Treatments	**December 20**		**January 30**		**April 05**	
N application Kg ha^{-1}	**Galaxy**	**AZRC-Dera**	**Galaxy**	**AZRC-Dera**	**Galaxy**	**AZRC-Dera**
0	129.4 e	142.4 d	143.4 f	157.1 f	166.2 d	168.4 d
40	175.3 bc	181.4 b	178.9 e	194.3 d	265.1 b	271.3 b
80	166.5 c	155.3 c	231.3 c	249.7 b	248.3 c	291.0 a
120	194.1 a	204.2 a	256.1 b	274.2 a	257.1 bc	305.9 a
LSD	13.94		13.98		15.11	

Tiller Production and Fertile Tillers

Tiller production, a key determinant of stand density, is influenced by both genetic factors and external environmental conditions. Cultivar AZRC-Dera demonstrated a superior ability to produce tillers throughout the crop growth period compared to Galaxy ($P < 0.01$). Nitrogen application significantly influenced tiller production, with higher rates resulting in an increased number of tillers. The nitrogen rate of 120 kg ha^{-1} resulted in the highest tiller count, further supporting the positive correlation between nitrogen application and tiller development [8,9]. Fertile tillers, which are crucial for grain yield, were significantly more abundant in AZRC-Dera than in Galaxy ($P < 0.01$). Nitrogen application, particularly at rates of 40, 80 and 120 kg ha^{-1}, significantly increased the number of fertile tillers. The highest nitrogen rate (120 kg ha^{-1}) resulted in the maximum number of fertile tillers, indicating a positive impact on reproductive potential.

Table 2. *Number of tillers and fertile tillers m^{-2} as influenced by the application of nitrogen at various rates*

Treatments	**No. of Tillers (m^{-2})**		**No. of Fertile Tillers (m^{-2})**	
N application (Kg ha^{-1})	**Galaxy**	**AZRC-Dera**	**Galaxy**	**AZRC-Dera**
0	208.3 f	209.6 f	169.2 g	189.5 f
40	279.6 e	342.9 d	274.1 e	338.0 d
80	371.7 c	416.2 b	352.9 c	411.8 b
120	461.4 a	481.1 a	482.6 a	489.4 a
LSD	23.42		18.72	

Grain Yield and Straw Yield

The ultimate goal in crop production is to maximize profitable yield. Cultivar AZRC-Dera achieved significantly higher grain yields (4.64 tons ha^{-1}) compared to Galaxy ($P < 0.01$). Nitrogen application at rates of 40, 80 and 120 kg ha^{-1} significantly increased grain yields, with the highest nitrogen rate producing the maximum grain yield (4.64 tons ha^{-1}). This aligns with previous research that highlights the positive influence of nitrogen on wheat growth and development [10,11]. Furthermore, cultivar AZRC-Dera exhibited a significantly higher straw yield (9.32 tons ha^{-1}) compared to Galaxy ($p < 0.01$). Nitrogen application, particularly at rates of 40, 80 and 120 kg ha^{-1}, significantly increased straw yields. The highest nitrogen rate (120 kg ha^{-1}) resulted in the maximum straw yield (9.32 tons ha^{-1}). This suggests that nitrogen use boosts vegetative growth, delays senescence, and increases overall biological yield.

Table 3. *Grain and Straw yields as influenced by application of nitrogen at various rates*

Treatments	**Grain Yield (Tons ha^{-1})**		**Straw Yield (Tons ha^{-1})**	
N application (Kg ha^{-1})	**Galaxy**	**AZRC-Dera**	**Galaxy**	**AZRC-Dera**
0	2.69 e	2.71 e	7.12 e	7.56 d
40	3.25 d	3.69 c	7.61 d	8.13 c
80	4.23 b	4.31 b	8.15 c	8.78 b
120	4.24 b	4.64 a	8.51 bc	9.32 a
LSD	0.31		0.37	

CONCLUSION

The importance of nitrogen fertilization in maximizing the growth and yield of the wheat cultivars Galaxy and AZRC-Dera is highlighted by this study. Comparing cultivar AZRC-Dera to Galaxy, the latter consistently performed lesser across important growth characteristics including as germination rate, tiller production, fertile tillers, grain yield, and straw yield. The highest increases in plant growth and production were obtained from the administration of nitrogen, namely at a rate of 120 kg ha^{-1}. These findings demonstrate how managing nitrogen levels and genetic potential work together to increase wheat yields. The study offers insightful advice for maximizing wheat yield, highlighting the necessity of cultivar selection and targeted nitrogen administration for long-term agricultural success.

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