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Analysis of the Performance of Cereal Farms based on Durum Wheat Production Cost Estimates in the Algerian Highlands

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ABSTRACT

Background: Durum wheat is a staple crop in Algeria, primarily used for local consumption and semolina production. Its strategic importance for national food security is particularly evident in the Sétif region, located in northeastern Algeria, which benefits from favorable Mediterranean climatic conditions and arable soils. This study aims to estimate the production costs of durum wheat and assess the profitability of cereal farms, identifying cost drivers and performance differences to propose strategies for improving efficiency and reducing costs.

Methods: The study was conducted at the National Higher School of Agronomy (ENSA), Algiers, during the 2023/2024 agricultural season. Data were collected from a representative sample of durum wheat producers in the Sétif region. A cost-accounting approach was used to estimate production costs, including both fixed and variable expenses. Farms were then classified into performance groups based on cost-efficiency indicators. Statistical tools such as analysis of variance and Pearson correlation were used to identify key determinants of cost variation and farm performance.

Result: The findings revealed significant disparities in production costs among farms. Labor, mechanization and fertilizer use were the most significant cost components. Farms with higher technical efficiency and optimized input use exhibited lower costs and better profitability. Access to extension services and superior soil quality also contributed to higher productivity.

Key words: Durum wheat, Food security, Production costs, Profitability.

INTRODUCTION

In Algeria, cereal production plays a major role in agriculture and is mostly conducted under rainfed conditions, resulting in yields highly dependent on rainfall variability (Tabet-Aoul, 2008; Chabane and Boussard, 2012; Benmehaia, Merniz and Oulmane, 2020). Challenges such as inadequate technical practices, weak mechanization and insufficient application of intensification inputs further constrain productivity (ITGC, 2010).

Since the colonial era, cereal cultivation has occupied between 2.4 and 3.2 million hectares, representing 28% to 40% of the Utilized Agricultural Area (UAA). Durum wheat remains the dominant crop (average of 1.27 million ha), followed by barley (800,000 ha), soft wheat (less than 500,000 ha) and oats (around 80,000 ha on average). Average annual cereal production since independence has ranged between 2.6 and 3.3 million tons, occasionally exceeding this range in favorable years (*e.g.*, 5.6 million tons in 2019). Yield improvements have been modest, increasing from under 10 q/ha in the 1960s-70s to an average of 15 q/ha in recent decades (Bekkis and Benmehaia, 2023).

Also, the consumption needs of a growing population are less and less covered by national production. This wheat consumption has increased slightly in recent years due to increased urbanization, population growth and increased milling capacity, but is expected to remain more or less stagnant (Hales and Rush, 2016).

According to the FAO, during the year 2014, Algeria was ranked fourth in Africa and seventeenth in the world with a wheat production of 2.4 million tons, collected and made up, on average, of 58.7% durum wheat and 33% soft wheat (FAO, 2014).

On the world market, Algeria still remains one of the major importers of cereals (particularly durum and soft wheat) due to the weak capacity of the national sector to meet the growing consumption needs of the population (Ammar, 2014).

Wheat imports increased 10-fold in Algeria between 1966-69 (698,500 tons) and 2000-2005 (6,796,000 tons), to around 8 million tons in 2010-2015. In fact, Algeria is one of the largest cereal-consuming countries in the world and is therefore one of the largest wheat importing countries in the world. Since the mid-2000s, it has been

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part of a small circle of 6 countries whose imports are more than 5 million tonnes/year. It is the world's third-largest importer of soft wheat and the world's largest importer of durum wheat (50% of world trade) (Bessaoud *et al.,* 2019).

The production deficit is made up by imports, whose bill for cereal products reached 2.71$ billion in 2019 against 3$ billion in 2018 according to the CNIS.

France remains the main supplier of wheat to Algeria, accounting for 54% of imports in 2015, mainly soft wheat. Durum wheat is imported from Canada, Mexico and the United States (Hales and Rush, 2016).

