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Correspondence Analysis to Know Factors Related to the Use of Reducant Herbicide on Pagaralam Coffee Farmers

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ABSTRACT

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Weed control is an attempt to care for agricultural land that can affect coffee production. This study aims to analyze the factors that have a relationship with the use of reductant herbicide in Pagaralam coffee farmers by using simple correspondence analysis. The research data included 19 variables and 3 categories of respondents based on the use of reductant herbicide, namely non-users, new users, and users. At the initial stage, each variable was carried out a mean difference test between 2 categories of respondents. Furthermore, each variable is divided into several categories. Then, by using the independence test, the categories of each variable are associated with the category of reductant use. There are 7 factors that have a relationship with the use of reductants, namely education of respondents, age of trees, length of harvest, frequency of herbicide use, frequency of chemical fertilizers used, frequency of organic fertilizers used, and number of labour outside the family (TL). The results of the correspondence analysis plot can show differences in the characteristics of the respondent's categories according to the use of reductant herbicide. The user category is dominantly characterized by having junior high school education, tree age more than 25 years, tend not to use organic fertilizer, and the harvest period can reach 3 months.

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1. Introduction

Indonesia's agricultural sector has an important role in improving the national economy. This role is able to absorb a lot of workers, earn foreign exchange, and contribute to national income [1]. Coffee plants are included in the plantation sub-sector in the agricultural sector which is one of the leading commodities as a contributor to the country's foreign exchange in addition to oil and gas. Indonesia is ranked 4th as a green bean producing country in the world after Brazil, Vietnam and Colombia. Based on data from the Directorate General of Plantations [2], 98% of the coffee area belongs to smallholder plantations. The coffee area in 2019 reached 1,245,368 hectares with coffee production reaching 752,511 tons.

South Sumatra is the largest robusta coffee producing province in Indonesia. South Sumatra has the characteristics of land area, coffee production, mature plant area, robusta area, and the highest robusta coffee production, immature plant area, damaged plant area, and a high number of farmers [3]. One of the coffee producer centers in South Sumatra is Pagaralam. Studies about cultural characteristics of Pagaralam coffee farming, factors that affect land productivity and farmers net income can be seen in [4] - [9].

The majority of Pagaralam coffee plants are more than 15 years old, so it is very necessary to take care of the land and proper plant care, so that these old plants can continue to produce optimally. This is also coupled with the condition of a fairly high tree density, with relatively close and irregular spacing of plants. Of course, this requires intensive care in the form of appropriate fertilization, rejuvenation, pruning of twigs, and weed control. Education on land care issues is very important, as in [10] - [14]. Farmers must also pay attention to the importance of shade trees with optimal numbers and according to their needs. Training materials for farmers about the importance of shade trees as a component in sustainable coffee cultivation also need to be done [15] - [16], especially for coffee farmers in South Sumatra [17]. Climate also affects the production of coffee plants [18] - [19]. One of the benefits of shade trees is that they help reduce the impact of uncertain temperature fluctuations, cool the air during the day and keep the farm warm at night, and reduce stress on the coffee plant.

Coffee cultivation in its development cannot be separated from pests and diseases that often attack and threaten its productivity, one of which is weeds. The use of herbicides with the right dose will kill weeds, but if applied inappropriately, namely not on target, right quality, right type, right time, right dose and right method of use (6T), then it can interfere and even kill cultivated plants [20] - [21]. Herbicides made from glyphosate enter the weed tissue and can also enter the coffee plant tissue, so those can reduce the quality of coffee [22]. Management policies and strategies in pest control are important for environmentally sustainable agriculture [23].

Based on [24] - [25], pesticide reductant is a product made from organic as a pesticide reducer. The use of reductants can still have the same effectiveness in eradicating weeds and have a positive impact on coffee plants. In addition, the reductant also does not have an impact on phytotoxicity and will reduce herbicide residues on the land so that it does not damage soil biota. In [26], the variables that have a significantly different mean between the categories of respondents from Pagaralam coffee farmers who use and farmers who do not use reductants are the average planting area per 1 tree, age of tree, maximum selling price of green beans, and number of workers. There was a relationship between the respondent's category and every category variable, including education, land conditions, frequency of herbicide use, number of workers, and length of harvest period. However, by using a multiple regression model, it was found that the factor of the use of reductant herbicide had no significant effect on the net income of coffee farmers [27].

