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Full Length Article

Assessment of the Agronomic Performance of Newly Introduced Rice Varieties in Morocco

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Abstract

This study assesses the agronomic performance of rice varieties introduced in Morocco using a randomized complete block design (RCBD) with three replications at the irrigated site of Sidi Allal Tazi Experimental Domain. Thirty-three Kafaci rice lines, selected from 100 introduced by the Africa Rice Center in Saint-Louis, Senegal, underwent comprehensive evaluation for agro-morphological parameters and yield potentials. The objective is to evaluate and categorize newly introduced rice varieties in Morocco based on their agronomic performance, employing statistical tools such as hierarchical cluster analysis (HCA) and principal component analysis (PCA) to identify distinct groups suitable for local cultivation. The HCA and PCA classified rice accessions into three classes based on their agronomic performances. Class 1 (KF20005, KF190112, KF20034, KF20059, KF190061) showed relatively lower performance, suggesting potential adaptation to environments requiring less biomass. Class 2 (KF190136, KF190006, KF20058, KF20019, KF190065, KF190022) demonstrated high potential in grain weight and seed production, particularly suited for climates with limited growing seasons. Class 3 (KF20017, KF20018, KF190114, KF20046, KF20006, KF20013), characterized by slower maturation and higher biomass production, is suitable for systems emphasizing biomass utilization. Additionally, PCA identified four quadrants based on similar agronomic characteristics: Top Right Quadrant (KF190063, KF190065, KF18045, KF20006, KF20046) characterized by high yields and resistance; Top Left Quadrant (Lagostino, KF20005, KF190136) with specific traits such as tiller number and sowing-heading cycle; Bottom Left Quadrant (KF20034, KF20059, KF190061) indicating areas needing significant improvement; Bottom Right Quadrant (KF20013, KF20017, KF20018, KF190114) targeted for specific breeding or improvement programs. This research provides insights into future selection and genetic improvement efforts to enhance food security and economic sustainability in the region.

Keywords: Rice; Agro-morphological; High yield; HCA; principal component analysis (PCA); Morocco

Introduction

Rice (*Oryza sativa* L.) stands as a crucial cereal crop, serving as a staple food for more than half of the world's population, thereby driving substantial agricultural and industrial activities (Mohidem *et al.* 2022). Its cultivation, processing, and global distribution sustain the livelihoods of 140 million people and play a pivotal role in national and international trade, underscoring rice's integral contribution to economic development and global food security (Muthayya *et al.* 2014; Mohidem *et al.* 2022).

In Morocco, rice cultivation is significant, contributing to agricultural diversity and economic stability. The introduction of new rice varieties presents an opportunity to enhance productivity and sustainability in this essential sector. Technologically, rice cultivation has experienced a dynamic surge, enabling domestic production to fulfill over 72% of the country's consumption needs. While concentrated in the Gharb and Loukkos regions, particularly Larache, successful rice production in Morocco heavily relies on efficient irrigation practices. Projections for the upcoming 2023–24 season indicate a stable harvested area of around 8,250 hectares, with an expected production of 45,000 metric tons, reflecting a notable increase of 7.1%

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from the previous year. This growth is primarily attributed to favorable weather conditions, as the United States Department of Agriculture reported in 2023.

The varietal profile used in the rice sector in Morocco is a little diversified and concerns both round rice varieties and medium and long rice varieties. All Moroccan rice farmers use selected seeds imported from abroad, despite the existence of 17 varieties of Moroccan origin selected at National Institute of Agronomic Research (INRA) between 1987 and 2001. The return to these Moroccan varieties and diversification through developing new national varieties is essential. It will help develop a diverse national genetic heritage to meet farmers' needs and make production costs profitable by reducing foreign seed imports and exchange outflows (Elwahab *et al.* 2024).

Agronomic performance evaluation of newly introduced rice varieties is essential for understanding their adaptability to Moroccan agro-ecological conditions. This includes assessing their resistance to biotic and abiotic stresses, yield potential, grain quality, and maturation cycle. Given the challenges of climate change and resource limitations, selecting varieties that are not only high-yielding but also efficient in water and nutrient use is critical for sustainable rice production in Morocco (Elwahab *et al.* 2023).