Since independence, the Algerian state has adopted the principle of supporting strategic sectors such as wheat, upstream and downstream. It is for this reason that the government has undertaken multiple agricultural public policies in agriculture towards the cereal sector, especially since the 2000s, PNDA/PNDAR (2000-2008), the PRAR policy (2008-2016), the Filaha plan (2016-2019) and currently the roadmap (2020-2024), through the implementation of trade control and market intervention measures (border measures and market price controls, for example) that create price incentives or disincentives, subsidies to producers and consumers (FAO, 2022).

The examination of the finance laws from 2000 to 2015 makes it possible to identify the multiple support funds dedicated to supporting land development, the use of agricultural inputs and equipment, agricultural production and processing (in particular cereals and milk), the regulation of consumer products, *etc*. and finally support for the consumption of basic food products (bread, milk, pulses, oils and sugar) (Bessaoud *et al.,* 2019).

The intensification of cereals has always been one of the main objectives of Algeria's agricultural policy. However, increasing wheat production by improving yields per hectare in order to meet the needs of the population and thus ensure the country's food security is an objective that has not yet been achieved.

The calculation of crop production costs is becoming a necessity for the farmer because it is a tool for managing his farm. Mastering this calculation allows him to determine his break-even point but also to quantify his margins for progress, to adapt his production methods and to anticipate the strategic choices of the farm. Indeed, knowledge of production costs provides information on the sensitivity of different production systems to changes in agricultural policy.

The United Kingdom has the earliest determination of farm income and production costs by product. The first steps towards a systematic study of the management of agricultural enterprises were begun in 1920 by the universities, based on data collected on farms. In the mid-1930s, the calculation of production costs became necessary in view of the need to regulate the prices of products by government measures and therefore to assess the real situation by production. (Denis CAMARET, Hervé STUM, Michael MURPHY, Asmus PETERSEN, 1990).

This study focuses on the case of the durum wheat sector, which is the basis of the diet of a large part of Algerians. The objective of the latter is to identify and analyze the factors explaining the formation of production costs of a quintal of durum wheat per hectare in cereal farms in the wilaya of Setif, in order to verify whether cereal farmers are efficient, underperforming or inefficient, among other things is that they manage to cover their expenses and make profits. To do this, in a first phase, we proceeded to determine the most important costs (fixed costs and variable costs) that enter into the formation of production costs, then to see their impact on yields and to calculate profitability.

MATERIALS AND METHODS

This study was conducted at the National Higher School of Agronomy (ENSA), Algiers, during the 2023–2024 agricultural season (June 2023 to August 2024).

Study area, farm sampling and data collection

The region of Sétif, located in the Algerian highlands, was selected due to its historical role and high potential in cereal production. Known for producing high-quality durum wheat varieties such as "Guemh El Beliouni" and "Mohamed Ben Bachir", Sétif ranks among the top five cereal-producing wilayas in Algeria. In 2016, it recorded a production of 2,236,646 quintals out of a national total of 44,922,665 quintals (DSA Sétif, 2017).

Given the large number of cereal farms 15,444 (DSA Sétif, 2018),we employed a purposive sampling strategy. The sample was designed to reflect the diversity of agroecological zones across the wilaya. Selection criteria included farmers' willingness to participate, especially those able to provide accurate financial data. The farms selected were representative of the dominant durum wheat production system, with a majority of the farmer's income derived from this crop.

Fig 1 presents the geographical distribution of surveyed farms across the three main bioclimatic zones of Sétif.

Survey design and cost calculation approach

The methodological approach is based on the analysis of data from surveys of cereal holdings in order to collect a certain amount of information of a structural, technical, economic and social nature. For the determination of the cost of production of a product, two methods can be developed: the reconstructed cost method and the observed cost method.

The calculation of production costs, in our case, is done according to the approach of the cost recorded at the end of a production cycle, on the basis of the elements actually paid and collected and thanks to an allocation of expenses. The calculation makes it possible to establish a cost of production (Camaret *et al*., 1990).

