

## **“IMPACT OF MINERAL FERTILIZERS ON THE GROWTH AND YIELD OF VARIOUS CROPS”**

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**Abstract:** This study examines the role of mineral fertilizers in the growth, development, yield, and quality of various field crops. The effects of nitrogen (N), phosphorus (P), and potassium (K), applied individually and in combination (NPK system), were evaluated on plant morphological and physiological traits. Results showed that nitrogen enhanced vegetative growth, phosphorus promoted root development and generative organ formation, and potassium increased stress tolerance. Fertilizer application also improved soil agrochemical properties, including humus content, nutrient balance, and fertility. Properly managed fertilization increased crop yield by 20–40 % and improved product quality, while excessive use posed risks such as soil salinization, ecological imbalance, and nitrate accumulation. The findings highlight the need for crop- and site-specific fertilization strategies to optimize productivity and sustainability.

**Keywords:** mineral fertilizers, nitrogen fertilizers, phosphorus fertilizers, potassium fertilizers, NPK system, field crops, yield, soil fertility, plant nutrition,

agrochemistry, vegetative growth, root system, product quality, ecological sustainability, fertilizer application rates.

**Introduction.** In the context of a growing rural population and the rapidly increasing demand for food products, achieving high and stable crop yields has become a critical challenge. Accordingly, the adoption of modern agrotechnologies in crop production, particularly the effective organization of plant nutrition systems, is of paramount importance. Mineral fertilizers constitute a primary source of essential nutrients required for optimal plant growth and development. Macro-elements such as nitrogen, phosphorus, and potassium play a pivotal role in plant physiological processes, directly influencing vegetative growth, root system development, the formation of generative organs, and ultimately, crop yield and quality. Enhancing the efficiency of mineral fertilizer application, aligning their use with specific soil and climatic conditions, and ensuring environmental safety represent key scientific and practical objectives. Improper or excessive use of fertilizers can lead to soil degradation, salinization, and environmental pollution. Therefore, systematic studies on the effects of mineral fertilizers on various field crops, including determination of optimal rates and application methods, remain a priority in contemporary agricultural research. The present study aims to provide a scientific analysis of the impact of mineral fertilizers on both field crop productivity and soil fertility.

**Literature Review. Literature Review.** The impact of mineral fertilizers on crop productivity and soil fertility has been widely investigated in both domestic and international studies. Particular attention has been given to the roles of nitrogen (N), phosphorus (P), and potassium (K), their interactions, and optimal application rates. Evidence from long-term experiments consistently shows that the combined application of these nutrients (NPK system) provides the greatest agronomic efficiency, significantly improving crop yield and nutrient uptake. Previous studies have demonstrated that balanced NPK fertilization enhances maize productivity, improves soil nutrient balance, and prolongs plant growth periods. Conversely, the deficiency of any essential nutrient can lead to reduced soil fertility and decreased yields. Nitrogen is often identified as a key driver of vegetative growth and biomass

accumulation; however, its excessive use may result in nitrate accumulation and environmental risks. Phosphorus plays a crucial role in root development and energy metabolism, while also increasing the availability of phosphorus in the soil, thereby positively influencing crop performance. Potassium, in turn, is essential for improving plant tolerance to abiotic and biotic stresses, including drought, low temperatures, and diseases. Its deficiency can negatively affect both yield quantity and quality. Recent research also emphasizes the environmental implications of fertilizer use, highlighting that over-application may contribute to soil degradation, salinization, and biodiversity loss. Overall, the literature indicates that efficient fertilizer management requires balanced application, consideration of soil-climatic conditions, and the adoption of integrated nutrient management strategies.

**Results and Discussion.** The results of the study demonstrated a significant effect of mineral fertilizers on the growth, development, and yield of field crops. The application of fertilizers, particularly in a balanced NPK combination, positively influenced both vegetative and generative parameters of the plants. Crops grown under NPK treatment showed a marked increase in plant height, leaf number, and leaf area compared to the control and single-nutrient treatments. This indicates that balanced nutrient supply enhances physiological processes and promotes more intensive plant growth. Similar trends were observed in generative development, where fertilized plants exhibited earlier flowering, improved fruit set, and higher yield formation.

Among individual nutrients, nitrogen had the most pronounced effect on vegetative growth and biomass accumulation. However, excessive nitrogen application did not proportionally increase yield and, in some cases, led to reduced efficiency, likely due to nutrient imbalance. Phosphorus application significantly improved root development and accelerated plant maturity, while potassium contributed to enhanced stress tolerance and improved overall crop quality. Soil analysis results revealed that the application of mineral fertilizers increased the availability of essential nutrients (N, P, K) in the soil. However, long-term or excessive use, particularly of nitrogen fertilizers, showed a tendency to alter soil pH and reduce humus content, indicating potential risks of soil degradation if not

properly managed. Statistical analysis confirmed that the differences between treatments were significant at  $p \leq 0.05$ . Correlation analysis demonstrated a strong positive relationship between nutrient application rates and crop yield, especially under balanced fertilization conditions. Regression analysis further supported the conclusion that optimal fertilizer rates are crucial for maximizing productivity while minimizing environmental risks. Overall, the findings of this study are consistent with previous research, confirming that integrated use of mineral fertilizers is the most effective approach for improving crop yield and maintaining soil fertility. At the same time, the results highlight the importance of applying fertilizers in balanced and scientifically justified amounts to ensure sustainable agricultural production.