The objective of this study is to assess the agronomic performance of newly introduced rice varieties in Morocco. Specifically, the study aims to evaluate 33 Kafaci rice lines recently introduced from the Africa Rice Center in Saint-Louis, Senegal. These varieties were selected based on their potential to adapt to diverse agro-climatic conditions within Morocco, with a focus on improving yield, quality, and resilience to environmental stresses. By categorizing these varieties into distinct groups and identifying agronomic patterns through advanced statistical analyses, this study seeks to provide insights that can inform targeted breeding and selection strategies. Ultimately, this research aims to optimize local cultivation practices, contribute to food security, and foster sustainable agricultural development in Morocco. This study not only contributes to scientific knowledge but also supports practical initiatives aimed at achieving sustainable food production and economic growth in the region.

Materials and Methods

Location of the study area

The study area encompasses the Gharb Plain, which extends along the Atlantic coast between latitudes 34° and 34° 45' N. It covers a vast hydrogeographic region spanning 7,500 square kilometres. The Gharb plain is famous for the diversity of its soils. Starting from Oued Sebou and moving inwards, we encounter the soils of Dehs, Shots and Merjas, each characterized by its own characteristics. The research focuses specifically on the Sidi Allal Tazi region, located about 57 kilometres from Kenitra, as illustrated in Fig. 1. In this region, rice cultivation is practiced on grey alluvial soils. These soils are mainly clayey, typically low in humus, deficient in phosphoric acid and often low in nitrogen. They have a slightly alkaline pH. The climate of this region is Mediterranean and offers important water resources from the Sebou River, its tributaries, the Merjas and groundwater.

Plant material

The plant material included 33 carefully selected accessions for the Sidi Allal Tazi experimental field. Among these, the KAFACI (Korea-Africa Food and Agriculture Cooperation Initiative) lines were chosen from a set of 100 lines introduced by the Rice Center for Africa in Saint-Louis, Senegal. Selection was made taking into account yield, specific plant characteristics, early maturity, reduced plant size and overall performance (Table 1).

Methodology

All tests scheduled for 2022 were conducted at the Sidi Allal Tazi experimental station (34°31'14.758 "N latitude 6°14'34.169 "W longitude). KAFACI lines were received from the Africa Rice Centre. They are selected from the previous season’s trials at the Africa Rice Centre in Saint Louis, Senegal, in November 2021 (Table 1). Selection is based on yield and components, early maturity, dwarf plant and overall performance. Mechanical soil preparation consisted of deep grinding followed by coating and tracing of seed lines. The showing was done on May 31, 2022. The plot size for each row is a 5 m long row with 25 plants. The plots are separated by 0.3 m. The KAFACI lines used in this experiment were selected from the previous year’s OYT test (Fig. 2). A three-replicate RCBD plan is used, the plot size is five rows 4 m long with 0.2 m spacing between rows and 0.2 m between plants (5 X 4 X 0. 2 m), resulting in a total area of 4 m2 and 100 plants. For the OYT and RYT tests, sowing was carried out in the nursery on 31 May 2022 and replanted on 7 July 2022 for OYT and 4 July 2022 for RYT.

On 18 May, 400 KG TPN/ha of 10-30-10 was applied as base fertilizer; on 7 July, 125 kg N/ha of urea (46 percent) was applied; and on 26 July, 125 kg N/ha of urea (46%) was applied. Chemical weeding was carried out twice: once on June 24 at a rate of 1 L/ha with Rainbow, and once on September 11 with Agroxone water. During the trials, weeding was done manually on occasion. On July 19 and August 9, insecticide and fungal treatments were applied.