This approach is supported by recent studies conducted in similar agroecological conditions in Algeria, which highlight the impact of tillage practices and rotations on wheat productivity and cost control (Chouter *et al*., 2022; Sebbane *et al*., 2021).

This method therefore requires:

- A sample of real farms;
- Accurate and real information on the accounts of these holdings;
- A "generator", *i.e.* a distribution and calculation system for extracting the loads related to the crop studied.

Our study of durum wheat production costs in the Setif region was carried out through the following steps:

a. Data collection

Characteristics of farms

Size of farms (hectares planted), type of farm (family, semi-mechanized, mechanized) and geographical location.

Direct and indirect costs

Direct costs include expenses related to the purchase of seeds, fertilizers, plant protection products, as well as labor. Indirect costs include depreciation of agricultural equipment and infrastructure maintenance costs.

Yield

we measured the yield in quintals per hectare, as this directly affects the unit cost of production.

b. Cost analysis

Cost analysis is divided into several categories.

Fixed costs

These costs are independent of the quantity produced, such as permanent wages, depreciation, insurance, *etc.*

Variable costs

These are directly related to the volume of production, such as seeds, inputs (fertilizers, crop protection products), fuel and seasonal labor.

To determine the estimated costs of production for a quintal of durum wheat, we calculated the following.

Depreciation

For the purpose of calculating depreciation, the following was considered:

- The depreciation period which corresponds to the period of use allowed in Algerian taxation (5 years for agricultural equipment and transport equipment, 20 years for a farm building).
- The year of acquisition or realization of the property.
- The method used is straight-line depreciation, which consists of dividing the purchase or realization price over the useful life (a constant amount over time).

Labour prices

The labour required on cereal farms comes from the family and the employees (permanent or seasonal).

The remuneration of the seasonal labour is obtained through the declarations of the operators.

For the unpaid family labour, it was estimated according to the most practiced value in the study area, which is 1500 DA per day. The number of days of intervention of the family labour is obtained according to the declarations of the cereal farmers.

For the cost of the labour dedicated to tillage, sowing, fertilisation, treatment and harvesting, the charge obtained through the farmers' declarations.

The rental value of the land

The determination of the rent value (the rental value of the land) has been determined in accordance with the regulations in force (Law No. 21-16 of 30 December 2021 on the Finance Act for 2022), which identifies a value according to the irrigated or dry areas and systems.

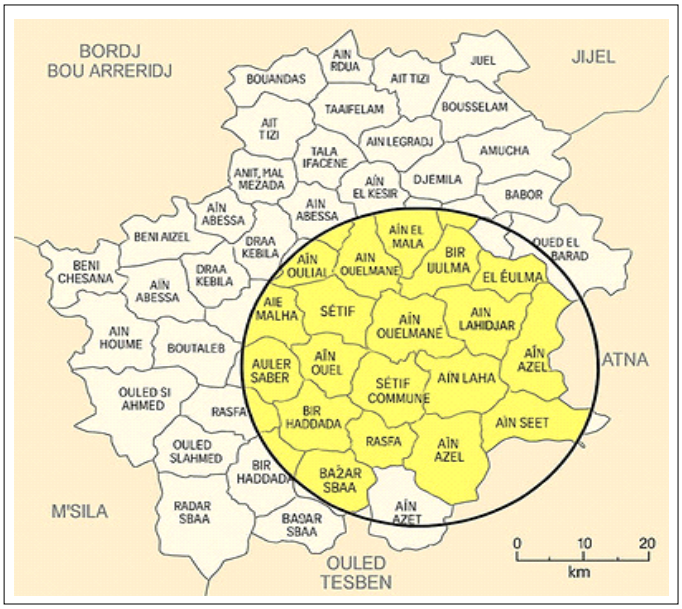


Fig 1: Geographical map of the distribution of surveys according to the three bioclimatic zones of the Wilaya.

The rental value used in our study is set at 5000 DA per hectare per year.

