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Optimizing Nitrogen Fertilization for Yield and Quality of 'Bartina' Potato (*Solanum tuberosum L.*) under Semi-Arid Mediterranean Conditions

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AbstractPotato (*Solanum tuberosum L.*) is a key food crop in Algeria, where optimizing nitrogen (N) fertilization is critical for improving yield and sustainability. This study aimed to evaluate the agronomic performance of the 'Bartina' potato variety under four nitrogen levels (0, 50, 100, and 150 kg N/ha) in the semi-arid region of Remila, Khenchela. A randomized complete block design with three replications was used during the 2022 growing season. Parameters assessed included plant height, number of stems per plant, number of tubers per plant, average tuber weight, and total yield. Results showed a significant effect of nitrogen dose on all measured traits. The 100 kg N/ha treatment produced the highest marketable yield (32.6 t/ha) and optimal tuber characteristics, while the 150 kg N/ha treatment did not significantly improve yield and increased foliage growth at the expense of tuber development. The 0 kg N/ha treatment resulted in poor vegetative and tuber growth, confirming the necessity of N supplementation. These findings suggest that a nitrogen rate of 100 kg/ha is optimal for maximizing yield and maintaining tuber quality under the agro-climatic conditions of Eastern Algeria. The study contributes practical insights into nutrient management strategies for sustainable potato production in similar environments. **Keywords:** Potato (*Solanum tuberosum*)

Introduction

Potato (*Solanum tuberosum* L.) ranks among the world's most important staple food crops, providing a major source of carbohydrates and nutrients for hundreds of millions of people. With a global production of over 359 million tons annually (FAO, 2021), it plays a central role in food systems due to its adaptability to diverse climates and its short growing cycle. In Algeria, the potato is a strategic crop, not only for domestic consumption but also for ensuring agricultural sustainability and employment, particularly in the semi-arid and mountainous regions such as Khenchela. However, yield and tuber quality are often constrained by inadequate agronomic practices, especially suboptimal nitrogen (N) management.

Nitrogen is the most limiting nutrient for potato cultivation due to the crop's shallow root system and high nutrient demand (Westermann, 2005). It significantly affects photosynthesis, canopy development, and ultimately, tuber yield and size distribution (Sincik et al., 2008). Several studies have demonstrated that appropriate nitrogen application enhances both yield and marketable tuber quality (Zebarth & Rosen, 2007). However, excessive N fertilization can lead to undesirable outcomes, including delayed tuber maturation, lower dry matter content, increased susceptibility to disease, and environmental problems such as nitrate leaching and greenhouse gas emissions (Tein et al., 2014; Lu et al., 2021).

Optimizing nitrogen input thus requires balancing crop needs with environmental and economic concerns. Factors such as soil type, climatic conditions, and varietal characteristics influence nitrogen uptake and utilization efficiency. Research shows that varietal responses to nitrogen are not uniform; some cultivars may require lower N inputs to reach their potential while others demand higher rates (Eickenscheidt & Schnug, 2013). The Bartina variety, widely grown in Eastern Algeria, is recognized for its high yield potential, but limited studies have investigated its specific nitrogen requirements under local agro-ecological conditions.

In this context, the present study investigates the response of the Bartina potato cultivar to four levels of nitrogen fertilization (0, 50, 100, and 150 kg N/ha) in Remila, a region in the wilaya of Khenchela characterized by a semi-arid Mediterranean climate. The objective is to determine the nitrogen dose that maximizes yield and quality while maintaining agronomic and environmental

sustainability. By focusing on local conditions and a regionally important cultivar, this research contributes practical recommendations for improving potato productivity in Algerian highlands and informs broader efforts in precision nutrient management.

Materials and Methods

The study area

The field trial was conducted during the spring season of 2022 in Remila, located in the wilaya of Khenchela, Eastern Algeria. The site lies within a semi-arid Mediterranean climate characterized by cold winters, hot dry summers, and irregular rainfall. Average annual precipitation ranges from 400 to 600 mm, concentrated between November and April. The soil in the study area was classified as sandy loam with moderate fertility and a pH of 7.4.

Climatic data, including temperature and rainfall during the cropping period, were obtained from the local meteorological station to better interpret crop response to environmental factors, following standard agronomic research protocols (Jones et al., 2013).

