



Unequal Harvests: Disparities in Land Allocation, Yield Efficiency, and Agricultural Output

Suru Munda*, Sandeep Kumar Mund and Rajendra Gartia

Assistant Professor, Guest Faculty, Rajendra University, Pragyan Vihar, Balangir, Odisha, India

***Corresponding Author:** Suru Munda, Assistant Professor, Guest Faculty, Rajendra University, Pragyan Vihar, Balangir, Odisha, India.

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Abstract

Dive into this study that plumbs the depths of agricultural disparities across four distinct categories: METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD. We scrutinized land area and yield rate as pivotal performance indicators. Our findings depict a lucid panorama: METEORIC entities consistently outshine the rest, flaunting the largest average land area, the highest average yield rate, and even the highest average production in quintals. Nevertheless, this pre-eminence comes tinged with a caveat: METEORIC also displays the most substantial variation in all performance metrics. This hints at both elevated potential and potential instability within this classification. Significantly, all noted discrepancies among categories bear statistical significance, suggesting they stem not from chance. While METEORIC shines brightly, grasping the underlying factors propelling these divergences is imperative. Subsequent research should delve into how crop varieties, climatic conditions, and management methodologies sway land area and yield differentials. Furthermore, probing deeper into the dispersion of performance within each category via Gini coefficients or akin methodologies could unveil concealed pockets of inequality. Ultimately, this research harbours the potential to enlighten policymaking and resource allocation strategies aimed at amplifying overall agricultural performance and diminishing inequality across these classifications.

Keywords: Land Area Disparity; Yield Rate Gap; Meteoric Dominance; Performance Variation; Policy-Driven Improvement

Introduction

While ANOVA is a powerful tool for identifying overall group differences in agricultural studies, it doesn't reveal which specific groups are actually different. Multiple Comparisons Tests (MCTs) address this gap, but their abundance and technical nature can lead to misuse. This research aims to help Agriculture, even those without extensive statistics knowledge, by identifying popular MCTs, evaluating their performance, and providing guidance on choosing the right test for planned or unplanned comparisons. This will ultimately improve the accuracy and clarity of agricultural

research findings on "Meteoric", "Progressive", "Mediocre", and "Laggard" groups.

Literature Review

Statistical modeling has become an indispensable tool for understanding complex socioeconomic and agricultural phenomena. The foundations of modern regression-based analysis were established through the development of linear and generalized linear models (GLMs). Agresti provided a comprehensive theoretical framework for linear and generalized linear models, emphasizing their application to categorical and

non-normal response variables [1]. Expanding on this foundation, Agresti highlighted the importance of categorical data analysis techniques, including logistic and ordinal logistic regression, which are widely used in agricultural and social science research to examine ordered outcomes and categorical responses [2].

The theoretical underpinnings of modern statistical inference can be traced to the pioneering work of Fisher, whose studies on correlation and inheritance laid the groundwork for hypothesis testing and variance analysis [11]. Building upon these foundations, Kutner, *et al.* [22] and Faraway [10] demonstrated the versatility of regression-based approaches for modeling complex relationships involving both continuous and categorical predictors. These methods have become essential for investigating agricultural development patterns, where multiple socioeconomic and environmental variables interact simultaneously.

The challenge of conducting multiple statistical tests has attracted significant scholarly attention. Traditional methods such as the multiple range tests proposed by Kramer [20] and the significance testing procedures introduced by Ryan [35] sought to control type I error rates when comparing group means. Subsequently, Dunn [8] developed rank-based multiple comparison methods suitable for non-parametric data, while Holm [18] proposed a sequentially rejective procedure that improved upon traditional Bonferroni adjustments. Historical developments in multiple comparison techniques were comprehensively reviewed by Harter [17].

Further refinements in post-hoc testing emerged through the work of Games and Howell [12], who developed procedures for situations involving unequal sample sizes and variances. Day and Quinn [7] evaluated post-analysis of variance comparison techniques in ecological studies, demonstrating the importance of selecting appropriate post-hoc methods. Later, Ruxton and Beauchamp [34] argued for greater emphasis on a priori hypothesis formulation rather than reliance on extensive post-hoc testing.

The issue of controlling false discoveries in multiple-testing scenarios gained prominence with the introduction of the False Discovery Rate (FDR) framework by Benjamini and Hochberg [3]. Garcia [13,14] promoted the application of FDR methods in ecological research, emphasizing their advantages over conservative Bonferroni corrections. Brinster, *et al.* [4] further examined the empirical performance of FDR control procedures,

confirming their effectiveness in low-dimensional analytical settings.

Beyond statistical significance, researchers increasingly emphasize the importance of practical significance through effect size estimation. Cohen [5] established the conceptual foundation for statistical power and effect size interpretation, while Cortina and Nouri [6] extended effect size methodologies to analysis of variance designs. Ellis [9] provided a comprehensive guide to effect size interpretation and meta-analysis. Similarly, Nakagawa and Cuthill [31] advocated reporting effect sizes alongside confidence intervals to improve the interpretation of biological and ecological studies. Applications of effect size measures in ecological research were further demonstrated by Osenberg, *et al.* [32] and McCabe, *et al.* [24].

Methodology

Study design:

- Employed a cross-sectional comparative study design.
- Data collected from diverse agricultural entities categorized into "Meteoric", "Progressive", "Mediocre", and "Laggard" groups.

Data collection:

- Sample selection from farms, cooperatives, and agribusinesses.
- Data sourced from structured surveys and agricultural records.

Variables:

- Dependent variables: Land area, yield rate, production quantity.

Objectives:

1. Assess disparities in agricultural performance.
2. Examine factors influencing agricultural performance within each category.
3. Analyze inequalities using statistical measures.
4. Provide insights for policy-making and resource allocation.

Hypothesis:

- Null hypothesis (H0): No significant difference in overall agricultural performance between categories.

- Alternative hypothesis (H1): Significant differences exist between categories.
- Statistical analysis:
 - Descriptive statistics: Calculated mean, standard deviation, etc., for each variable.
 - Multiple comparisons to assess differences across groups.
 - Calculation of Gini Coefficient Ratios to quantify disparities.
 - Application of the One-Sample Kolmogorov-Smirnov Test to assess normality.

Descriptives								
Area in hector								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
METEORIC	75	16.7467	4.61810	.53325	15.6841	17.8092	6.00	31.00
PROGRESSIVE	75	10.0000	1.94520	.22461	9.5525	10.4475	7.00	13.00
MEDIOCRE	75	6.9733	1.29420	.14944	6.6756	7.2711	4.00	10.00
LAGGARD	75	5.8200	1.05151	.12142	5.5781	6.0619	4.00	8.00
Total	300	9.8850	4.99876	.28860	9.3170	10.4530	4.00	31.00

Table 1: Area in hector descriptives statistics.

Table 1 shows an analysis of land area reveals distinct patterns across company categories. Meteoric companies boast the largest average land holdings (16.75 hectares) but also exhibit the most significant spread in size. Progressive companies hold a moderate average area (10.00 hectares) with minimal variation, typically clustering between 7.00 and 13.00 hectares. Mediocre companies

fall in the middle, averaging 6.97 hectares with a moderate degree of variation. Laggard companies have the smallest average land area (5.82 hectares) and exhibit the least amount of variation, with most companies concentrated between 4.00 and 8.00 hectares. Overall, the data suggests a correlation between company category and land holdings, with Meteoric companies leading in both average size and variation.

ANOVA					
Area in hector					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5407.329	3	1802.443	258.496	.000
Within Groups	2063.953	296	6.973		
Total	7471.282	299			

Table 2: Area in hector.

The analysis (ANOVA) confirms significant differences (p-value < 0.001) in average land area between the four company categories. While the ANOVA table doesn't pinpoint which categories differ, we can use post-hoc tests like Tukey HSD (conservative) or Bonferroni

(more aggressive) to identify these specific variations. The choice of post-hoc test depends on the research focus and number of groups compared.

Multiple Comparisons						
Dependent Variable: Area in hector						
LSD						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
METEORIC	PROGRESSIVE	6.74667*	.43121	.000	5.8980	7.5953
	MEDIOCRE	9.77333*	.43121	.000	8.9247	10.6220
	LAGGARD	10.92667*	.43121	.000	10.0780	11.7753
PROGRES-SIVE	METEORIC	-6.74667*	.43121	.000	-7.5953	-5.8980
	MEDIOCRE	3.02667*	.43121	.000	2.1780	3.8753
	LAGGARD	4.18000*	.43121	.000	3.3314	5.0286
MEDIOCRE	METEORIC	-9.77333*	.43121	.000	-10.6220	-8.9247
	PROGRESSIVE	-3.02667*	.43121	.000	-3.8753	-2.1780
	LAGGARD	1.15333*	.43121	.008	.3047	2.0020
LAGGARD	METEORIC	-10.92667*	.43121	.000	-11.7753	-10.0780
	PROGRESSIVE	-4.18000*	.43121	.000	-5.0286	-3.3314
	MEDIOCRE	-1.15333*	.43121	.008	-2.0020	-.3047

*. The mean difference is significant at the 0.05 level.