Data collected

Data were collected from three randomly selected plants in the middle of each plot at the physiological maturity stage of rice. The data collected included the following parameters observed included plant height (cm), panicle length (cm),

Table 1: List of 33 rice varieties used

Access. No	Serial	Entry n°	Pedigree
1	KF190136	2019WS/9230343	HR32057F1-4-4-1-1-5-1
2	KF190006	2019WS/9210008	KR55-2-4
3	KF20005	2020WS/20210008	HR32058F1-1-10-1-4-1-1
4	KF190112	2019WS/9230259	HR32054F1-2-17-1-1-3-3
5	KF20017	2020WS/20220007	KR55-2-1-1-2-1
6	KF20018	2020WS/20220008	KR55-2-3-4-1-1
7	KF190114	2019WS/9230265	HR32054F1-2-17-1-1-5-1-2
8	KF20036	2020WS/20270275	Ohselfed-1-4-2-3
9	KF20058	2020WS/20120139	HR32058F1-4-18-1-2-3-3
10	KF20045	2020WS/20120083	HR32051F1-3-11-1-5-4-2
11	KF20046	2020WS/20120007	HR32054F1-2-17-1-1-5-1-2
12	KF20006	2020WS/20210013	HR32058F1-4-18-1-3-1-1
13	KF20013	2020WS/20220029	HR32056F1-4-14-1-4-2-2
14	KF20034	2020WS/20270262	ARS1960-5-1-1-2
15	KF20059	2020WS/20120106	HR32058F1-4-18-1-5-1-2
16	KF190018	2019WS/9210033	SR35266-2-11-4-1-1
17	KF20019	2020WS/20220009	KR55-2-3-4-1-2
18	KF190061	2019WS/9220061	SR35266-HB3580-110
19	KF20035	20270273	Ohselfed-1-4-2-1
20	KF18045	2018WS/8220057	SR35357F1-1-3-4-1
21	KF18046	2018WS/8220058	SR35357F1-1-3-4-1
22	KaWS 9294292	2019ws	
23	KF18044	2018WS/8220056	SR35357F1-1-3-4-1
24	CB MS11	2019ws	
25	KF190063	2019WS/9220065	SR35285-HB3573-48
26	KF190026	2019WS/9210046	ARS1974-5-2
27	KF190051	2019WS/9220038	SR34574-HB3565-285
28	KF190027	2019WS/9210047	ARS1974-5-3
29	KF190052	2019WS/9220039	SR34574-HB3565-290
30	KF190064	2019WS/9220066	SR35285-HB3573-72
31	KF190065	2019WS/9220067	SR35285-HB3573-75
32	KF190022	2019WS/9210037	SR34045-HB3487-11-1-1
33	KF190066	2019WS/9220069	SR34567-HB3573-113

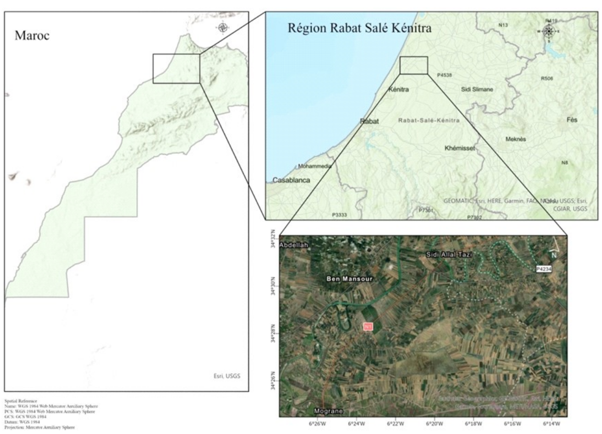

Fig. 1: Geographic map of study area

number of tillers per plant (NTp), number of panicles per plant (NPp), 50% Seedling-Harvest Cycle (CSE), 80% seed-to-maturity cycle (SMC) and 1000-grain weight (PMG). In addition to these measurements, we also assessed the quantity of seeds and straw in kilograms.

Statistical analysis

In this study, we applied several statistical methods to analyze the agronomic characteristics of 33 rice accessions. Analyses were carried out using R Studio

Fig. 2: Planting and sowing of Kafaci rice lines in 2022

software (version 4.4.0) and included hierarchical ascending classification (HAC) and principal component analysis (PCA).

The HAC was used to group accessions according to their agro-morphological similarities. This classification method enables a hierarchy of groups to be constructed, starting with each individual accession and building up to larger and larger groups based on their similarities. The HAC has helped to visualize the structuring of rice accessions and to identify homogeneous groups of varieties with similar characteristics.

