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Research Article

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Effect of Nitrogen Fertilization Levels on the Yield of Groundnut (Ashford Cultivar) under the Conditions of Abyan Delta

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ABSTRACT

This study evaluated the response of groundnut Ashford cultivar, to four nitrogen-fertilization treatments under field conditions in Al-Khamilah, Abyan Governorate, Yemen (Arachis hypogaea L). The experiment was conducted during the 2023–2024 growing season using a Randomized Complete Block Design (RCBD), with four treatments and six blocks, giving a total of 24 experimental units. The treatments consisted of 71.4, 142.8, and 214.2 g of urea per plot, and an unfertilized control. The mean yields for T1, T2, T3, and T4 were 1,970.00, 2,532.83, 3,865.33, and 1,678.67, respectively, in the units recorded in the original dataset. Analysis of variance indicated statistically significant differences among fertilization treatments ($F(3,15) = 1128.478$, $p < 0.001$); the block effect was also significant ($F(5,15) = 3.111$, $p = 0.040$). The reported pairwise comparisons indicated differences among all treatment pairs at the 0.05 significance level. T3 produced the highest mean yield among the tested treatments; however, this result alone does not establish a generally optimal agronomic rate. Residual normality should be assessed before a final conclusion is made about the normality assumption of the ANOVA model.

Keywords: Groundnut, Nitrogen Fertilization Levels, Urea, Crop yield, Abyan Delta

Introduction

Groundnut is an economically and nutritionally important oilseed and leguminous crop. Its seeds are used for food and vegetable-oil production, while crop residues may also be used as animal feed. Crop yield is influenced by several environmental and agronomic factors, including cultivar, soil characteristics, water availability, and crop-management practices (Arachis hypogaea L).

Fertilization is one of the agronomic practices that can affect plant growth and crop productivity. Nitrogen availability is important for plant development; however, the response of groundnut to applied nitrogen may vary with soil properties, environmental conditions, cultivar, and fertilization rate. As a legume, groundnut may also obtain nitrogen through biological nitrogen fixation when suitable conditions are present. Consequently, the effect of additional nitrogen should be evaluated under the specific conditions in which the crop is grown.

Previous studies have examined the effects of nutrient management on groundnut growth and yield components [1]. for example, investigated the effects of iron and nitrogen on yield and yield components, while examined organic and inorganic fertilizers in relation to selected plant characteristics [2]. Such studies provide background for assessing crop responses to fertilization, although differences in experimental sites, cultivars, and treatment rates must be considered when comparing findings.

The present study evaluates differences in groundnut yield among four nitrogen-fertilization treatments under field conditions in the Al-Khamilah area of Abyan Delta, using an RCBD to account for spatial variation among blocks.

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Research Problem, Objective, and Hypotheses

Research problem

The study addresses the need for field-based evidence comparing groundnut yield under different nitrogen-fertilization levels in the study area. The central research question is whether mean crop yield differs significantly among the four fertilization treatments.

Objective

The objective was to evaluate the effect of four urea-based nitrogen-fertilization levels on the yield of groundnut, Ashford cultivar, under the conditions of Abyan Delta, and to determine whether treatment means differ statistically while accounting for block effects.

Hypotheses

Null hypothesis (treatments): The mean yields are equal across the four nitrogen-fertilization treatments.

Alternative hypothesis: At least one treatment mean differs from the others.

The block effect is evaluated separately in the ANOVA model. Blocks are used as a blocking factor and are not the principal treatment factor of interest.

Materials and Methods

Experimental Site and Period

The field experiment was conducted on a farm in the Al-Khamilah area of Abyan Governorate, Yemen, using locally identified Ashford groundnut seed. According to the original manuscript, planting took place on 11 November 2023 and harvesting on 10 April 2024. Flood irrigation was used, and the recorded agronomic operations included gap filling, weeding, and earthing-up during flowering.

Soil physical and chemical characteristics should be reported if they were measured. If no soil analysis was performed, this should be stated explicitly rather than supplying unmeasured values.

Treatments and Experimental Design

The experiment was a single-factor study arranged in a Randomized Complete Block Design (RCBD). The experimental factor was nitrogen fertilization, represented by four treatment levels; the six blocks were included to account for spatial variability. The experiment therefore comprised 4 × 6 = 24 experimental units.

Treatment	Description	Urea rate per plot
T1	Urea fertilization	71.4 g
T2	Urea fertilization	142.8 g
T3	Urea fertilization	214.2 g
T4	Unfertilized control	0 g

Each experimental plot measured 18 m² (6 m × 3 m). Each plot consisted of five rows, each 6 m long, with a plot width of 3 m; the total area of the 24 experimental units was 432 m². Row spacing was 50 cm and within-row plant spacing was 30 cm. Two to three seeds were sown per planting hole at a depth of 3–5 cm, followed by thinning to one plant after emergence, according to the original field record. The random allocation of treatments within each block should be described if the allocation record is available.

Response Variable and Statistical Analysis

The response variable was groundnut yield as recorded for each experimental unit. The data were analyzed in SPSS using an ANOVA model appropriate for an RCBD, including treatment and block effects. Post-hoc comparisons among treatment means were conducted using LSD and Duncan procedures as reported in the original output, at a significance level of 0.05.

The normality of the ANOVA residuals and the homogeneity of variance should be assessed. Normality tests conducted separately for each treatment do not replace assessment of the model residuals. The treatment-specific Shapiro–Wilk results are reported only as supplementary information; the reported p-value for T2 (0.040) is below 0.05.