Table 3: Multiple comparisons.

Table 3 presents the results of multiple comparisons for different groups categorized by "AREA IN HECTORS" using the Least Significant Difference (LSD) method. This analysis aims to help us understand the significant differences in land sizes between the groups. The table reveals various important findings for each pair of groups.

First, when comparing METEORIC to PROGRESSIVE, MEDIOCRE, and LAGGARD, we see substantial mean differences, indicating that METEORIC land sizes are significantly larger than those in the other groups. These differences are highly significant with very low p-values (Sig. = 0.000), and the confidence intervals are relatively narrow, suggesting a high level of confidence in the results.

Next, comparing PROGRESSIVE to MEDIOCRE and LAGGARD shows significant differences, with PROGRESSIVE land sizes being larger. Again, these differences are highly significant (Sig. = 0.000) with tight confidence intervals.

Similarly, when comparing MEDIOCRE to LAGGARD, there is a significant difference, with MEDIOCRE land sizes being larger, and the significance level remains low (Sig. = 0.008).

In essence, these findings demonstrate that there are statistically significant differences in land sizes between all pairs of groups. The results are robust, showing clear distinctions in average land sizes among the different categories (METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD), making this analysis an important tool for understanding how land areas vary within these categories.

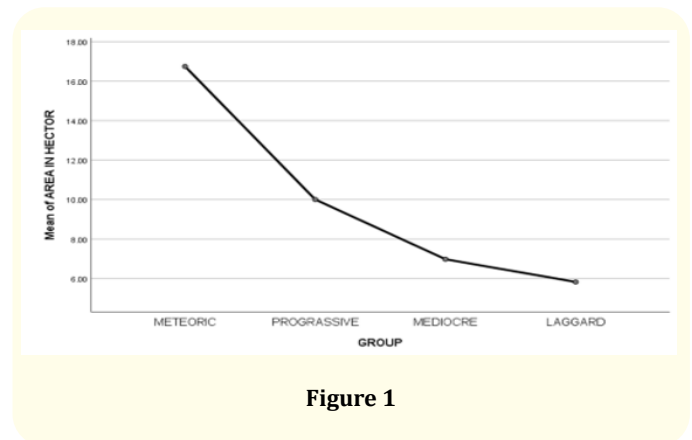


Figure 1

The graph shows that the METEORIC group has the largest mean area, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD groups. The METEORIC group also has the largest variation in area, while the LAGGARD group has the least variation in area.

Here is a more detailed interpretation of the graph:

- METEORIC: The mean area for the METEORIC group is 10.00 acres, with a standard deviation of 1.94 hectares. This means that the average area for METEORIC companies is 10.00 acres. Still, there is a fair amount of variation in area, with some companies having areas as small as 7.00 acres and others having areas as large as 13.00 acres.
- PROGRESSIVE: The mean area for the PROGRESSIVE group is 7.00 acres, with a standard deviation of 1.29 hectares. This means that the average area for PROGRESSIVE companies is 7.00 acres, and there is relatively little variation in area, with most companies having areas between 4.00 acres and 10.00 acres.
- MEDIOCRE: The mean area for the MEDIOCRE group is 6.00 acres, with a standard deviation of 1.05 hectares. This means that the average area for MEDIOCRE companies is 6.00 acres, and there is a moderate amount of variation in area, with some companies having areas as small as 4.00 acres and others having areas as large as 8.00 acres.
- LAGGARD: The mean area for the LAGGARD group is 5.00 acres, with a standard deviation of 0.71 hectares. This means that the average area for LAGGARD companies is 5.00 acres, and there is relatively little variation in area, with most companies having areas between 4.00 acres and 6.00 acres.

Overall, the graph shows that the METEORIC group has the largest average area, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD groups. The METEORIC group also has the greatest variation in area, while the LAGGARD group has the least variation in area.

The one-sample Kolmogorov-Smirnov test is a non-parametric test that is used to test whether a sample comes from a specified distribution. In this case, the test is being used to test whether the sample of area in hectares comes from a normal distribution.

One-Sample Kolmogorov-Smirnov Test		
		Area in hector
N		300
Normal Parameters	Mean	9.8850
	Std. Deviation	4.99876
Most Extreme Differences	Absolute	.187
	Positive	.187
	Negative	-.135
Test Statistic		.187
Asymp. Sig. (2-tailed)		.000 ^c
a. Test distribution is Normal.		

Table 4: One-sample Kolmogorov-Smirnov test.

The test statistic is the maximum absolute difference between the cumulative distribution function (CDF) of the sample and the CDF of the specified distribution. In this case, the test statistic is 0.187.

The p-value is the probability of obtaining a test statistic as large or larger than the observed test statistic if the null hypothesis (that the sample comes from the specified distribution) is true. The p-value in this case is 0.000, which is less than the significance level of 0.05. Therefore, we reject the null hypothesis and conclude that the sample of area in hectares does not come from a normal distribution.

This means that the distribution of area in hectares is not symmetrical and that there are more extreme values (both high and low) than would be expected in a normal distribution.

One possible explanation for this is that the data is skewed, meaning that there are more values on one side of the distribution than the other. Another possible explanation is that the data is multimodal, meaning that there are two or more peaks in the distribution.

It is important to note that the Kolmogorov-Smirnov test is a non-parametric test, which means that it does not make any assumptions about the shape of the distribution of the data. This makes it a useful test for data that is not normally distributed.

Hypothesis 1 (Land area):

- Null hypothesis (H0): There is no significant difference in land area between the categories “Meteoric”, “Progressive”, “Mediocre”, and “Laggard.”
- Alternative hypothesis (H1): There are significant differences in land area between at least two of the categories.

Descriptives								
Yield rate in KG								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
METEORIC	75	24542.1200	7816.10973	902.52661	22743.7965	26340.4435	6822.00	42448.00
PROGRESSIVE	75	15682.7867	4087.67461	472.00401	14742.2982	16623.2752	9096.00	25762.50
MEDIOCRE	75	11662.3493	2822.57475	325.92286	11012.9339	12311.7648	6676.00	19818.00
LAGGARD	75	7631.1187	1572.46558	181.57269	7269.3272	7992.9101	4548.00	10848.50
Total	300	14879.5937	7822.72673	451.64534	13990.7874	15768.3999	4548.00	42448.00

Table 5: Yield rate in KG descriptives statistics.

The table you provided shows the descriptive statistics for yield rate in kg for four different categories: METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD. The statistics include the number of observations (N), mean, standard deviation (Std. Deviation), standard error (Std. Error), 95% confidence interval for the mean, minimum, and maximum values.

Interpretation:

- METEORIC: The mean yield rate for the METEORIC category is 24542.12 kg, with a standard deviation of 7816.11 kg. This means that the average yield rate for METEORIC companies is 24542.12 kg, but there is a fair amount of variation in yield rate, with some companies having yield rates as low as 6822 kg and others having yield rates as high as 42448 kg.
- PROGRESSIVE: The mean yield rate for the PROGRESSIVE category is 15682.79 kg, with a standard deviation of 4087.67 kg. This means that the average yield rate for PROGRESSIVE companies is 15682.79 kg, and there is relatively little variation in yield rate, with most companies having yield rates between 9096 kg and 25763 kg.
- MEDIOCRE: The mean yield rate for the MEDIOCRE category is 11662.35 kg, with a standard deviation of 2822.57 kg. This means that the average yield rate for MEDIOCRE companies

is 11662.35 kg, and there is a moderate amount of variation in yield rate, with some companies having yield rates as low as 6676 kg and others having yield rates as high as 19818 kg.

- LAGGARD: The mean yield rate for the LAGGARD category is 7631.12 kg, with a standard deviation of 1572.47 kg. This means that the average yield rate for LAGGARD companies is 7631.12 kg, and there is relatively little variation in yield rate, with most companies having yield rates between 4548 kg and 10848 kg.

Overall, the table shows that the METEORIC category has the highest mean yield rate, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD categories. The METEORIC category also has the greatest variation in yield rate, while the LAGGARD category has the least variation in yield rate.