The PCA was developed to reduce the dimensionality of the data while retaining the maximum possible variance. This statistical technique transforms the original variables into a new set of variables (the principal components), which are linear combinations of the initial variables. PCA enabled us to identify the main components explaining the variation observed among the rice accessions. It provided a clear visualization of relationships between variables and helped to understand the main traits that differentiate accessions.

Results

In our study, we carried out an analysis of the agronomic characteristics of different rice accessions using hierarchical ascending classification (HAC) and principal component analysis (PCA). HAC enabled us to group accessions according to their agro-morphological similarities, while PCA helped us identify the main components explaining the variation observed among accessions. Together, these analyses provide us with valuable information for the selection and crossing of rice varieties. The results highlight the most promising accessions for the development of new varieties adapted to the specific conditions of Morocco, thus contributing to improved yields and seed quality.

Hierarchical ascending classification (HAC) of different rice accessions

The agronomic characteristics of the different rice accessions were analyzed using hierarchical ascending classification (HAC). This method groups accessions according to the similarity of their agronomic characteristics. The resulting dendrogram (Fig. 3) highlights three distinct classes, each presenting specific agronomic traits.

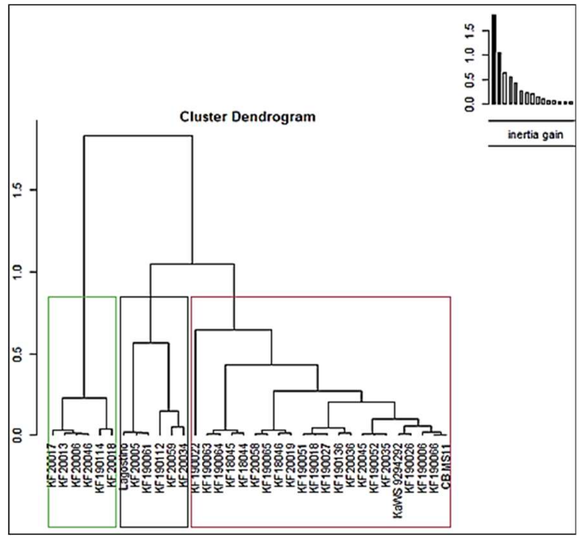

Fig. 3: Hierarchical classification of different rice accessions based on agro morphological parameters

Classification of the individuals reveals 3 classes

Class 1 includes accessions KF20005, KF190112, KF20034, KF20059, KF190061 and Lagostino. This group is characterized by relatively low values for the following variables: Seeds (kg), Panicle length (LP, cm); Number of tillers per plant (NTP) Number of panicles per plant (NPP), Straw (kg) These accessions therefore show the lowest performance for these agronomic characteristics, which could indicate accessions that are less productive or adapted to specific environments requiring less biomass.

Class 2 is made up of accessions KF190136, KF190006, KF20058, KF20019, KF190065 and KF190022. This group is characterized by: High values for 1,000 Grain Weight (GW), Panicle Length (PL, cm) and Seeds (kg) and Low values for 80% sowing-maturity cycle (SMC).

These accessions show good potential in terms of grain weight and seed production, but they ripen more quickly, which can be advantageous in climates where the growing season is limited.

Class 3 includes accessions KF20017, KF20018, KF190114, KF20046, KF20006 and KF20013. The characteristics of this group are:

High values for Sowing-Maturity Cycle at 80% (SMC), Number of tillers per plant (NTP), Number of panicles per plant (NPP) and straw (kg). And low values for weight per 1000 grains (PMG). These accessions are characterized by slower ripening and high biomass production, but with a lower grain weight. They could be advantageous in cropping systems where biomass is also valorized (for fodder or compost, for example).

Analysis of the HAC of the different rice accessions, shown in the dendrogram (Fig. 3), reveals several distinct groups. Each of these groups shows significant similarities in the agronomic traits of the accessions, which can be exploited for varietal improvement and crop selection.