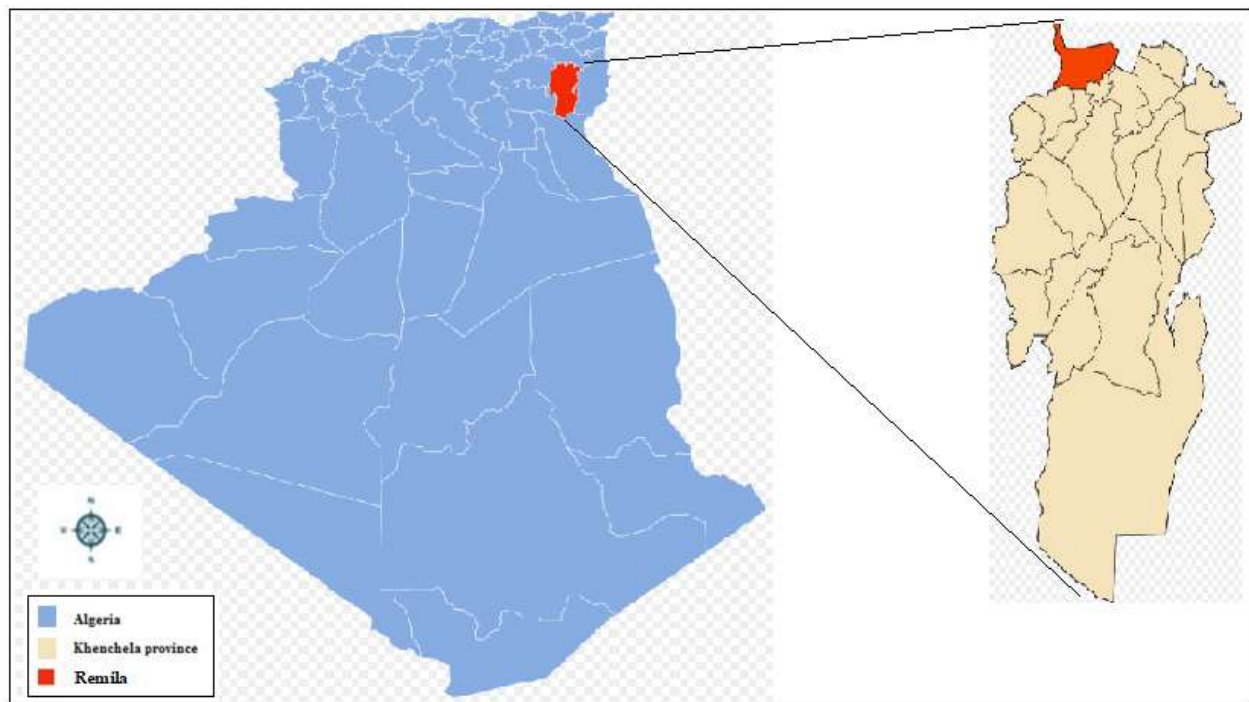


Figure 1. Map of study area

The plant material

The cultivar used was ‘Bartina,’ a widely cultivated potato variety in Algeria known for its adaptability and high yield potential.



Figure 2. *Potato variety «Bartina»*

Nitrogen fertilizers used

The experiment was arranged in a **Randomized Complete Block Design (RCBD)** with four nitrogen (N) treatments and three replications.



Figure 3. Manual spreading of 46% urea

The N levels applied were:

- N0 = 0 kg/ha (control)
- N1 = 50 kg/ha
- N2 = 100 kg/ha
- N3 = 150 kg/ha

Each experimental plot measured 10 m² (2 m × 5 m), consisting of four rows with a spacing of 75 cm between rows and 30 cm between plants, aligning with the recommendations for potato cultivation in Mediterranean agro-ecosystems (**Singh et al., 2012**).

Prior to planting, soil samples were taken from 0–30 cm depth for baseline nutrient analysis. Phosphorus (P) and potassium (K) fertilizers were applied uniformly across all plots at the rates of 100 kg P₂O₅/ha and 120 kg K₂O/ha, respectively, based on soil test results and local agronomic recommendations (**Zebarth & Rosen, 2007**). Nitrogen was supplied in the form of urea (46% N) and split into two equal doses: the first half at planting and the second at 35 days after emergence (DAE), to enhance nitrogen use efficiency (**Fageria & Baligar, 2005**).