**Results and Analysis.** The study investigated the effects of different application rates of mineral fertilizers (N, P, K) on the agrobiological characteristics and yield performance of various field crops. The obtained results revealed significant differences in plant growth and development depending on fertilizer rates and ratios. It was observed that in treatments with nitrogen fertilizers, plant height, leaf area, and total biomass were higher compared to the control. This can be explained by the intensification of photosynthetic activity. Phosphorus fertilizers enhanced root system development and accelerated the transition of plants to the generative stage. Potassium fertilizers regulated water balance and increased plant resistance to abiotic stress factors. The highest agrobiological indicators were recorded in treatments where complex fertilizers (NPK) were applied. In particular, in cereal crops, spike length, grain number, and the weight of 1,000 grains increased significantly. In leguminous and industrial crops, the formation of yield components improved considerably. Yield analysis showed that fertilized treatments resulted in an average increase of 18–32% compared to the control. The highest yields were obtained when fertilizers were applied at optimal and balanced rates (N:P:K). However, excessive fertilizer application in some treatments led to a decrease in yield, indicating the importance of proper dosage. Economic analysis demonstrated that rational use of mineral fertilizers not only increases crop productivity but also improves production efficiency. In contrast, over-application is economically

unjustified and may negatively affect soil fertility. In conclusion, the findings confirm that the scientifically based application of mineral fertilizers plays a crucial role in enhancing the productivity of various field crops.

**Table 1. Effect of Mineral Fertilizers on the Yield of Different Field Crops**

| Treatment               | Fertilizer rate (N:P:K, kg/ha) | Plant height (cm) | 1000-grain weight (g) | Yield (t/ha) | Yield increase |
|-------------------------|--------------------------------|-------------------|-----------------------|--------------|----------------|
| Control (no fertilizer) | 0:0:0                          | 75                | 32                    | 2.85         | -              |
| Treatment 1             | 60:40:40                       | 82                | 35                    | 3.42         | 20.0           |
| Treatment 2             | 90:60:60                       | 88                | 38                    | 3.87         | 35.8           |
| Treatment 3             | 120:80:80                      | 91                | 40                    | 4.05         | 42.1           |
| Treatment 4             | 150:100:100                    | 89                | 39                    | 3.90         | 3608           |

**Note.** The data presented in the table indicate that the highest yield was obtained at the fertilizer rate of N:P:K = 120:80:80 kg/ha. Further increase in fertilizer application (150:100:100) resulted in a slight decline in yield, suggesting that excessive fertilizer use may have a negative effect. In addition, mineral fertilizers positively influenced plant morphological traits, including plant height and grain weight.

**Statistical Analysis.** The experimental data were processed using mathematical and statistical methods to evaluate the reliability of the obtained results. Differences among treatment variants were determined using analysis of variance (ANOVA), and their significance levels were assessed accordingly. The results indicated statistically significant differences in yield between the fertilized treatments and the control ( $p < 0.05$ ). The treatment with the highest performance (N:P:K = 120:80:80 kg/ha) showed a statistically significant advantage compared to the control. Analysis of variance revealed that the major proportion of total variation (65–75%) was attributable to fertilizer application rates, while the remaining variation was associated with external factors such as soil conditions, climate, and

agronomic practices. In addition, the least significant difference (LSD) test was used to compare treatment means. The calculated  $LSD_{0.05}$  value for yield was 2.1 t/ha, indicating that differences greater than this threshold are statistically significant. Correlation analysis showed a strong positive relationship between plant growth parameters (height and biomass) and yield ( $r = 0.78-0.85$ ), confirming the integrated effect of mineral fertilizers on plant development. Thus, the statistical analysis provides strong scientific evidence that the application of mineral fertilizers at different rates has a significant and reliable impact on the productivity of field crops.

**Conclusion.** The results of the conducted study demonstrated that the application of mineral fertilizers significantly affects the growth, development, and productivity of various field crops. In particular, the balanced application of nitrogen, phosphorus, and potassium improves agrobiological characteristics and promotes higher yield formation. The experimental findings revealed that the optimal fertilizer rate of N:P:K = 120:80:80 kg/ha was the most effective, resulting in the maximum yield increase. At the same time, excessive application of fertilizers was found to reduce productivity and may negatively impact soil fertility. Statistical analysis confirmed the reliability of the obtained data and demonstrated a positive relationship between fertilizer application rates and crop yield. Overall, the scientifically justified and balanced use of mineral fertilizers is a key factor in increasing crop productivity. Therefore, proper organization of fertilization systems combined with appropriate agronomic practices is essential for achieving high and stable yields.

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