Correspondence analysis is one of the techniques in multivariate analysis that is used to find the relationship between two data variables by displaying row and column categories simultaneously from a two-way contingency table in a low-dimensional vector space [28] - [29]. Correspondence analysis can be used for various bidirectional contingency tables, even though the cell frequency is relatively small. By correspondence analysis, it can be investigated the factors that affect coffee land productivity [6] and farmers' income [9]. The previous research on the characteristics of Pagaralam coffee farmers did not discuss the relationship between the factors of the social, economic, and cultural background of farmers' farming, and also the condition of the land on the factor of the use of reductant herbicide. In addition, the division of farmer categories based on the use of reductant herbicide is only divided into 2, namely users and non-users of reductants.

This study aims to determine the factors that have a relationship with the use reductant herbicide in Pagaralam coffee farmers by using simple correspondence analysis. The number of factors used in this study were 19 factors. Categorization of farmers based on the use of reductants is divided into 3 categories, namely users, new users, and non-users. In the early stages of data processing, descriptive statistics and mean difference tests were also carried out on the comparison of each of the 2 categories of respondents, so that the results could be compared with the results of the correspondence analysis. This study only displayed the output graph of the correspondence analysis on the variables related to the respondent's category only or the variables whose mean is significantly different in the results of the mean difference test. The graph of the results of the correspondence analysis can provide an overview and analysis of the typical characteristics of the social, economic, farming culture, and land conditions of coffee farmers based on the use of reductant herbicide in the effort to maintain coffee plantations. It can also interpret the motivation background of farmers to use reductant herbicide.

2. Research Methods

This study is primary data obtained from questionnaires on coffee farmers in Pagaralam Municipality. Respondents were taken as samples by purposive sampling. Based on the use of reductant herbicide, Pagaralam coffee farmers are divided into 3 categories, namely farmers who do not use reductant herbicide, farmers who are new to using reductant herbicide, and farmers who use reductant herbicide. Farmers who are categorized as users are farmers who have applied the use of reductants more than 3 times. On the other hand, farmers who are categorized as new user are farmers who apply the use of reductants 1 to 2 times. The number of respondents studied were 165 people. There are 19 variables studied. Furthermore, this variable data is also divided into categories. The steps taken include:

1. Do descriptive statistics
2. Perform mean difference test on each variable by using the Z test, namely by the equation

$$\boldsymbol{Z} = \frac{\overline{x_1}-\overline{x_2}}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}} \tag{1}$$

where $\overline{\boldsymbol{x_1}}$ is mean of sample taken from population 1; $\overline{\boldsymbol{x_2}}$ is mean of samples taken from population 2; $\boldsymbol{s_1^2}$ is variance of sample 1; $\boldsymbol{s_2^2}$ is variance of sample 2; $\boldsymbol{n_1}$ is number of samples taken from population 1; and $\boldsymbol{n_2}$: number of samples taken from population 2 [30] - [32].

The mean difference test is based on $\boldsymbol{H_0}$: the sample mean of the two populations is the same. If $|\boldsymbol{Z_{count}}| \geq \mathbf{Z_{table}}$ or if Sig. < 0.05 then reject $\boldsymbol{H_0}$.

3. Converting each variable's data into row categories.
4. Defining categories of respondents based on the use of reductant herbicide as column variables.
5. Arranging the data for each row variable in the form of a contingency table as shown in Table 1.