Fixed costs

In the case of pluriactive holdings, the calculation of fixed costs takes into account the share of the income from durum wheat for consumption in the total income of the agricultural holding in order to allocate the costs jointly at all stages.

Turnover

Its calculation is based on sales of durum wheat for consumption.

Conducting the survey

For the realization of our surveys, we chose the period between June and August 2024.

It was a socio-economic survey that we carried out among farmers on the basis of a questionnaire structured around the following themes:

Agricultural speculations practiced and their technical conduct;

The financing of operations (operating and investment) and access to State subsidies;

The data collected on these themes made it possible to identify the relationship between the farmer and his environment.

Data analysis and processing tools

The sample studied, which is 52 cereal farms, with the many questions asked of each, results in the collection of a large mass of data that has been entered and subjected to statistical analysis.

The statistical processing and management of the survey database were carried out by the SPHINX software and EXCEL.

RESULTS AND DISCUSSION

Structural features

The cereal farms studied have a total area of 2294 hectares (ha), with an average area sown to 22 ha. The smallest area sown is 3 ha and the largest is 120 ha. 31% of farms are EAIs, 29% are EACs and 29% are private. As for the age of cereal farmers, it is on average 53 years old, with a minimum age of 23 years old and a maximum age of 87 years old.

The classification of the 52 cereal farms based on the sown area revealed three distinct categories:

Small farms (<10 ha)

9 farms, representing 17.3% of the total sample. These units are generally family-run and operate with limited mechanization and input use.

Medium farms (10-50 ha)

38 farms, representing 73.1%, form the majority. They reflect a transitional model, often semi-mechanized and more open to improved practices.

Large farms (>50 ha)

Only 5 farms, or 9.6%, fall into this category. These tend to be more capital-intensive, well-structured and capable of implementing efficient technologies.

This structural diversity illustrates the heterogeneity of cereal farming in the region and helps explain the performance gaps observed between farm types.

Wheat cultivation (Fig 2, Fig 3)

Previous work has shown that appropriate tillage systems and crop rotations improve productivity and economic performance in semi-arid regions (Chouter *et al*., 2022).

Economic performance of cereal farms

Importance of the categories of expenses (Fig 4)

The differences observed in production costs and yields between farm types may be partly explained by variations in tillage systems and crop rotation strategies, which are known to influence technical and economic performance (Chouter *et al*., 2022).

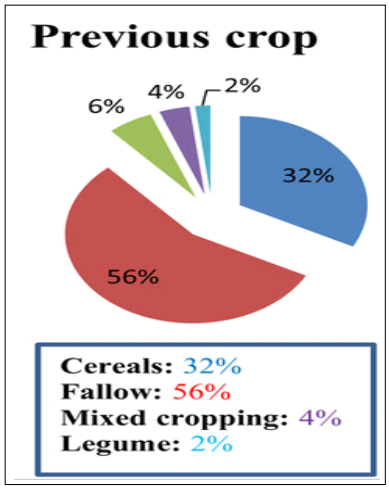


Fig 2: Representation of the applied crop precedent.

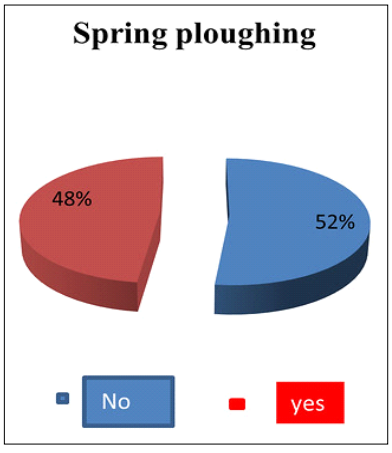


Fig 3: Representation of spring ploughing practices.