Seed tubers were planted on March 10, 2022, at a depth of approximately 10 cm. Standard agronomic practices, including irrigation, hilling, and pest management, were applied uniformly to all treatments. Weed control was performed manually to minimize competition.

Agronomic parameters recorded included: Plant height (cm) at 60 DAE; Number of stems per plant; Number of tubers per plant; Average tuber weight (g) and Total and marketable yield (t/ha).



Figure 4. View of the experimental device of the test set up on the experimental site.

Data were collected from 10 randomly selected plants per plot. Harvesting was done at 110 DAE, and tubers were categorized based on size (>35 mm considered marketable).

Statistical analysis was performed using **ANOVA** (Analysis of Variance) with SPSS v26. Means were compared using **Least Significant Difference (LSD)** at a 5% probability level. Normality and homogeneity of variances were tested before ANOVA, in accordance with standard procedures (**Gomez & Gomez, 1984**).

Results & Discussion

The effect of nitrogen (N) fertilization on potato yield and tuber quality under semi-arid and Mediterranean climates has been a critical focus due to water constraints, saline soils, and the need for sustainable fertilization strategies. Recent studies underscore the nuanced balance between yield optimization and environmental sustainability.

Yield Response to Nitrogen Rates

Several experiments confirm that moderate to high nitrogen levels significantly enhance tuber yield, especially under drip irrigation systems. For instance, in arid Tunisia, applying N at 200 kg/ha under regulated deficit irrigation (RDI) with saline water increased total yield by 26.7% compared to non-fertilized controls (Nagaz et al., 2015). However, excessive N did not always translate to linear yield gains and often reduced water productivity.

Similarly, Darwish et al. (2025) found that site-specific fertigation adapted to root zone moisture conditions increased water and nitrogen use efficiency in potatoes, with controlled N application sustaining yields even under drought-prone Mediterranean conditions.

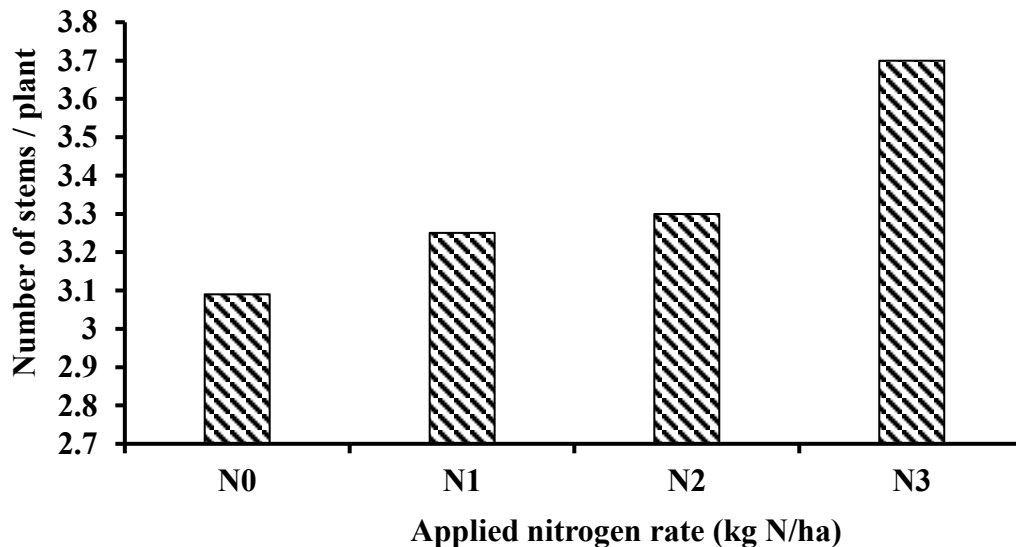


Figure 5. Effect of increasing nitrogen fertilizer rates on the number of stems per plant