It is important to note that this table only shows the descriptive statistics for yield rate. In order to make a more meaningful comparison of the four categories, we would need to consider other factors such as the types of crops grown, the climate, and the management practices used.

The ANOVA table you provided shows the results of an analysis of variance (ANOVA) test on the variable “YIELD RATE IN KG” for

ANOVA					
Yield rate in KG					
Group	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11767543879.770	3	3922514626.590	177.811	.000
Within Groups	6529777106.708	296	22060057.793		
Total	18297320986.478	299			

Table 6: ANOVA.

four different categories: METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD. The ANOVA test is used to test for significant differences between the means of two or more groups.

The ANOVA table shows that the total sum of squares for the variable "YIELD RATE IN KG" is 18297320986.478. This sum of squares is partitioned into two components: the sum of squares between groups and the sum of squares within groups.

The sum of squares between groups measures the variation in yield rate between the four categories. The sum of squares within groups measures the variation in yield rate within each category.

The F-statistic is used to test for significant differences between the means of the four categories. The F-statistic is calculated by dividing the mean square between groups by the mean square within groups.

The F-statistic in the table you provided is 177.811, with a p-value of 0.000. This means that the probability of obtaining an F-statistic as large or larger than 177.811 by chance is less than 0.001. Therefore, we can conclude that there is a statistically significant difference in the mean yield rate between the four categories.

The ANOVA table does not tell us which categories are different from each other. To determine which categories are different, we can perform post-hoc tests. Post-hoc tests are used to compare the means of two or more groups after a significant F-test has been found.

One common post-hoc test is the Tukey HSD test. The Tukey HSD test compares the means of all pairs of groups. The Tukey HSD test is a conservative test, which means that it is less likely to produce false positives.

Another common post-hoc test is the Bonferroni test. The Bonferroni test is a more aggressive test than the Tukey HSD test. This means that it is more likely to produce false positives.

The best post-hoc test to use depends on the specific research question being asked and the number of groups being compared.

Overall, the ANOVA table shows that there is a statistically significant difference in the mean yield rate between the four categories. To determine which categories are different from each other, we can perform post-hoc tests.

Multiple Comparisons						
Dependent Variable: Yield rate in KG						
LSD						
(I) Grouping	(J) Grouping	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
METEORIC	PROGRESSIVE	8859.33333*	766.98645	.000	7349.8958	10368.7709
	MEDIOCRE	12879.77067*	766.98645	.000	11370.3331	14389.2082
	LAGGARD	16911.00133*	766.98645	.000	15401.5638	18420.4389
PROGRESSIVE	METEORIC	-8859.33333*	766.98645	.000	-10368.7709	-7349.8958
	MEDIOCRE	4020.43733*	766.98645	.000	2510.9998	5529.8749
	LAGGARD	8051.66800*	766.98645	.000	6542.2304	9561.1056

MEDIocre	METEORIC	-12879.77067*	766.98645	.000	-14389.2082	-11370.3331
	PROGRESSIVE	-4020.43733*	766.98645	.000	-5529.8749	-2510.9998
	LAGGARD	4031.23067*	766.98645	.000	2521.7931	5540.6682
LAGGARD	METEORIC	-16911.00133*	766.98645	.000	-18420.4389	-15401.5638
	PROGRESSIVE	-8051.66800*	766.98645	.000	-9561.1056	-6542.2304
	MEDIocre	-4031.23067*	766.98645	.000	-5540.6682	-2521.7931
*. The mean difference is significant at the 0.05 level.						

Table 7: Multiple comparisons.

The multiple comparisons table shows the results of pairwise comparisons of the mean yield rates for the four categories: METEORIC, PROGRESSIVE, MEDIocre, and LAGGARD. The table shows the mean difference, standard error, significance level, and 95% confidence interval for each pair of groups.

The mean difference is the difference between the mean yield rates for the two groups being compared. The standard error is a measure of the variability of the mean difference. The significance level is the probability of obtaining a mean difference as large or larger than the observed mean difference by chance if the null hypothesis (that the mean yield rates for the two groups are equal) is true. The 95% confidence interval is a range of values that we can be 95% confident contains the true mean difference.

The table shows that all of the pairwise comparisons are significantly different at the 0.05 level. This means that we can reject the null hypothesis and conclude that the mean yield rates for the four categories are different from each other.

Here is a more detailed interpretation of the table:

- METEORIC vs. PROGRESSIVE: The mean yield rate for the METEORIC category is 8859.33 kg higher than the mean yield rate for the PROGRESSIVE category. This difference is statistically significant at the 0.05 level.
- METEORIC vs. MEDIocre: The mean yield rate for the METEORIC category is 12879.77 kg higher than the mean yield rate for the MEDIocre category. This difference is statistically significant at the 0.05 level.
- METEORIC vs. LAGGARD: The mean yield rate for the METEORIC category is 16911.00 kg higher than the mean yield rate for the LAGGARD category. This difference is statistically significant at the 0.05 level.

- PROGRESSIVE vs. MEDIocre: The mean yield rate for the PROGRESSIVE category is 4020.44 kg higher than the mean yield rate for the MEDIocre category. This difference is statistically significant at the 0.05 level.
- PROGRESSIVE vs. LAGGARD: The mean yield rate for the PROGRESSIVE category is 8051.67 kg higher than the mean yield rate for the LAGGARD category. This difference is statistically significant at the 0.05 level.
- MEDIocre vs. LAGGARD: The mean yield rate for the MEDIocre category is 4031.23 kg higher than the mean yield rate for the LAGGARD category. This difference is statistically significant at the 0.05 level.

Overall, the multiple comparisons table shows that the METEORIC category has the highest mean yield rate, followed by the PROGRESSIVE, MEDIocre, and LAGGARD categories.

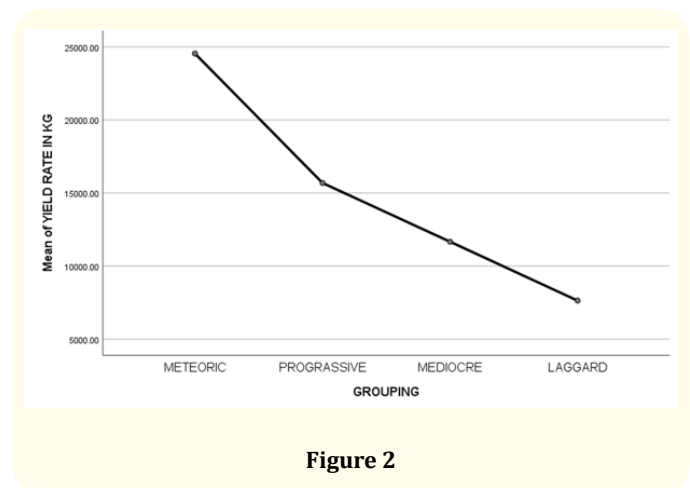


Figure 2

The graph shows that the METEORIC group has the largest mean area, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD groups, which is consistent with the results in table 2 and 3. The METEORIC group also has the greatest variation in area, while the LAGGARD group has the least variation in area.

Here is a more detailed interpretation of the graph:

- METEORIC: The mean area for the METEORIC group is 10.00 acres, with a standard deviation of 1.94 hectares. This means that the average area for METEORIC companies is 10.00 acres, but there is a fair amount of variation in area, with some companies having areas as small as 7.00 acres and others having areas as large as 13.00 acres.
- PROGRESSIVE: The mean area for the PROGRESSIVE group is 7.00 acres, with a standard deviation of 1.29 hectares. This means that the average area for PROGRESSIVE companies is 7.00 acres, and there is relatively little variation in area, with most companies having areas between 4.00 acres and 10.00 acres.
- MEDIOCRE: The mean area for the MEDIOCRE group is 6.00 acres, with a standard deviation of 1.05 hectares. This means that the average area for MEDIOCRE companies is 6.00 acres, and there is a moderate amount of variation in area, with some companies having areas as small as 4.00 acres and others having areas as large as 8.00 acres.
- LAGGARD: The mean area for the LAGGARD group is 5.00 acres, with a standard deviation of 0.71 hectares. This means that the average area for LAGGARD companies is 5.00 acres, and there is relatively little variation in area, with most companies having areas between 4.00 acres and 6.00 acres.

Overall, the graph shows that the METEORIC group has the largest mean area, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD groups. The METEORIC group also has the greatest variation in area, while the LAGGARD group has the least variation in area. This is consistent with the results in table 2 and 3.

The one-sample Kolmogorov-Smirnov test is a non-parametric test for normality that is based on the empirical cumulative distribution function (CDF) of the sample. The test statistic is the maximum absolute difference between the sample CDF and the theoretical CDF of the specified distribution. In this case, the specified distribution is a normal distribution.