Analysis of formed groups

The dendrogram shows several distinct groups of rice accessions. Each group reflects a certain homogeneity in terms of agronomic characteristics, suggesting that accessions within the same group share similar traits.

Group 1: Medium-height, high-yield accessions: This group includes accessions such as KF190136 and KF20058, which have moderate plant heights, a relatively high number of tillers per plant (NTp) and number of panicles per plant (NPp), as well as a good 1000-grain weight (PMG). Agronomic characteristics: Plant height is average, around 110-114 cm. The number of tillers per plant is moderate to high, around 26 to 30. The number of panicles per plant is moderate, around 21–29. The weight of 1,000 grains is good, around 23–27 g.

Group 2: Fast-growth and mid-size accessions: Accessions such as KF20018 and KF190114 are characterized by intermediate height and rapid ripening cycles. They also show moderate to high numbers of tillers and panicles. The agronomic characteristics of this group of varieties, including accessions such as KF190136 and KF20058, stand out for their intermediate plant height, fluctuating around 112-114 cm. They also have a high number of tillers per plant, generally around 35, and a high number of panicles per plant, varying around 30-34. As for the weight of 1,000 grains, it's in the moderate to high range, weighing around 17–19 g. These combined characteristics make these varieties promising options for growers seeking to optimize yield while maintaining high quality standards. Accessions in this group are adapted to short growing cycles, making them ideal for regions with limited growing seasons or for off-season cultivation. The combination of intermediate height and a good number of panicles can contribute to efficient field management and optimized yield.

Groupe 3: Accession à faible hauteur et maturation longue: This group includes accessions such as KF20046 and CB MS11, which are shorter in height but show longer ripening cycles. The agronomic characteristics of this group of varieties are characterized by a relatively low plant height, around 92-100 cm. They also have a moderate number of tillers per plant, around 26-30 and a moderate number of panicles per plant, around 24-25. As for the weight of 1,000 grains, it's in the moderate range, weighing around 18-24 g. These combined characteristics make them suitable for certain growing conditions, offering interesting potential for growers looking for options corresponding to these specific criteria. These accessions are ideal for conditions where plant height management is crucial, such as regions prone to strong winds or growing systems requiring shorter plants for mechanization. Longer ripening times enable us to take advantage of extended growing seasons, maximizing yield potential. The groups identified by the dendrogram provide valuable information for varietal selection in rice breeding programs. Each group has specific traits that can be exploited to meet particular agronomic needs, such as plant height management, yield optimization and adaptation to regional growth cycles. This hierarchical classification and interpretation of groups reinforces the importance of genetic diversity in breeding programs, enabling the development of resilient, high-performance rice varieties adapted to different environmental conditions and agricultural requirements. These results can be effectively integrated into your thesis manuscript, highlighting the value of advanced statistical analysis in guiding crop improvement decisions.

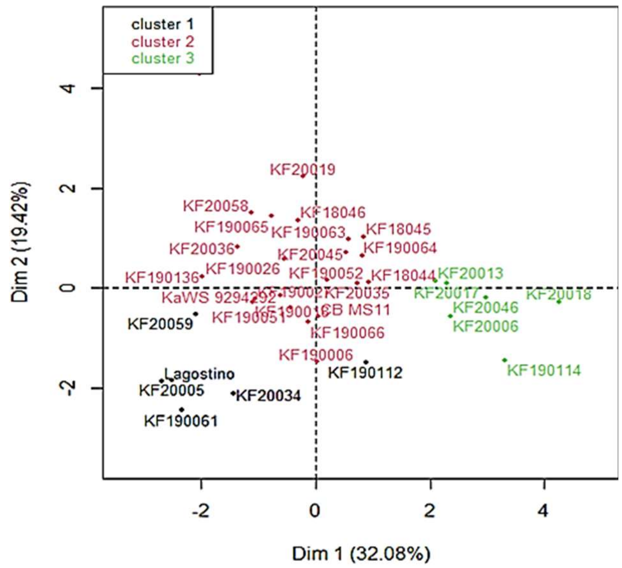

Fig. 4: Individuals graph (ACP) the individuals with the most input to the construction of the plan is those who have been named

Principal component analysis (PCA)

In our study, PCA was applied to the agronomic characters of 33 rice accessions to identify the main sources of variation and the relationships between different accessions. The first two PCA dimensions together explain 51.01% of the total variance (Dim 1: 32.67% and Dim 2: 18.34%).