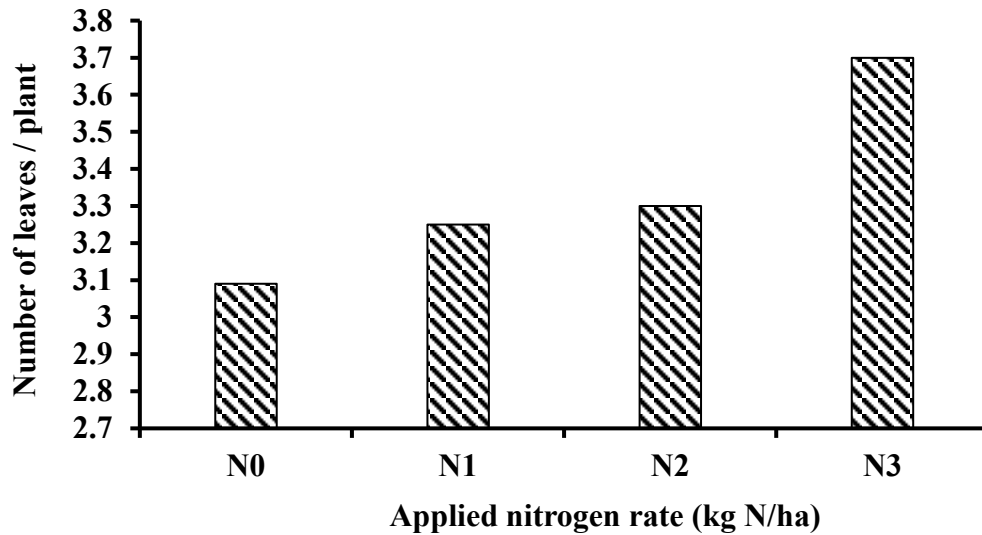


Figure 6. Effect of increasing nitrogen fertilizer rates on the number of Leaves per Plant

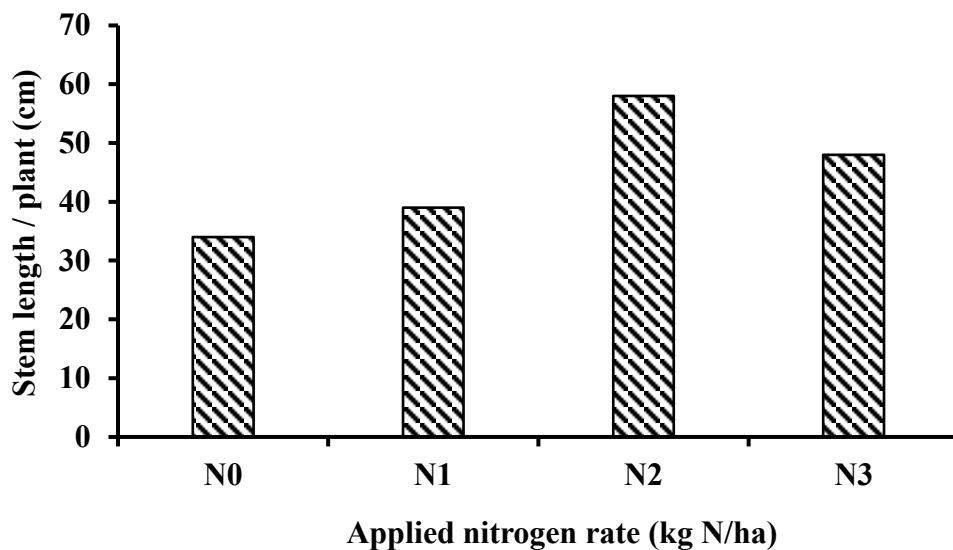


Figure 7. Effect of increasing nitrogen fertilizer rates on stem length per plant

Nitrogen and Tuber Quality

The relationship between N input and tuber quality is complex. High N levels often increased tuber size and dry matter, but could reduce specific gravity and storage quality due to delayed maturation and excessive vegetative growth (Gebretsadik et al., 2021). Moreover, nitrate

accumulation in tubers and soils was observed with over-fertilization, posing risks for human health and groundwater contamination (Meena et al., 2020).