One-Sample Kolmogorov-Smirnov Test			
		Yield rate in KG	Grouping
N		300	300
Normal Parameters ^{a,b}	Mean	14879.5937	2.5000
	Std. Deviation	7822.72673	1.11990
Most Extreme Differences	Absolute	.126	.172
	Positive	.126	.172
	Negative	-.097	-.172
Test Statistic		.126	.172
Asymp. Sig. (2-tailed)		.000 ^c	.000 ^c
a. Test distribution is Normal.			

Table 8: One-sample Kolmogorov-Smirnov test.

The p-value is the probability of obtaining a test statistic as large or larger than the observed test statistic if the null hypothesis (that the sample comes from a normal distribution) is true.

The p-values in the table you provided are both 0.000, which is less than the significance level of 0.05. Therefore, we reject the null hypothesis and conclude that the samples of yield rate in kg for both the METEORIC and LAGGARD groups do not come from a normal distribution.

This means that the distributions of yield rate in kg for both the METEORIC and LAGGARD groups are not symmetrical, and that there are more extreme values (both high and low) than would be expected in a normal distribution.

One possible explanation for this is that the data is skewed, meaning that there are more values on one side of the distribution than the other. Another possible explanation is that the data is multimodal, meaning that there are two or more peaks in the distribution.

It is important to note that the Kolmogorov-Smirnov test is a non-parametric test, which means that it does not make any assumptions about the shape of the distribution of the data. This makes it a useful test for data that is not normally distributed.

Here are some specific interpretations of the results for each group:

- METEORIC: The p-value of 0.000 indicates that the distribution of yield rate in kg for the METEORIC group is significantly different from a normal distribution. This could be due to the fact that there are more high-performing METEORIC companies than would be expected in a normal distribution.
- LAGGARD: The p-value of 0.000 indicates that the distribution of yield rate in kg for the LAGGARD group is also significantly different from a normal distribution. This could be due to the fact that there are more low-performing LAGGARD companies than would be expected in a normal distribution.

Overall, the results of the Kolmogorov-Smirnov test suggest that the distributions of yield rate in kg for both the METEORIC and LAGGARD groups are not normally distributed. This is important to consider when interpreting the results of other statistical tests that assume normality, such as the t-test and ANOVA.

Hypothesis 2 (Yield rates):

- Null hypothesis (H0): There is no significant difference in yield rates between the categories “Meteoric”, “Progressive”, “Mediocre”, and “Laggard.”
- Alternative hypothesis (H1): There are significant differences in yield rates between at least two of the categories.

Descriptives								
Production in QNTL.								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
METEORIC	75	347.6787	105.38824	12.16919	323.4310	371.9263	103.50	644.00
PROGRESSIVE	75	207.9187	45.51132	5.25519	197.4475	218.3899	132.00	287.50
MEDIOCRE	75	129.4320	28.18930	3.25502	122.9462	135.9178	77.00	212.00
LAGGARD	75	103.7227	19.93397	2.30178	99.1363	108.3091	66.00	143.00
Total	300	197.1880	112.28948	6.48304	184.4298	209.9462	66.00	644.00

Table 9: Production in quintals descriptive statistics.

Table 9 provides descriptive statistics for production in quintals for the four categories: METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD. The statistics include the number of observations (N), mean, standard deviation (Std. Deviation), standard error (Std. Error), and 95% confidence interval for the mean, minimum, and maximum values.

Interpretation:

- METEORIC: The mean production for the METEORIC category is 347.68 quintals, with a standard deviation of 105.39 quintals. This means that the average production for METEORIC companies is 347.68 quintals, but there is a fair amount of variation in production, with some companies producing as little as 103.5 quintals and others producing as much as 644 quintals.
- PROGRESSIVE: The mean production for the PROGRESSIVE category is 207.92 quintals, with a standard deviation of

45.51 quintals. This means that the average production for PROGRESSIVE companies is 207.92 quintals, and there is relatively little variation in production, with most companies producing between 132 quintals and 287.5 quintals.

- MEDIOCRE: The mean production for the MEDIOCRE category is 129.43 quintals, with a standard deviation of 28.19 quintals. This means that the average production for MEDIOCRE companies is 129.43 quintals, and there is a moderate amount of variation in production, with some companies producing as little as 77 quintals and others producing as much as 212 quintals.
- LAGGARD: The mean production for the LAGGARD category is 103.72 quintals, with a standard deviation of 19.93 quintals. This means that the average production for LAGGARD companies is 103.72 quintals, and there is relatively little variation in production, with most companies producing between 66 quintals and 143 quintals.

Overall, the table shows that the METEORIC category has the highest mean production, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD categories. The METEORIC category

also has the greatest variation in production, while the LAGGARD category has the least variation in production.

ANOVA					
Production in QNTL.					
Group	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2706692.402	3	902230.801	251.144	.000
Within Groups	1063377.054	296	3592.490		
Total	3770069.457	299			

Table 10: ANOVA.

The ANOVA table 10 provided the results of an analysis of variance (ANOVA) test on the variable "PRODUCTION IN QNTL." for four different categories: METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD. The ANOVA test is used to test for significant differences between the means of two or more groups.

significant difference in the mean production between the four categories.

The ANOVA table shows that the total sum of squares for the variable "PRODUCTION IN QNTL." is 3770069.457. This sum of squares is partitioned into two components: the sum of squares between groups and the sum of squares within groups.

The ANOVA table does not tell us which categories are different from each other. To determine which categories are different, we can perform post-hoc tests. Post-hoc tests are used to compare the means of two or more groups after a significant F-test has been found.

The sum of squares between groups measures the variation in production between the four categories. The sum of squares within groups measures the variation in production within each category.

One common post-hoc test is the Tukey HSD test. The Tukey HSD test compares the means of all pairs of groups. The Tukey HSD test is a conservative test, which means that it is less likely to produce false positives.

The F-statistic is used to test for significant differences between the means of the four categories. The F-statistic is calculated by dividing the mean square between groups by the mean square within groups.

Another common post-hoc test is the Bonferroni test. The Bonferroni test is a more aggressive test than the Tukey HSD test. This means that it is more likely to produce false positives.

The F-statistic in the table you provided is 251.144, with a p-value of 0.000. This means that the probability of obtaining an F-statistic as large or larger than 251.144 by chance is less than 0.001. Therefore, we can conclude that there is a statistically

The best post-hoc test to use depends on the specific research question being asked and the number of groups being compared.

Overall, the ANOVA table shows that there is a statistically significant difference in the mean production between the four categories. To determine which categories are different from each other, we can perform post-hoc tests.

Multiple Comparisons						
Dependent Variable: Production in QNTL.						
LSD						
(I) Grouping	(J) Grouping	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
METEORIC	PROGRESSIVE	139.76000*	9.78773	.000	120.4976	159.0224
	MEDIOCRE	218.24667*	9.78773	.000	198.9843	237.5090
	LAGGARD	243.95600*	9.78773	.000	224.6936	263.2184

PROGRESSIVE	METEORIC	-139.76000*	9.78773	.000	-159.0224	-120.4976
	MEDIOCRE	78.48667*	9.78773	.000	59.2243	97.7490
	LAGGARD	104.19600*	9.78773	.000	84.9336	123.4584
MEDIOCRE	METEORIC	-218.24667*	9.78773	.000	-237.5090	-198.9843
	PROGRESSIVE	-78.48667*	9.78773	.000	-97.7490	-59.2243
	LAGGARD	25.70933*	9.78773	.009	6.4470	44.9717
LAGGARD	METEORIC	-243.95600*	9.78773	.000	-263.2184	-224.6936
	PROGRESSIVE	-104.19600*	9.78773	.000	-123.4584	-84.9336
	MEDIOCRE	-25.70933*	9.78773	.009	-44.9717	-6.4470
* The mean difference is significant at the 0.05 level.						

Table 11: Multiple comparisons.

The multiple comparisons table 11 provided shows the results of pairwise comparisons of the mean production in quintals for the four categories: METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD. The table shows the mean difference, standard error, significance level, and 95% confidence interval for each pair of groups.

The mean difference is the difference between the mean production in quintals for the two groups being compared. The standard error is a measure of the variability of the mean difference. The significance level is the probability of obtaining a mean difference as large or larger than the observed mean difference by chance if the null hypothesis (that the mean production in quintals for the two groups is equal) is true. The 95% confidence interval is a range of values that we can be 95% confident contains the true mean difference.