The PCA graph (Fig. 4) shows the distribution of rice accessions on the plane formed by the first two principal components. Each point represents a rice accession, and its relative position indicates its agronomic characteristics. The PCA revealed that 18.34% of the total variance was explained by the first dimension. This dimension is correlated with variables such as the number of tillers per plant and the sowing-epiposition cycle. Accessions located above the origin (0) on this first axis are particularly distinguished by these characteristics.

Quadrants and accession groups

The quadrants formed by the two PCA dimensions are used to group together accessions with similar agronomic characteristics.

Quadrant supérieur droit (Q1): Accessions: KF190063, KF190065, KF18045, KF20006, KF20046. These accessions are characterized by high values on both dimensions, indicating that they have favorable agronomic characteristics for the variables strongly correlated with these dimensions. They could be priorities for breeding programs aimed at improving yield and resistance.

Upper left quadrant (Q2): Accessions: Lagostino, KF20005, KF190136. These accessions have high values for the second dimension but low values for the first. They are advantageous for specific characteristics represented by the second dimension, such as number of tillers and sowing-epiposition cycle.

Lower left quadrant (Q3): Accessions: KF20034, KF20059, KF190061. Accessions in this quadrant show low values on both dimensions, suggesting less favorable agronomic characteristics. They may need significant improvement to be competitive.

Lower right quadrant (Q4): Accessions: KF20013, KF20017, KF20018, KF190114. PCA revealed the main agronomic characteristics that distinguish the different rice accessions. Accessions at the extremes of the quadrants have distinct agronomic characteristics and can be targeted for specific breeding or improvement programs. This analysis provides a sound basis for informed breeding decisions, helping to improve the productivity and resilience of rice crops. The graph analysis detects a singular individual who strongly influences the observed results. We'll begin by highlighting the extreme nature of this individual, before removing him from the analysis. Looking at the graph, we can see that one individual is very special and contributes enormously to the construction of the plan. His contribution to the construction of the plan is 14.3%.

Inertia distribution

The inertia of the factorial axes provides insight into whether the variables are well-structured and helps determine the appropriate number of principal components to analyze. In this study, the first two axes of the PCA capture 51% of the total dataset inertia, meaning they account for 51% of the total variability among the individuals (or variables) in the dataset. This substantial percentage indicates that the variability of a significant portion of the active dataset is well-represented in this plane. Since this value exceeds the reference threshold of 42.09%—the 0.95-quantile of inertia percentages derived from simulations of 509 random datasets with similar dimensions based on a normal distribution—the variability explained by this analysis is statistically significant. Given these findings, it may be beneficial to also consider dimensions greater than or equal to the third axis in the analysis.

Fig. 5 illustrates the breakdown of total inertia into percentages for each dimension of the PCA. Inertia represents the variance explained by each dimension and the bar chart highlights the relative significance of each component in capturing the original data's variance. When estimating the number of relevant axes to interpret, the analysis suggests focusing on the first two axes, as they display higher inertia compared to the 0.95-quantile of random distributions (51% versus 42.09%). This indicates that these axes alone contain meaningful information. Therefore, the discussion of the analysis will be limited to these axes.

Moreover, the PCA can identify clusters of accessions with similar agro-morphological traits, as shown in Fig. 6. These clusters are valuable for selecting varieties suited to specific growing conditions.

Rice accessions with high values for principal components associated with high-yielding characteristics, such as plant height, number of panicles per plant and grain weight, can be considered high performers. High values for the variables CSM, NTP, NPP, PMG and CSE (from most extreme to least extreme), as well as low values for the variable PMG, indicate a positive trend. For example, a strong positive correlation between panicle length and 1000-grain weight might suggest that longer panicles tend to produce heavier grains. These results provide valuable information for the selection and improvement of rice varieties based on key agro-morphological characteristics. The use of PCA facilitates the visualization of complex relationships between the different variables studied.