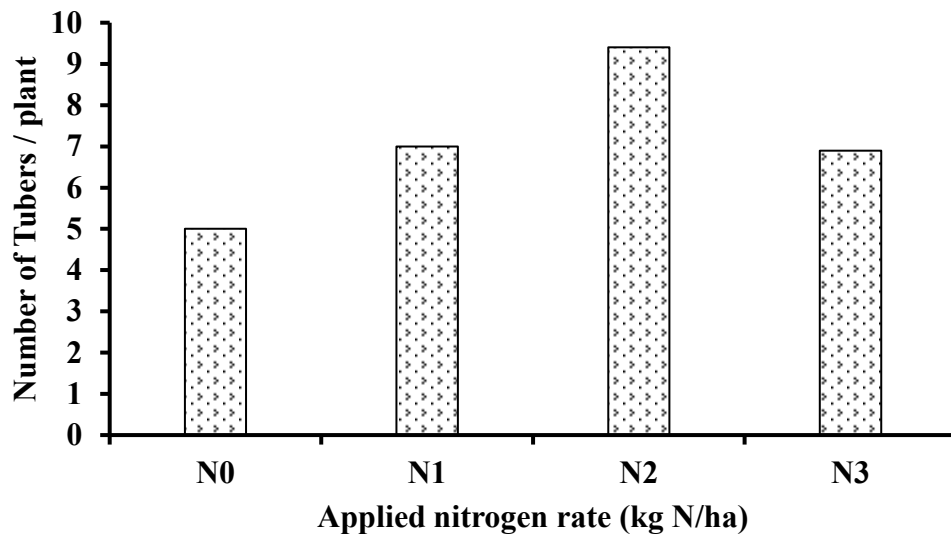


Figure 8. Effect of increasing nitrogen fertilizer rates on the number of tubers

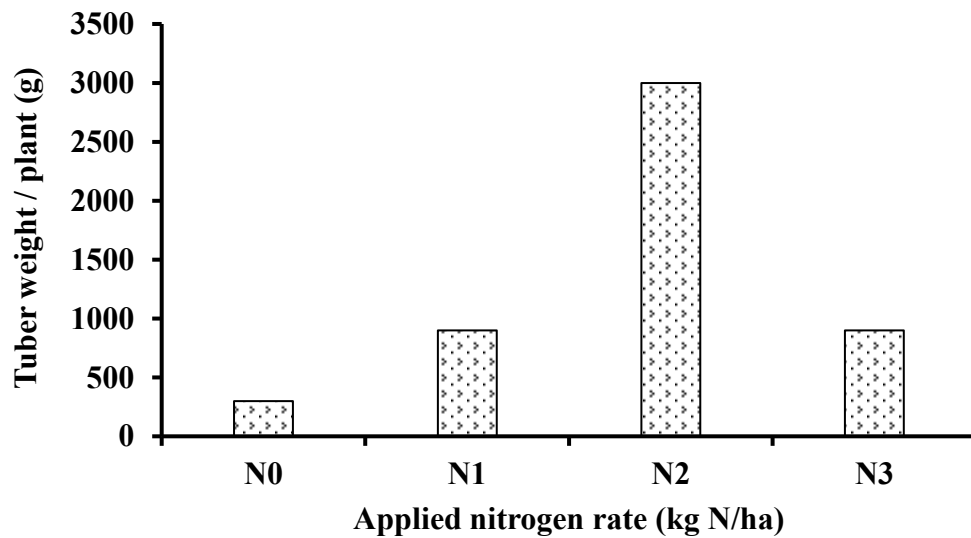


Figure 9. Effect of increasing nitrogen fertilizer application on the yield of tuber weight