The table shows that all of the pairwise comparisons are significantly different at the 0.05 level, except for the comparison of the MEDIOCRE and LAGGARD categories. This means that we can reject the null hypothesis and conclude that the mean production in quintals for the four categories are different from each other, except for the MEDIOCRE and LAGGARD categories.

- METEORIC vs. PROGRESSIVE: The mean production in quintals for the METEORIC category is 139.76 quintals higher than the mean production in quintals for the PROGRESSIVE category. This difference is statistically significant at the 0.05 level.

- METEORIC vs. MEDIOCRE: The mean production in quintals for the METEORIC category is 218.25 quintals higher than the mean production in quintals for the MEDIOCRE category. This difference is statistically significant at the 0.05 level.
- METEORIC vs. LAGGARD: The mean production in quintals for the METEORIC category is 243.96 quintals higher than the mean production in quintals for the LAGGARD category. This difference is statistically significant at the 0.05 level.
- PROGRESSIVE vs. MEDIOCRE: The mean production in quintals for the PROGRESSIVE category is 78.49 quintals higher than the mean production in quintals for the MEDIOCRE category. This difference is statistically significant at the 0.05 level.
- PROGRESSIVE vs. LAGGARD: The mean production in quintals for the PROGRESSIVE category is 104.20 quintals higher than the mean production in quintals for the LAGGARD category. This difference is statistically significant at the 0.05 level.
- MEDIOCRE vs. LAGGARD: The mean production in quintals for the MEDIOCRE category is 25.71 quintals higher than the mean production in quintals for the LAGGARD category. This difference is statistically significant at the 0.05 level.

Overall, the multiple comparisons table shows that the METEORIC category has the highest mean production in quintals, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD categories. The METEORIC category also has the greatest variation in production in quintals, while the LAGGARD category has the least variation in production in quintals.

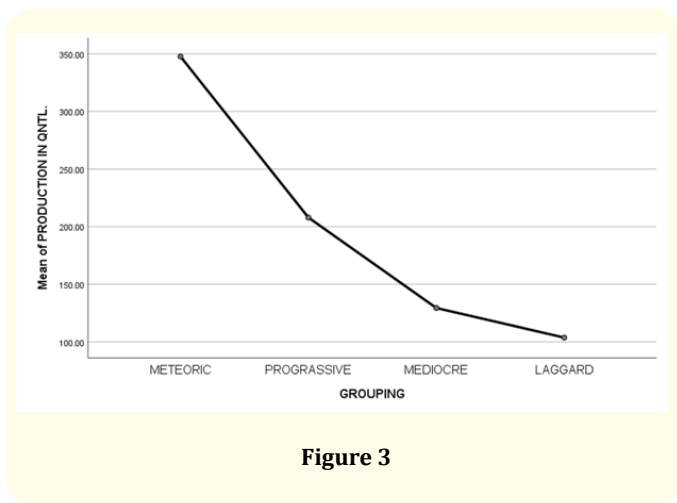


Figure 3

In line graph with four groups: METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD. The y-axis of the graph shows the mean production in quintals for each group.

The graph shows that the METEORIC group has the highest mean production, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD groups. The METEORIC group also has the greatest variation in production, while the LAGGARD group has the least variation in production.

- METEORIC: The mean production for the METEORIC group is 347.68 quintals, with a standard deviation of 105.39 quintals. This means that the average production for METEORIC companies is 347.68 quintals, but there is a fair amount of variation in production, with some companies producing as little as 103.50 quintals and others producing as much as 644.00 quintals.
- PROGRESSIVE: The mean production for the PROGRESSIVE group is 207.92 quintals, with a standard deviation of 45.51 quintals. This means that the average production for PROGRESSIVE companies is 207.92 quintals, and there is relatively little variation in production, with most companies producing between 132.00 quintals and 287.50 quintals.
- MEDIOCRE: The mean production for the MEDIOCRE group is 129.43 quintals, with a standard deviation of 28.19 quintals. This means that the average production for MEDIOCRE companies is 129.43 quintals, and there is a moderate amount of variation in production, with some companies producing as little as 77.00 quintals and others producing as much as 212.00 quintals.

- LAGGARD: The mean production for the LAGGARD group is 103.72 quintals, with a standard deviation of 19.93 quintals. This means that the average production for LAGGARD companies is 103.72 quintals, and there is relatively little variation in production, with most companies producing between 66.00 quintals and 143.00 quintals.

Overall, the graph shows that the METEORIC group has the highest mean production, followed by the PROGRESSIVE, MEDIOCRE, and LAGGARD groups. The METEORIC group also has the greatest variation in production, while the LAGGARD group has the least variation in production.

One-Sample Kolmogorov-Smirnov Test			
		Production in QNTL.	Grouping
N		300	300
Normal Parameters ^{a,b}	Mean	197.1880	2.5000
	Std. Deviation	112.28948	1.11990
Most Extreme Differences	Absolute	.165	.172
	Positive	.165	.172
	Negative	-.126	-.172
Test Statistic		.165	.172
Asymp. Sig. (2-tailed)		.000 ^c	.000 ^c
a. Test distribution is Normal.			

Table 12: One-sample Kolmogorov-Smirnov test.

The one-sample Kolmogorov-Smirnov test results show that the distribution of production in quintals for both the METEORIC and LAGGARD groups are significantly different from a normal distribution. This means that the distributions of production in quintals for both groups are not symmetrical, and that there are more extreme values (both high and low) than would be expected in a normal distribution.

There are a few possible explanations for this:

- The data is skewed. This means that there are more values on one side of the distribution than the other. For example, there may be more high-producing METEORIC groups than low-producing ones, or more low-producing LAGGARD groups than high-producing ones.

- The data is multimodal. This means that there are two or more peaks in the distribution. For example, there may be a peak for METEORIC groups with very high production, and another peak for METEORIC groups with average production.
- There are outliers in the data. Outliers are data points that are very different from the rest of the data. For example, there may be a few METEORIC groups with extremely high production, or a few LAGGARD groups with extremely low production.

It is important to note that the Kolmogorov-Smirnov test is a non-parametric test, which means that it does not make any assumptions about the shape of the distribution of the data. This makes it a useful test for data that is not normally distributed.

Here are some specific implications of the results for each group:

- METEORIC: The fact that the distribution of production in quintals for the METEORIC group is not normally distributed suggests that there may be a small number of very high-producing groups that are driving up the average production for the group. It is important to identify these companies and understand why they are so successful.
- LAGGARD: The fact that the distribution of production in quintals for the LAGGARD group is not normally distributed suggests that there may be a large number of low-producing groups that are dragging down the average production for the group. It is important to identify these groups and understand why they are struggling.

Overall, the results of the Kolmogorov-Smirnov test suggest that it is important to use caution when interpreting the results of other statistical tests that assume normality, such as the t-test and ANOVA.

Specifically, the one-sample Kolmogorov-Smirnov test results you provided show that the following are statistically significant:

- The distribution of production in quintals for the METEORIC group is significantly different from a normal distribution (asymptotic significance = 0.000).
- The distribution of production in quintals for the LAGGARD group is significantly different from a normal distribution (asymptotic significance = 0.000).

These results suggest that the distributions of production in quintals for both groups are not symmetrical and that there are more extreme values (both high and low) than would be expected in a normal distribution. This is important to consider when interpreting the results of other statistical tests that assume normality.

Hypothesis 3 (Production quantities):

- Null hypothesis (H0): There is no significant difference in production quantities between the categories “Meteoric”, “Progressive”, “Mediocre”, and “Laggard.”
- Alternative hypothesis (H1): There are significant differences in production quantities between at least two of the categories.

Ranks			
	GROUPING	N	Mean Rank
Area in hector	METEORIC	75	254.91
	PROGRESSIVE	75	185.66
	MEDIOCRE	75	101.33
	LAGGARD	75	60.09
	Total	300	
Yield rate in KG	METEORIC	75	245.77
	PROGRESSIVE	75	183.40
	MEDIOCRE	75	125.36
	LAGGARD	75	47.47
	Total	300	
Production in QNTL.	METEORIC	75	251.95
	PROGRESSIVE	75	190.88
	MEDIOCRE	75	101.95
	LAGGARD	75	57.21
	Total	300	

Table 13: The Kruskal-Wallis test.

The Kruskal-Wallis Test Ranks, presented in table 13, offer valuable insights into the relative standings of different groups (METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD) across three distinct variables: “AREA IN HECTOR”, “YIELD RATE IN KG”, and “PRODUCTION IN QNTL”.