Results

Recorded Yield Data

Treatment	B1	B2	B3	B4	B5	B6	Total
T1	1918	1998	2061	1888	1968	1987	11820
T2	2411	2592	2614	2565	2422	2593	15197
T3	3822	3859	3980	3717	3941	3873	23192
T4	1664	1738	1641	1511	1720	1798	10072
Block total	9815	10187	10296	9681	10051	10251	60281

Note: The block columns are presented in B1–B6 order for readability. Before publication, the assignment of each observation to its block should be checked against the original field records.

Descriptive Statistics

Treatment	n	Mean	SD	SE	Minimum	Maximum
T1	6	1970.00	61.296	25.024	1888	2061
T2	6	2532.83	91.510	37.359	2411	2614

T3	6	3865.33	92.578	37.795	3717	3980
T4	6	1678.67	99.212	40.503	1511	1798
Overall	24	2511.71	861.587	175.87	1511	3980

T3 had the highest mean yield (3865.33), followed by T2 (2532.83), T1 (1970.00), and the unfertilized control T4 (1678.67). The original manuscript labels the measurements in kilograms; the authors must clarify whether these values represent kilograms per experimental plot or have been converted to a standard area-based yield unit. The means alone do not establish an optimum rate beyond the levels tested.

Normality and Homogeneity of Variance

The Shapiro–Wilk test applied separately to the treatment data gave the following p-values: T1, 0.927; T2, 0.040; T3, 0.883; and T4, 0.774. Thus, only T2 had a p-value below 0.05. These separate tests do not, by themselves, establish whether the ANOVA residuals satisfy the normality assumption; the model residuals should be examined directly.

Treatment	Shapiro–Wilk W	df	p-value
T1	0.975	6	0.927
T2	0.782	6	0.040
T3	0.969	6	0.883
T4	0.954	6	0.774

Levene's test for homogeneity of variance yielded $p = 0.664$, which is greater than 0.05; therefore, the test did not provide sufficient evidence to reject the equal-variance assumption. This result should be interpreted alongside residual plots and the design, and a residual-normality test should be added from the fitted model output before final submission.

Analysis of variance

Source	Type III SS	df	Mean square	F	p-value
Corrected model	16998672.670	8	2124834.083	425.124	<0.001
Fertilization treatment	16920919.460	3	5640306.487	1128.478	<0.001
Blocks	77753.208	5	15550.642	3.111	0.040
Error	74972.292	15	4998.153	—	—
Corrected total	17073644.960	23	—	—	—

ANOVA indicated statistically significant differences among mean yields across nitrogen-fertilization treatments ($F(3,15) = 1128.478$, $p < 0.001$); therefore, the null hypothesis of equal treatment means was rejected. The block effect was also statistically significant ($F(5,15) = 3.111$, $p = 0.040$), indicating variation among blocks that was appropriately accounted for in the model.

The reported coefficient of determination was $R^2 = 0.996$, with an adjusted R^2 of 0.993. This indicates that the fitted model accounted for a high proportion of the observed variation in this experiment; it does not, by itself, prove causality or guarantee that the results generalize to other locations or seasons

Multiple Comparisons

Comparison	Mean difference (first − second)	Reported p-value
T1 − T2	−562.83	<0.001
T1 − T3	−1895.33	<0.001
T1 − T4	291.33	<0.001
T2 − T3	−1332.50	<0.001
T2 − T4	854.17	<0.001
T3 − T4	2186.67	<0.001

According to the LSD output in the original manuscript, all pairwise treatment comparisons were statistically significant at the 0.05 level. Duncan's test placed the four treatments into four separate homogeneous subsets, ordered from the lowest mean (T4), to T1, T2, and the highest mean (T3). These statements should be verified against the original statistical output before publication, and the choice of post-hoc procedure should be justified.

Discussion

The results indicate differences in mean groundnut yield among the four nitrogen-fertilization treatments, with T3 producing the highest mean and the unfertilized control T4 the lowest. This general pattern is consistent with the importance of nutrient management in crop production; however, comparisons with previous studies must account for differences in site, soil, cultivar, fertilization rates, climate, and yield measurement.

A single experiment conducted at one site in one season does not establish T3 as the agronomic optimum under all conditions. Nor should the block effect be interpreted as a direct treatment that increases yield: blocks are included to control spatial variability and improve comparisons among treatments. The significant block effect indicates that variation among blocks contributed to the observed variation.

Important limitations should be acknowledged. The available manuscript does not provide documented soil-analysis results, and the normality tests presented were conducted separately for treatment groups rather than on the model residuals. Residual diagnostics and clarification of the yield units and fertilizer rates on an area basis are therefore needed before broader agronomic recommendations can be made [3-9].

Conclusions

- ANOVA showed statistically significant differences in mean groundnut yield among the nitrogen-fertilization treatments tested.
- T3, which received 214.2 g of urea per experimental plot, had the highest mean yield (3865.33 in the unit recorded in the dataset).
- The unfertilized control T4 had the lowest mean yield (1678.67), while T1 and T2 had mean yields of 1970.00 and 2532.83, respectively.
- The block effect was statistically significant at the 0.05 level, supporting its inclusion in the model under the RCBD.
- The normality assumption for the ANOVA model cannot be concluded from treatment-specific normality tests alone; residual diagnostics are required before making a final statement about this assumption.

Recommendations

- Repeat the experiment across multiple growing seasons and locations to assess the consistency of the crop response to nitrogen fertilization.
- Test additional nitrogen rates and report fertilizer application in standardized units, such as kilograms of urea or nitrogen per hectare, to support practical recommendations.
- Analyze and report soil properties, and document irrigation, rainfall, and relevant crop-management practices.
- Examine the normality of residuals from the RCBD model and assess variance homogeneity, then revise the assumptions section using the actual statistical output.
- Do not recommend T3 as the generally optimal rate until additional experiments and an economic assessment of fertilizer-use efficiency have been conducted.

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