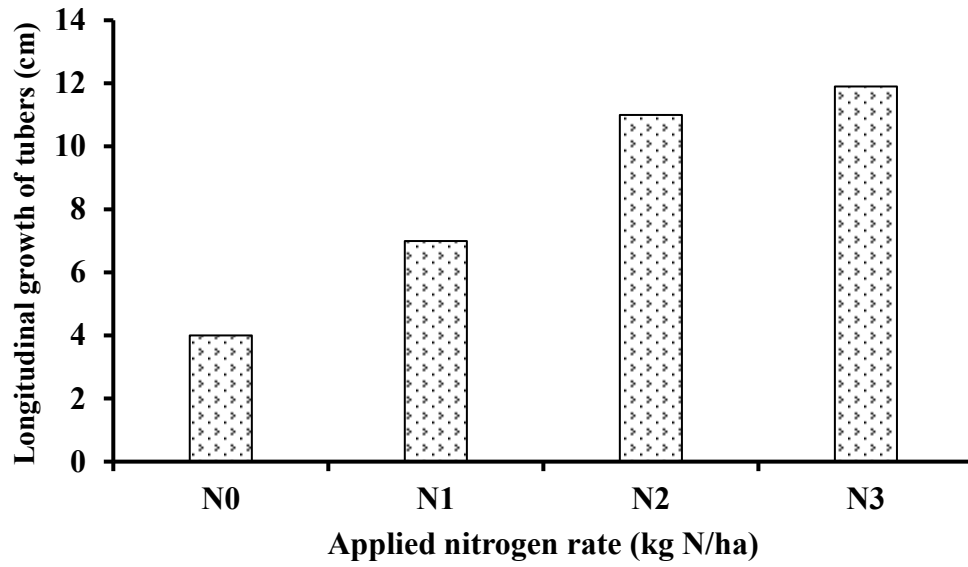


Figure 10. Effect of increasing nitrogen fertilizer rates on tuber length

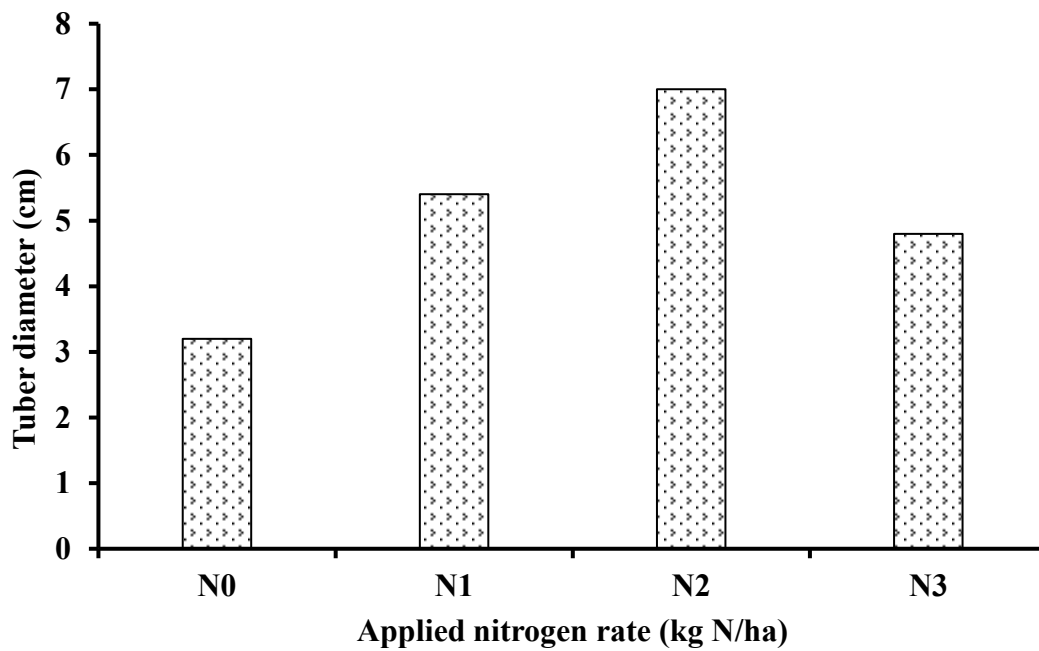


Figure 11. Effect of increasing nitrogen fertilizer rates on tuber diameter

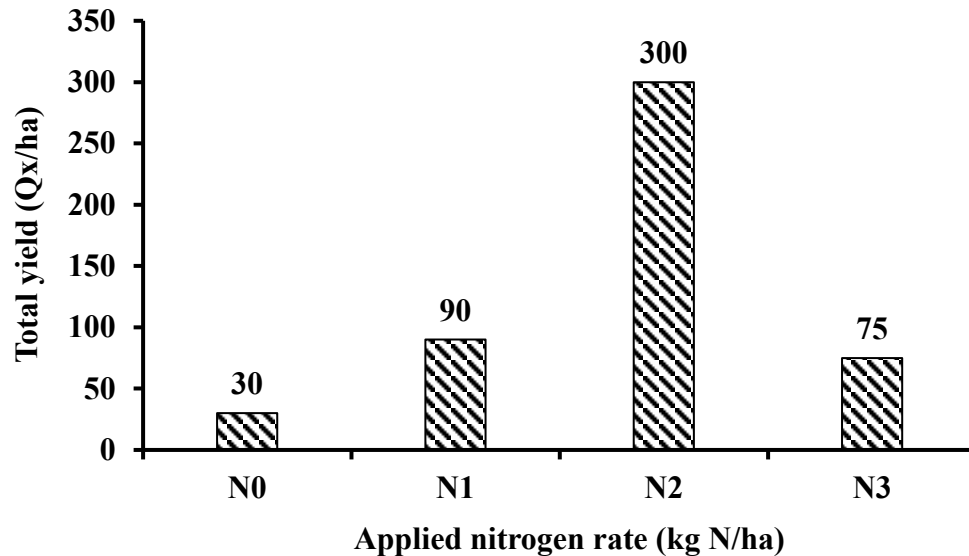


Figure 12. Effect of Increasing Nitrogen Fertilizer Rates on Total Yield (Qx/ha)