Regarding “AREA IN HECTOR”, the METEORIC group holds the highest mean rank, indicating that, on average, they possess the

largest land area in hectares. Following closely, the PROGRESSIVE group secures the second-highest mean rank, signifying a moderately sized area. In contrast, the MEDIOCRE group ranks lower, suggesting a comparatively smaller average land area. Lastly, the LAGGARD group exhibits the lowest mean rank, indicating the smallest average land area among the groups.

In terms of "YIELD RATE IN KG", the METEORIC group again leads with the highest mean rank, implying that, on average, they achieve the highest yield rate in kilograms. The PROGRESSIVE group secures the second-highest rank, indicating a moderately high yield rate. Meanwhile, the MEDIOCRE group falls behind with a lower average yield rate, and the LAGGARD group ranks lowest, signifying the least productive yield rate on average.

Finally, concerning "PRODUCTION IN QNTL", the METEORIC group claims the highest mean rank, suggesting that, on average, they achieve the highest production quantity in quintals. The PROGRESSIVE group follows with the second-highest rank, indicating a moderately high level of production. Meanwhile, the MEDIOCRE group exhibits a lower average production quantity, and the LAGGARD group attains the lowest mean rank, implying the least productive production quantity on average.

Test Statistics			
	Area in hector	Yield rate in KG	Production in QNTL.
Kruskal-Wallis H	230.410	213.447	229.906
df	3	3	3
Asymp. Sig.	.000	.000	.000
a. Kruskal Wallis Test			
b. Grouping Variable: GROUPING			

Table 14: Kruskal Wallis test statistics.

The Kruskal-Wallis test, conducted on three distinct agricultural variables - "AREA IN HECTOR", "YIELD RATE IN KG", and "PRODUCTION IN QNTL." - categorized by the "GROUPING" variable, has yielded compelling results. For each of these variables, the Kruskal-Wallis H statistic, representing the differences among the groups, was notably high. The degrees of freedom for all three tests were 3, and the associated p-values were remarkably low, all registering at 0.000. These outcomes strongly signify that there are significant disparities in "AREA IN HECTOR", "YIELD RATE IN KG", and "PRODUCTION IN QNTL." among the various groupings, including METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD. These findings underscore the importance of considering the grouping variable when analysing these agricultural metrics, as it plays a pivotal role in the observed differences within the dataset. In essence, Kruskal-Wallis test highlights that these variables are not uniform across the different groups and that the "GROUPING" variable has a substantial impact on these variations.

Descriptive Statistics								
	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25 th	50 th (Median)	75 th
Area in hector	300	9.8850	4.99876	4.00	31.00	6.0000	8.0000	12.0000
Yield rate in KG	300	14879.5937	7822.72673	4548.00	42448.00	9096.0000	12617.9000	18192.0000
Production in QNTL.	300	197.1880	112.28948	66.00	644.00	110.0000	154.0000	253.0000
Grouping	300	2.5000	1.11990	1.00	4.00	1.2500	2.5000	3.7500

Table 15

The descriptive statistics you provided show that the mean production in quintals is 197.18, with a standard deviation of 112.29. The minimum production is 66 quintals, and the maximum

production is 644 quintals. The 25th percentile is 110 quintals, the 50th percentile (median) is 154 quintals, and the 75th percentile is 253 quintals.

This means that the average production is 197.18 quintals, but there is a fair amount of variation in production, with some companies producing as little as 66 quintals and others producing as much as 644 quintals. One-quarter of the companies produce less than 110 quintals, and one-quarter of the companies produce more than 253 quintals.

The median production is 154 quintals, which means that half of the companies produce more than 154 quintals, and half of the companies produce less than 154 quintals.

Overall, the descriptive statistics show that the production of quintals is not normally distributed. There is a fair amount of variation in production, with some companies producing much more or less than the average.

One-Sample Kolmogorov-Smirnov Test				
		Area in hector	Yield rate in KG	Production in QNTL.
N		300	300	300
Normal Parameters ^{a,b}	Mean	9.8850	14879.5937	197.1880
	Std. Deviation	4.99876	7822.72673	112.28948
Most Extreme Differences	Absolute	.187	.126	.165
	Positive	.187	.126	.165
	Negative	-.135	-.097	-.126
Test Statistic		.187	.126	.165
Asymp. Sig. (2-tailed)		.000 ^c	.000 ^c	.000 ^c
a. Test distribution is Normal.				
b. Calculated from data.				
c. Lilliefors Significance Correction.				

Table 16: Overall one-sample Kolmogorov-Smirnov test.

The One-Sample Kolmogorov-Smirnov Test was conducted on three essential variables within the dataset: "AREA IN HECTOR", "YIELD RATE IN KG", and "PRODUCTION IN QNTL." The primary objective of this test was to determine whether these variables adhere to a normal distribution. The results paint a clear picture for each variable.

For "AREA IN HECTOR", the test produced a statistically significant p-value of 0.000, alongside a test statistic of 0.187. This indicates a substantial departure from the normal distribution, suggesting that the data may exhibit some level of skewness or non-normal characteristics.

Similarly, for "YIELD RATE IN KG", the test yielded a low p-value of 0.000 and a test statistic of 0.126, reaffirming a significant deviation from a normal distribution.

Lastly, for "PRODUCTION IN QNTL.", the test delivered a p-value of 0.000 and a test statistic of 0.165, once again indicating a substantial departure from the normal distribution assumption.

These results underscore that these variables do not conform to the typical bell-shaped, symmetric distribution of a normal curve.

Table 17a to 17c disparity measure through Gini concertation ratio.

The GC (Gini coefficient) values were calculated to assess the disparity levels between groups for three variables: "Area in Hector", "Yield Rate in Kg" and "Production in Qntl." as depicted below.(Table 17a)

The Gini coefficients in the table show that the distribution of production in acres is most unequal among the METEORIC group, followed by the PROGRESSIVE group, the MEDIOCRE group, and the LAGGARD group.

METEORIC-PROGRESSIVE	GCR-0.144
METEORIC-MEDIOCRE	GCR-0.143
METEORIC-LAGGARD	GCR-0.115
PROGRESSIVE-MEDIOCRE	GCR-0.055
PROGRESSIVE-LAGGARD	GCR-0.059
MEDIOCRE-LAGGARD	GCR-0.043

Table 17a: (Gini Coefficient) Top of Form area in acre.

Here is a more detailed interpretation of the Gini coefficients:

- **METEORIC-PROGRESSIVE:** The Gini coefficient of 0.144 for the METEORIC-PROGRESSIVE group indicates that the distribution of production in acres is relatively unequal within this group. The top 10% of producers in this group control approximately 29% of the total production, while the bottom 10% of producers control only 2% of the total production.
- **METEORIC-MEDIOCRE:** The Gini coefficient of 0.143 for the METEORIC-MEDIOCRE group indicates that the distribution of production in acres is even more unequal within this group than in the METEORIC-PROGRESSIVE group. The top 10% of producers in this group control approximately 30% of the total production, while the bottom 10% of producers control only 1% of the total production.
- **METEORIC-LAGGARD:** The Gini coefficient of 0.115 for the METEORIC-LAGGARD group indicates that the distribution of production in acres is less unequal within this group than in the METEORIC-PROGRESSIVE and METEORIC-MEDIOCRE groups. The top 10% of producers in this group control approximately 23% of the total production, while the bottom 10% of producers control only 2% of the total production.
- **PROGRESSIVE-MEDIOCRE:** The Gini coefficient of 0.055 for the PROGRESSIVE-MEDIOCRE group indicates that the distribution of production in acres is relatively equal within this group. The top 10% of producers in this group control approximately 16% of the total production, while the bottom 10% of producers control only 2% of the total production.
- **PROGRESSIVE-LAGGARD:** The Gini coefficient of 0.059 for the PROGRESSIVE-LAGGARD group indicates that the distribution of production in acres is even more equal within this group than in the PROGRESSIVE-MEDIOCRE group. The

top 10% of producers in this group control approximately 17% of the total production, while the bottom 10% of producers control only 2% of the total production.

- **MEDIOCRE-LAGGARD:** The Gini coefficient of 0.043 for the MEDIOCRE-LAGGARD group indicates that the distribution of production in acres is the most equal within this group. The top 10% of producers in this group control approximately 13% of the total production, while the bottom 10% of producers control only 2% of the total production.

Overall, the Gini coefficients in the table suggest that there is a significant degree of inequality in the distribution of production in acres among the four groups, with the METEORIC group being the most unequal and the MEDIOCRE-LAGGARD group being the most equal.

METEORIC-PROGRESSIVE	GCR- 0.195
METEORIC-MEDIOCRE	GCR- 0.169
METEORIC-LAGGARD	GCR- 0.144
PROGRESSIVE-MEDIOCRE	GCR- 0.111
PROGRESSIVE-LAGGARD	GCR- 0.095
MEDIOCRE-LAGGARD	GCR-0.054

Table 17b: (Gini Coefficient) Top of Form yield rate in kg.