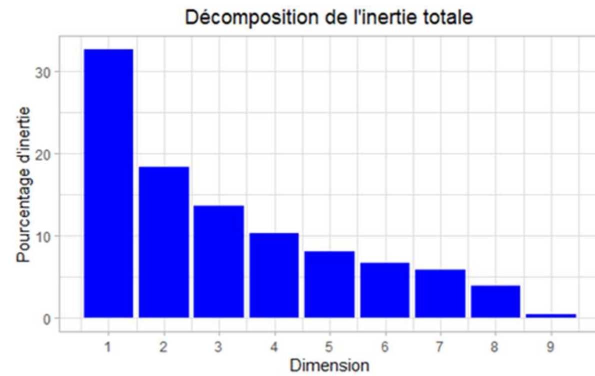

Fig. 5: Total inertia breakdown

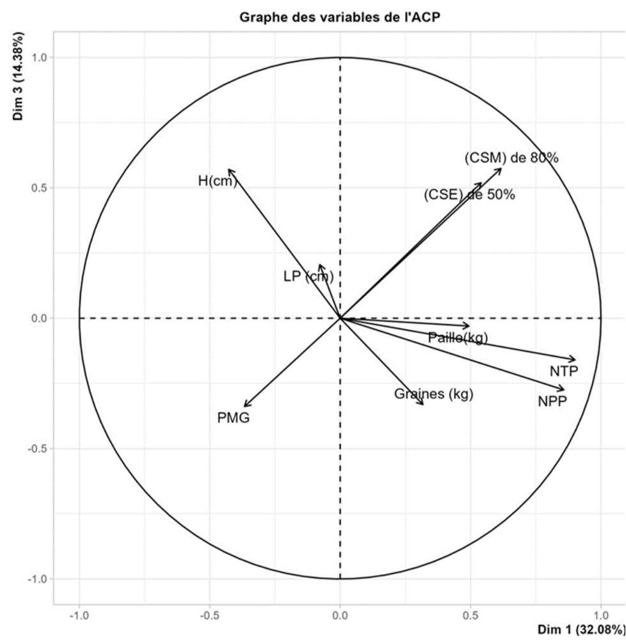

Fig. 6: Variable graph (ACP) the variables with the names are those best represented on the plan

Discussion

This study evaluated the agronomic performance of 33 Kafaci rice lines introduced to Morocco, using advanced statistical tools like HCA and PCA. The research highlights the critical role of agro-morphological characterization in the success of varietal improvement programs, aligning with findings by Bello *et al.* (2018), who emphasized that understanding plant genetic resources is essential for developing high-yield, high-quality varieties. In this study, key agro-morphological traits such as plant height, panicle length, number of tillers per plant, number of panicles per plant, seed-to-seed and seed-to-maturity cycles and the weight of 1,000 grains were analyzed. These traits are crucial for assessing the potential of rice varieties in varying environments, providing a foundation for breeding programs. Our analysis grouped the rice lines into three distinct clusters based on their agronomic characteristics, offering valuable insights for targeted cultivation strategies. Our analysis grouped the rice lines into three distinct clusters based on their agronomic characteristics, offering valuable insights into targeted cultivation strategies (Fig. 3). Cluster 1, despite showing relatively lower overall performance, includes lines like KF20005 and KF20059 that may thrive in environments with lower biomass demands, such as marginal lands or low-input systems. This finding is consistent with the work of Claude *et al.* (2020), who noted that certain rice varieties perform better under specific environmental conditions. Cluster 2, which includes KF190136 and KF190006, exhibited high potential in grain weight and seed production, making them suitable for regions with shorter growing seasons where rapid crop maturity is crucial. Cluster 3, with its slower maturation and higher biomass production, aligns with research by Chandraker *et al.* (2024), who found that varieties with these traits are ideal for dual-purpose systems that require both grain and straw yield.