For the performance study

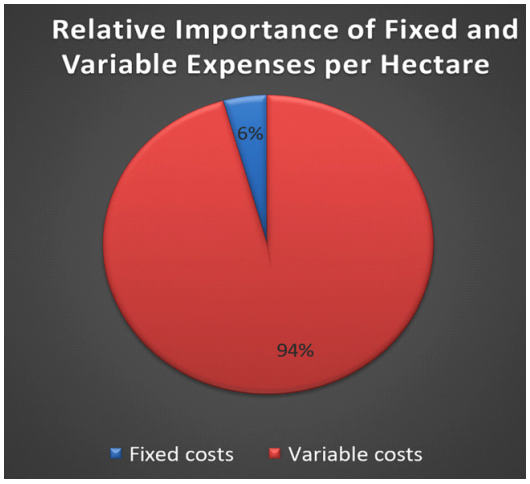
We used the gross margin/variable costs ratio, which is a financial indicator that measures the profitability of a farm:
Gross margin = Turnover-cost of goods or cost of sales.
Total expenses = Sum of operating expenses excluding interest and taxes.
This indicator allowed us to identify three groups:

The first group

Composed of 13 cereal farms, the gross margin/cost ratio is negative, they are non-efficient farms and have a problem in cost management (production cost is higher than the cost of production), their average yield is 23 q/ha.

The second group

Composed of 14 cereal farms, the performance index is between 0.05 and 0.8, they are efficient farms and cereal farmers manage to cover their costs and make profits. Their average yield is 18 q/ha.



This pie chart illustrates the proportional distribution of total production costs per hectare in cereal farms. Variable costs (in red), such as seeds, fertilizers, fuel and seasonal labor, account for the vast majority of total expenses (94%), while fixed costs (in blue), including depreciation, rent and permanent wages, represent only 6%. This highlights the dominant role of variable inputs in durum wheat production costs in the Sétif region.

Fig 4: Relative importance of fixed and variable expenses per hectare.

The third group

Made up of 25 cereal farms, the performance index is between 1 and 5, they are very efficient farms.

The analysis reveals that high-performing farms (Group 3) are generally better mechanized, benefit from more frequent access to state subsidies and apply more intensive and structured cropping techniques. In contrast, low-performing farms (Group 1) tend to rely on outdated methods and lack financial planning and technical support.

The classification highlights clear contrasts between performance groups. High-performing farms typically combine larger cultivated areas with higher yields, leading to significantly better profit margins (Table 1).

Medium performers represent the majority and show acceptable economic viability without outstanding efficiency.

Low-performing farms, on the other hand, suffer from both low yields and unfavorable cost structures, resulting in negative or marginal profitability.

This segmentation provides useful insights into the diversity of farm strategies and supports targeted policy or technical interventions.

To explore the relationships between economic performance, yield and cultivated area, pearson correlation coefficients were calculated among the following variables: the gross margin-to-variable costs ratio, yield (in quintals per hectare) and cultivated area (in hectares) (Table 2).

The results reveal moderate, positive correlations between key variables (Table 1). The gross margin ratio is moderately correlated with yield (r = 0.27) and cultivated area (r = 0.26), suggesting that farms achieving higher productivity or operating on larger surfaces tend to perform better economically. However, these relationships are not strong, indicating that yield and size are not the sole determinants of profitability.

Furthermore, a correlation of r = 0.30 was observed between yield and cultivated area, implying that larger farms may have slightly better yields, potentially due to improved access to inputs, mechanization, or economies of scale.

Table 1: Classification of farms according to economic performance.

Performance group	Classification criteria	Number of farms	Average margin	Average yield (q/ha)	Average area (ha)
Low	Margin ratio < 0.5	10	-0.2	15	12
Medium	0.5 ≤ Margin ratio ≤ 2	25	1.2	23	18
High	Margin ratio > 2	17	3.2	30	35

This table classifies the 52 surveyed cereal farms into three performance groups based on the gross margin-to-variable cost ratio. Farms with a ratio below 0.5 are considered low-performing, those between 0.5 and 2 are moderately efficient and those above 2 are classified as high-performing. The table also provides average values for gross margin, wheat yield (in quintals per hectare) and cultivated area (in hectares) for each group.

Table 2: Pearson correlation coefficients between economic and structural variables.