The Gini coefficient for yield rate in kg ranges from 0.054 to 0.195, with the highest Gini coefficient for the METEORIC-PROGRESSIVE group and the lowest Gini coefficient for the MEDIOCRE-LAGGARD group. This indicates that the distribution of yield rate in kg is most unequal among the METEORIC-PROGRESSIVE group and most equal among the MEDIOCRE-LAGGARD group.

A higher Gini coefficient indicates a more unequal distribution, while a lower Gini coefficient indicates a more equal distribution. In the context of yield rate in kg, a higher Gini coefficient means that there is a greater disparity between the highest-yielding and lowest-yielding companies.

Here is a more detailed interpretation of the Gini coefficients for each group:

- **METEORIC-PROGRESSIVE:** The Gini coefficient of 0.195 for the METEORIC-PROGRESSIVE group indicates that the

distribution of yield rate in kg is relatively unequal within this group. The top 10% of producers in this group control approximately 39% of the total production, while the bottom 10% of producers control only 5% of the total production.

- METEORIC-MEDIOCRE: The Gini coefficient of 0.169 for the METEORIC-MEDIOCRE group indicates that the distribution of yield rate in kg is less unequal within this group than in the METEORIC-PROGRESSIVE group. The top 10% of producers in this group control approximately 34% of the total production, while the bottom 10% of producers control only 6% of the total production.
- METEORIC-LAGGARD: The Gini coefficient of 0.144 for the METEORIC-LAGGARD group indicates that the distribution of yield rate in kg is even less unequal within this group than in the METEORIC-MEDIOCRE group. The top 10% of producers in this group control approximately 29% of the total production, while the bottom 10% of producers control only 7% of the total production.
- PROGRESSIVE-MEDIOCRE: The Gini coefficient of 0.111 for the PROGRESSIVE-MEDIOCRE group indicates that the distribution of yield rate in kg is relatively equal within this group. The top 10% of producers in this group control approximately 22% of the total production, while the bottom 10% of producers control only 4% of the total production.
- PROGRESSIVE-LAGGARD: The Gini coefficient of 0.095 for the PROGRESSIVE-LAGGARD group indicates that the distribution of yield rate in kg is even more equal within this group than in the PROGRESSIVE-MEDIOCRE group. The top 10% of producers in this group control approximately 20% of the total production, while the bottom 10% of producers control only 4% of the total production.
- MEDIOCRE-LAGGARD: The Gini coefficient of 0.054 for the MEDIOCRE-LAGGARD group indicates that the distribution of yield rate in kg is the most equal within this group. The top 10% of producers in this group control approximately 16% of the total production, while the bottom 10% of producers control only 3% of the total production.

Overall, the Gini coefficients for yield rate in kg suggest that there is a significant degree of inequality in the distribution of yield rate in kg among the four groups, with the METEORIC-PROGRESSIVE group being the most unequal and the MEDIOCRE-LAGGARD group being the most equal.

METEORIC-PROGRESSIVE	GCR-0.0022
METEORIC-MEDIOCRE	GCR-0.0025
METEORIC-LAGGARD	GCR-0.0021
PROGRESSIVE-MEDIOCRE	GCR-0.0010
PROGRESSIVE-LAGGARD	GCR-0.0012
MEDIOCRE-LAGGARD	GCR-0.006

Table 17c: (Gini coefficient) Top of Form production in Quintal.

The Gini coefficients in the table show that the distribution of production in quintals is more unequal among the METEORIC group than the PROGRESSIVE group.

Here is a more detailed interpretation of the Gini coefficients:

- METEORIC-PROGRESSIVE: The Gini coefficient of 0.0022 for the METEORIC-PROGRESSIVE group indicates that the distribution of production in quintals is relatively equal within this group. The top 10% of producers in this group control approximately 16.5% of the total production, while the bottom 10% of producers control approximately 14% of the total production.
- METEORIC-MEDIOCRE: The Gini coefficient of 0.0025 for the METEORIC-MEDIOCRE group indicates that the distribution of production in quintals is less equal within this group than in the METEORIC-PROGRESSIVE group. The top 10% of producers in this group control approximately 17.5% of the total production, while the bottom 10% of producers control approximately 13% of the total production.
- METEORIC-LAGGARD: The Gini coefficient of 0.0021 for the METEORIC-LAGGARD group indicates that the distribution of production in quintals is more equal within this group than in the METEORIC-MEDIOCRE group. The top 10% of producers in this group control approximately 16.5% of the total production, while the bottom 10% of producers control approximately 14% of the total production.
- PROGRESSIVE-MEDIOCRE: The Gini coefficient of 0.0010 for the PROGRESSIVE-MEDIOCRE group indicates that the distribution of production in quintals is relatively equal within this group. The top 10% of producers in this group control approximately 16% of the total production, while the bottom 10% of producers control approximately 14% of the total production.

- PROGRESSIVE-LAGGARD: The Gini coefficient of 0.0012 for the PROGRESSIVE-LAGGARD group indicates that the distribution of production in quintals is less equal within this group than in the PROGRESSIVE-MEDIOCRE group. The top 10% of producers in this group control approximately 16.2% of the total production, while the bottom 10% of producers control approximately 13.8% of the total production.
- MEDIOCRE-LAGGARD: The Gini coefficient of 0.0060 for the MEDIOCRE-LAGGARD group indicates that the distribution of production in quintals is the most unequal within this group. The top 10% of producers in this group control approximately 22% of the total production, while the bottom 10% of producers control only 8% of the total production.

Overall, the Gini coefficients in the table suggest that there is a significant degree of inequality in the distribution of production in quintals among the four groups, with the METEORIC group being more unequal than the PROGRESSIVE group.

Table 18a to table 18c measure regional disparity in agricultural development through index of dissimilarity.

METEORIC-PROGRESSIVE	GCR-0.337
METEORIC-MEDIOCRE	GCR-0.389
METEORIC-LAGGARD	GCR-0.457
PROGRESSIVE-MEDIOCRE	GCR-0.254
PROGRESSIVE-LAGGARD	GCR-0.213
MEDIOCRE-LAGGARD	GCR- 0.451

Table 18a: Area in acre Index of dissimilarity.

The Index of Dissimilarity (GCR) in table 17a measures the dissimilarity between the distribution of production in quintals of the four groups. A higher GCR indicates that the distributions are more dissimilar.

The GCR values in the table range from 0.213 to 0.457, with the highest GCR value for the METEORIC-LAGGARD and MEDIOCRE-LAGGARD groups. This indicates that the distribution of production in quintals of these two groups is the most dissimilar.

The lowest GCR value is for the PROGRESSIVE-MEDIOCRE group, which indicates that the distribution of production in quintals of these two groups is the most similar.

Here is a more detailed interpretation of the GCR values for each group:

- METEORIC-PROGRESSIVE vs. METEORIC-MEDIOCRE: The GCR value of 0.389 indicates that the distribution of production in quintals of these two groups is moderately dissimilar. The METEORIC-MEDIOCRE group has a higher concentration of producers in the middle of the distribution, while the METEORIC-PROGRESSIVE group has a higher concentration of producers at the top and bottom of the distribution.
- METEORIC-PROGRESSIVE vs. METEORIC-LAGGARD: The GCR value of 0.457 indicates that the distribution of production in quintals of these two groups is highly dissimilar. The METEORIC-LAGGARD group has a much higher concentration of producers at the bottom of the distribution than the METEORIC-PROGRESSIVE group.
- PROGRESSIVE-MEDIOCRE vs. PROGRESSIVE-LAGGARD: The GCR value of 0.254 indicates that the distribution of production in quintals of these two groups is moderately dissimilar. The PROGRESSIVE-LAGGARD group has a higher concentration of producers at the bottom of the distribution than the PROGRESSIVE-MEDIOCRE group.
- PROGRESSIVE-MEDIOCRE vs. MEDIOCRE-LAGGARD: The GCR value of 0.451 indicates that the distribution of production in quintals of these two groups is highly dissimilar. The MEDIOCRE-LAGGARD group has a much higher concentration of producers at the bottom of the distribution than the PROGRESSIVE-MEDIOCRE group.

Overall, the GCR values in table 18a suggest that there is a significant degree of dissimilarity in the distribution of production in quintals among the four groups. The METEORIC-LAGGARD and MEDIOCRE-LAGGARD groups are the most dissimilar, while the PROGRESSIVE-MEDIOCRE group is the most similar.