The hierarchical grouping of the rice lines underscores their commendable agronomic performance and adaptability to diverse constraints across various ecosystems, including rainfed and irrigated conditions. Cluster 1 accessions emerged as the most promising, thanks to their consistent performance across different sites and seasons, and their early maturation cycle, which is particularly advantageous for areas with short growing periods. PCA further refined the understanding of the rice lines, identifying key factors driving variability in quantitative traits (Fig. 4). Similar to the findings of Sanni *et al.* (2012), our PCA results demonstrated that higher coefficient values, regardless of their direction, are more effective in distinguishing between accessions. The analysis revealed four distinct quadrants grouping accessions with similar agronomic traits: the Top Right Quadrant, marked by high yields and resistance (KF190063 and KF20046); the Top Left Quadrant, featuring lines with high tiller numbers and optimal sowing-heading cycles (Lagostino and KF190136); the Bottom Left Quadrant, which identified accessions needing improvement (KF20034); and the Bottom Right Quadrant, which includes lines targeted for specific breeding or improvement programs (KF20017 and KF20018). The study's findings underscore the importance of agro-morphological characterization for successful varietal improvement. By identifying distinct groups based on agronomic performance, the study provides a foundation for targeted breeding programs focused on enhancing specific traits such as yield, biomass production, and resistance to stresses. This approach allows breeding efforts to be more efficient and aligned with local cultivation needs, contributing to the sustainability and productivity of the rice sector in Morocco.

Conclusion

The study of the agro-morphological characteristics of rice varieties introduced in Morocco revealed significant variations in key parameters such as plant height, panicle length and grain weight. To improve rice production, it is essential to select suitable varieties, invest in research into genetic improvement, promote good agricultural practices and foster international collaboration. By following these recommendations, Morocco can move towards more sustainable, profitable and high-quality rice production, thereby contributing to national food security and economic prosperity for farmers.

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Author Contributions

All authors actively contributed to this paper's formulation, discussion of findings, and composition, collectively assuming responsibility for its content.

Conflict of Interest

The authors assert that they have no conflicts of interest to declare.

Data Availability

The data underpinning the conclusions of this study can be obtained from the corresponding author upon a reasonable request.

Ethics Approval

Not applicable

References

Bello AI, Y Agnoun, HA Salami, C Akakpo, B Agbessi, J Toviho, M Sie, A Adjanohoun, C Agbangla (2018). Assessment of the phenotypic variability of rice accessions (*Oryza* sp.) collected in Benin using agro morphological markers. *J Nat Prod Plant Resour* 8:17–31

Chandraker P, B Sharma, M Parikh, RR Saxena (2024). Assessment of genetic diversity in aromatic short grain rice (*Oryza sativa* L.) genotypes using pca and cluster analysis. *Intl J Plant Soil Sci* 36:82–94

Claude G, BF Amoussou, S Sall, B Manneh, B Toulou, F Ametonou, J Moreira, P Azokpota, M Sie (2020). Agro-morphological characterization of african rice accessions (*Oryza glaberrima*) in rainfed and irrigated cultural conditions. *J Exp Biol Agric Sci* 8:140–147

Elwahab F, H Roudi, O Chetto, AE Finti, N Brhadda, R Ziri, M Sedki (2024). Genetic diversity and grouping of new rice accessions in morocco based on yield and seed quality. *Intl J Agric Biol* 31:311–320

Elwahab F, M Sedki, N Brhadda, R Ziri (2023). Review of agronomic and genetic diversity of Moroccan rice varieties, and their resistance to blast disease (*Pyricularia oryzae*). *Agron Res* 21:267–290

Mohidem NA, N Hashim, R Shamsudin, HC Man (2022). Rice for food security: Revisiting its production, diversity, rice milling process and nutrient content. *Agriculture* 12:741-768

Muthayya S, JD Sugimoto, S Montgomery, GF Maberly (2014). An overview of global rice production, supply, trade, and consumption: Global rice production, consumption, and trade. *Ann New York Acad Sci* 1324:7–14

Sanni KA, I Fawole, SA Ogunbayo, DD Tia, EA Somado, K Futakuchi, M Sie, FE Nwilene, RG Guei (2012). Multivariate analysis of diversity of landrace rice germplasm. *Crop Sci* 52:494–504