Variables	Correlation coefficient (r)
Gross margin ratio vs yield (q/ha)	+0.27
Gross margin ratio vs cultivated area (ha)	+0.26
Yield (q/ha) vs cultivated area (ha)	+0.30

This table presents the Pearson correlation coefficients calculated between three key variables: the gross margin-to-variable cost ratio (economic performance), wheat yield (in quintals per hectare) and cultivated area (in hectares). The results indicate moderate positive correlations, suggesting that both higher yields and larger farm sizes are moderately associated with improved economic performance.

These findings highlight the multi factorial nature of farm performance, where both technical and structural factors interact. However, as the coefficients remain moderate, additional explanatory variables (*e.g.*, management practices, input use intensity, climatic conditions) should be considered in further analysis.

Note: All correlation coefficients are based on Pearson's method.

The analysis of relationships between various characteristics of cereal farms and their economic performance reveals several meaningful trends.

Farm size and profitability

Larger farms tend to achieve better economic results. This can be explained by economies of scale: costs are spread more efficiently, equipment is generally more productive and management practices are more structured. These farms also tend to have better access to mechanization and external resources.

Yield and gross margin

Unsurprisingly, higher yields lead to increased gross margins. This confirms that productivity is a key lever for improving profitability. However, this relationship depends on cost control: producing more is only profitable if costs do not rise disproportionately.

Variable costs and gross margin

The relationship between input spending (*e.g.*, fertilizers, seeds) and economic outcomes is not always linear. Up to a point, investing more can increase margins, but beyond that, if expenses are not well managed or do not lead to higher yields, they may reduce overall profitability.

Cost management and economic efficiency

Farms that manage their variable costs efficiently tend to display stronger economic indicators. Input optimization, rather than simply increasing inputs, appears to be a critical factor for performance.

Legal status and economic outcomes

The legal structure of a farm also plays a role. Private farms, often more flexible and autonomous in their management, tend to perform better than collective (EAC) or public individual (EAI) farms. Their responsiveness to technical and economic challenges gives them a competitive advantage.

CONCLUSION

The present study has made it possible to estimate the production costs of a quintal of durum wheat in the Setif region and its cost price which shows the profitability of this production. The results brought out 3 groups: the first group: composed of 13 cereal farms, the gross margin/cost ratio is negative, they are non-performing farms and have a problem in cost management (production cost is higher than the cost cost), their average yield is 23 q/ha, the second group which is made up of 14 cereal farms with a performance index of between 0.05 and 0.8, it is efficient farms that manage to cover their costs and make profits. Their average yield is 18 q/ha. The third group: made up of 25 cereal farms, the performance index is between 1 and 5, they are very efficient farms.

Field surveys have shown that the main constraints of wheat intensification in the Setif region are first and foremost the supply of seeds and their high cost, as well as the costs of fertilizers and weed killers. The majority of cereal farmers do not sufficiently master production techniques related to tillage, seedbed improvement and fertilizer rates are applied approximately. Chemical weeding is ignored completely.

Proper management of farm resources, logistics and organisation (management of production costs, sowing planning, harvesting and sales) is essential to maximise profits.

The correlation analysis revealed that farm profitability is influenced by both technical and structural factors. Yield and farm size were positively associated with economic efficiency, while excessive variable costs could hinder performance. Legal structure also played a role, with private farms tending to outperform collective units in terms of flexibility and input use efficiency.

Through our study we also made the following recommendations:

Cost optimization

Reduce fixed and variable costs, by reducing input consumption and improving yields.

Improved productivity

Through the diversification of agricultural practices and the adoption of innovative technologies.

Strengthening training and support

Grain farmers will benefit from better cost management through training on best agricultural practices and financial management.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily reflect the official positions of their affiliated institutions. The authors bear full responsibility for the accuracy and completeness of the content and disclaim any liability for consequences arising from its use or interpretation.

Conflict of interest

The authors declare that there are no conflicts of interest related to the publication of this article. No external influence affected the design, data collection, analysis, interpretation, or writing of the manuscript.

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