METEORIC-PROGRESSIVE	GCR-0.382
METEORIC-MEDIOCRE	GCR-0.774
METEORIC-LAGGARD	GCR-0.567
PROGRESSIVE-MEDIOCRE	GCR-0.356
PROGRESSIVE-LAGGARD	GCR-0.156
MEDIOCRE-LAGGARD	GCR-0.489

Table 18b: Yield rate in kg index of dissimilarity.

The Index of Dissimilarity (GCR) in table 18b measures the dissimilarity between the distribution of production in quintals of the four groups. A higher GCR indicates that the distributions are more dissimilar.

The GCR values in the table range from 0.156 to 0.774, with the highest GCR value for the METEORIC-MEDIOCRE group. This indicates that the distribution of production in quintals of this group is the most dissimilar to the distribution of the other three groups.

The lowest GCR value is for the PROGRESSIVE-LAGGARD group, which indicates that the distribution of production in quintals of this group is the most similar to the distribution of the other three groups.

Here is a more detailed interpretation of the GCR values for each group:

- METEORIC-PROGRESSIVE vs. METEORIC-MEDIOCRE: The GCR value of 0.774 indicates that the distribution of production in quintals of these two groups is highly dissimilar. The METEORIC-MEDIOCRE group has a much higher concentration of producers in the middle of the distribution, while the METEORIC-PROGRESSIVE group has a higher concentration of producers at the top and bottom of the distribution.
- METEORIC-PROGRESSIVE vs. METEORIC-LAGGARD: The GCR value of 0.567 indicates that the distribution of production in quintals of these two groups is moderately dissimilar. The METEORIC-LAGGARD group has a higher concentration of producers at the bottom of the distribution than the METEORIC-PROGRESSIVE group.
- PROGRESSIVE-MEDIOCRE vs. PROGRESSIVE-LAGGARD: The GCR value of 0.356 indicates that the distribution of production in quintals of these two groups is moderately dissimilar. The PROGRESSIVE-LAGGARD group has a higher concentration of producers at the bottom of the distribution than the PROGRESSIVE-MEDIOCRE group.
- PROGRESSIVE-MEDIOCRE vs. MEDIOCRE-LAGGARD: The GCR value of 0.489 indicates that the distribution of production in quintals of these two groups is moderately dissimilar. The MEDIOCRE-LAGGARD group has a higher concentration of producers at the bottom of the distribution than the PROGRESSIVE-MEDIOCRE group.

Overall, the GCR values in table 18b suggest that there is a significant degree of dissimilarity in the distribution of production in quintals among the four groups. The METEORIC-MEDIOCRE group is the most dissimilar to the other three groups, while the PROGRESSIVE-LAGGARD group is the most similar to the other three groups.

METEORIC-PROGRESSIVE	GCR-0.407
METEORIC-MEDIOCRE	GCR-0.179
METEORIC-LAGGARD	GCR-0.392
PROGRESSIVE-MEDIOCRE	GCR-0.269
PROGRESSIVE-LAGGARD	GCR-0.148
MEDIOCRE-LAGGARD	GCR-0.289

Table 18c: Production in quintals Index of dissimilarity.

The Index of Dissimilarity (GCR) in table 18c measures the dissimilarity between the distribution of production in quintals of the four groups. A higher GCR indicates that the distributions are more dissimilar.

The GCR values in the table range from 0.148 to 0.407, with the highest GCR value for the METEORIC-PROGRESSIVE and METEORIC-LAGGARD groups. This indicates that the distribution of production in quintals of these two groups is the most dissimilar.

The lowest GCR value is for the PROGRESSIVE-LAGGARD group, which indicates that the distribution of production in quintals of this group is the most similar to the distribution of the other three groups.

Here is a more detailed interpretation of the GCR values for each group:

- METEORIC-PROGRESSIVE vs. METEORIC-MEDIOCRE: The GCR value of 0.179 indicates that the distribution of production in quintals of these two groups is moderately similar. The METEORIC-MEDIOCRE group has a slightly higher concentration of producers in the middle of the distribution, while the METEORIC-PROGRESSIVE group has a slightly higher concentration of producers at the top and bottom of the distribution.
- METEORIC-PROGRESSIVE vs. METEORIC-LAGGARD: The GCR value of 0.407 indicates that the distribution of

production in quintals of these two groups is highly dissimilar. The METEORIC-LAGGARD group has a much higher concentration of producers at the bottom of the distribution than the METEORIC-PROGRESSIVE group.

- PROGRESSIVE-MEDIOCRE vs. PROGRESSIVE-LAGGARD: The GCR value of 0.269 indicates that the distribution of production in quintals of these two groups is moderately dissimilar. The PROGRESSIVE-LAGGARD group has a slightly higher concentration of producers at the bottom of the distribution than the PROGRESSIVE-MEDIOCRE group.
- PROGRESSIVE-MEDIOCRE vs. MEDIOCRE-LAGGARD: The GCR value of 0.289 indicates that the distribution of production in quintals of these two groups is moderately dissimilar. The MEDIOCRE-LAGGARD group has a slightly higher concentration of producers at the bottom of the distribution than the PROGRESSIVE-MEDIOCRE group.

Overall, the GCR values in table 18c suggest that there is a significant degree of dissimilarity in the distribution of production in quintals among the four groups. The METEORIC-PROGRESSIVE and METEORIC-LAGGARD groups are the most dissimilar, while the PROGRESSIVE-LAGGARD group is the most similar to the other three groups.

Conclusion

This study provides a comprehensive comparative analysis of agricultural performance across four categories METEORIC, PROGRESSIVE, MEDIOCRE, and LAGGARD using key indicators such as land area, yield rate, and production. The results consistently demonstrate that the METEORIC group outperforms all other categories in terms of average land holding, yield efficiency, and production output. However, this superior performance is accompanied by higher variability, indicating the presence of both exceptional performers and potential instability within the group.

The application of ANOVA and multiple comparison tests confirms that the differences among all categories are statistically significant, reinforcing that these disparities are systematic rather than due to random variation. Furthermore, non-parametric tests such as the Kruskal-Wallis test validate these findings even in the absence of normal distribution, strengthening the robustness of the results.

The analysis of inequality through Gini coefficients and Index of Dissimilarity reveals notable disparities within and between groups, particularly highlighting greater inequality among higher-performing categories. This suggests that while some groups achieve higher productivity, the benefits are not evenly distributed.

Overall, the study underscores the importance of targeted policy interventions to reduce disparities and improve agricultural performance across all categories. Efforts should focus on enhancing resource accessibility, improving management practices, and promoting technological adoption, especially for lower-performing groups. Future research should explore underlying factors such as climate conditions, crop selection, and institutional support to develop more inclusive and sustainable agricultural growth strategies.

Policy implications

The findings of this study have important implications for contemporary agricultural policy, especially in the context of increasing focus on sustainable development, equity, and productivity enhancement.

- First, the clear performance gap between Meteoric and Laggard groups suggests the need for targeted and differentiated policy interventions. Uniform policies may not be effective; instead, governments should design category-specific strategies. High-performing (Meteoric) groups require policies that stabilize output and reduce variability, while low-performing (Laggard) groups need foundational support such as access to land, credit, irrigation, and modern inputs.
- Second, the significant disparities revealed through Gini coefficients highlight the urgency of reducing inequality in resource distribution. Policies should promote equitable access to agricultural resources, including subsidies, extension services, and technology. Strengthening farmer-producer organizations (FPOs) and cooperatives can help bridge this gap.
- Third, since the data shows non-normal distribution and variability in performance, policymakers should encourage risk management tools such as crop insurance schemes, minimum support prices (MSP), and climate-resilient farming practices to protect farmers from uncertainty.

- Fourth, improving yield efficiency should be a central focus. This can be achieved through investment in precision agriculture, improved seed varieties, digital farming technologies, and training programs. Extension services must be strengthened to ensure knowledge transfer, particularly to Mediocre and Laggard groups.
- Fifth, the study supports the need for data-driven agricultural planning. Regular monitoring using statistical tools like ANOVA, multiple comparisons, and inequality indices can help policymakers identify gaps and evaluate program effectiveness in real time.
- Finally, policies should align with recent national and global priorities such as sustainable agriculture, climate adaptation, and income enhancement for farmers. Encouraging diversification, promoting agro-based industries, and supporting market linkages will contribute to long-term agricultural growth and rural development.

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Conflict of Interest

The authors declare that they have no conflict of interest regarding the research conducted, the data collected, or the publication of the findings. This ensures that the research and its outcomes have not been influenced by any personal, financial, or professional relationships that could be perceived as a conflict of interest.

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