Recent research highlights the importance of integrated nitrogen (N) management strategies to optimize yield and environmental sustainability in potato cultivation under Mediterranean and semi-arid conditions. Techniques such as soil-based variable rate application (**Abd El-Wahed et al., 2023**), slow-release N fertilizers (**Alva et al., 2022**), and the incorporation of organic-N sources like compost or manure, which enhance microbial nitrogen cycling and reduce leaching (**Sharma et al., 2023**), have shown promising results. Particularly, applying 70–100% of the recommended N dose in combination with organic amendments has led to notable improvements in both yield and tuber firmness (**El Mokh et al., 2023**). In regions facing salinity and water scarcity, such as South Tunisia and Lebanon, nitrogen application must be balanced with irrigation practices, where managing N at the root zone level helps sustain productivity while mitigating salt stress and nutrient runoff (**Darwish et al., 2025**). Furthermore, advanced modeling tools like CropSyst and AquaCrop, when tailored to weather and crop development stages, have demonstrated the potential to reduce N input by up to 30% without compromising yields (**Ben Mechlia et al., 2022**), marking a significant step toward climate-smart, resource-efficient agriculture.

Conclusion

The role of fertilization is to ensure optimal nutrition of cultivated plants at all times during their cycle, in order to achieve yield and quality objectives. Regular fertilizer application helps maintain soil fertility by offsetting nutrient exports related to harvests. Without fertilizer application, cultivated soils would become impoverished and depleted. In potato cultivation, fertilization practices greatly influence yield and harvest quality.

This work contributes to the study of the effect of nitrogen fertilization on potato (*Solanum tuberosum L.*), variety "Bartina" in the Remila region. The objective of this work is to study the influence of different doses of nitrogen on the behavior of a potato crop and on changes in nitrogen levels in the plant. This work reveals that vegetative Growth Parameters shows that the analyses of variance indicate a significant difference between increasing nitrogen doses on the aboveground measurement parameters. The effect of nitrogen is positive on the number of stems/plant, number of leaves/plant, and stem length when increasing these doses up to N2 (180 nitrogen units/ha); the N3 dose (270 nitrogen units/ha) appears to have a depressive effect on stem length. The yield Parameters Regarding tuber count, the highest tuber counts were recorded with the N2 treatment (180 nitrogen units/ha) with an average of 10.06 and the tuber diameter, statistical analysis shows a significant effect between the different nitrogen doses. The largest diameter was 7.20 cm, obtained with the N2 doses (180 nitrogen units/ha). The tuber length and the longest tubers were recorded with the N2 treatment (180 nitrogen units/ha) with an average of 12.12 cm. The tuber weight increase was recorded with the N2 doses. The highest tuber weight was 3108.53 g, obtained with the N2 treatment (180 nitrogen units/ha). For yield, the analysis of variance shows a highly significant effect of the different nitrogen fertilization doses. The highest yield was recorded with the N2 dose (180 nitrogen units/ha) at 310.86 qx/ha. The N3 dose (270 nitrogen units/ha) appears to be depressing in the underground part. The Changes in Nitrogen Content in the Plant for the leaves during the different stages of plant development increases with increasing nitrogen doses. The nitrogen content of tubers increases significantly with increasing nitrogen doses. During the crop cycle (vegetative growth, tuberization, and maturity), the

available nitrogen content decreases, likely due to the plant's uptake of this element for tuber development and growth.

Across the Mediterranean and semi-arid agro-ecologies, site-specific, moderate nitrogen application (100–150 kg N/ha) coupled with efficient irrigation (especially drip systems) consistently improves potato yield and quality. However, exceeding these levels may compromise both quality and environmental integrity. Integration of precision fertilization technologies and organic amendments is emerging as a cornerstone for sustainable potato production in water-limited regions.

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