Table 1. Contingency table $a \times b$

Variable	Column Variable					
	$\boldsymbol{Y_1}$	...	$\boldsymbol{Y_j}$	...	$\boldsymbol{Y_b}$	**Total row**
$\boldsymbol{X_1}$	n_{11}	...	n_{1j}	...	n_{1b}	$n_{1.}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮
$\boldsymbol{X_i}$	n_{i1}	...	n_{ij}	...	n_{ib}	$n_{i.}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮
$\boldsymbol{X_a}$	n_{a1}	...	n_{aj}	...	n_{ab}	$n_{a.}$
Total column	$n_{.1}$	...	$n_{.j}$	...	$n_{.b}$	$n_{..}$

where

$n_{i.} = \sum_{j=1}^{b} n_{ij}$; $i = 1,2,\dots,a$ (total row)

$n_{.j} = \sum_{i=1}^{a} n_{ij}$; $j = 1,2,\dots,b$ (total column)

$n_{..} = \sum_{i=1}^{a}\sum_{j=1}^{b} n_{ij}$ (total frequency of observations)

n_{ij} : Frequency of observations of the i-th row and j-th column.

Table 1 can be arranged in the form of a correspondence matrix $\mathrm{P} = (p_{ij})$ with $p_{ij} = \frac{n_{ij}}{n_{..}}$ (2)

6. Performing the independence test with the chi square test statistic, with these steps:

a. Formulate hypotheses H_0 and H_1

H_0 : There is no significant effect between the two variables.

H_1 : There is a significant effect between the two variables.

b. Determine the expected frequency value (e_{ij}):

$$e_{ij} = \frac{(total\ row)(total\ column)}{total\ observations} = \frac{(n_{i.})(n_{.j})}{n_{..}} \tag{3}$$

c. Calculate chi-square test statistics:

$$\chi^2 = \sum_{j=1}^{b}\sum_{i=1}^{a}\frac{(o_{ij}-e_{ij})^2}{e_{ij}} \tag{4}$$

o_{ij} : the observation value of the i-th row and j-th column

e_{ij} : the expected value of the i-th row and j-th column j; $i = 1, 2, \ldots, a$; $j = 1, 2, \ldots, b$. [29]-[32]

Determining the value of χ^2_{tabel}; with a significance level of $\alpha = 0.05$ and with degrees of freedom $df = (a-1)(b-1)$.

d. Determining the test criteria, that is, if $\chi^2_{count} \geq \chi^2_{\text{table}}$ or if Sig. < 0.05 then reject H_0. Otherwise, accept H_0.

e. Making decision results.

7 Perform a simple correspondence analysis, with steps:

a. Interpretation Step 6.

b. Calculate the total inertia of the first two largest inertia values. The inertia value states the amount of contribution made by each of the first and second dimensions.

c. Define row profile and column profile matrices.

d. Defines the i-th row profile and j-th column profile.

e. Displays the visualization of row profiles and column profiles from Step 7.4 into 2-dimensional Euclid space by chi-square distance approach.

f. Interpret symmetric and asymmetric plots.

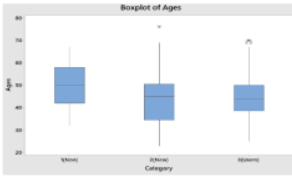
Symmetric plots are used to interpret the distance between row points and between column points, but the distance between row points and column points cannot be interpreted. The relationship between variables can also be seen from the distribution of the points in the graph, if the points spread further from the center of the coordinates, it means that there is a relationship between the two variables. While asymmetric plots can interpret the distance between row points and column points but the distance between column points or the distance between row points cannot be interpreted [29], [33].

The steps in this study were assisted by using the Minitab 19 software.

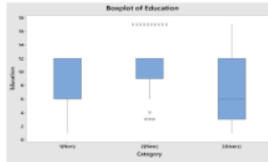
8. Interpretation of results.

3. Results And Discussion

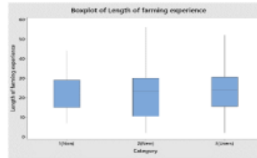
According to the use of reductant herbicide factors, respondents were divided into 3 categories, namely non-users denoted by “1”, new users denoted by “2”, and users denoted by “3”. Descriptive statistics of 19 variables in the three categories of respondents can be seen in the boxplot form in Figure 1. Furthermore, the categories of respondents based on the use of reductant herbicide are referred to as non-users, new users, and users.



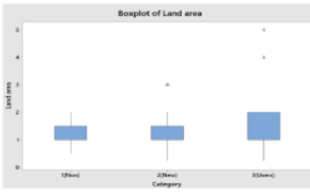
(a) Boxplot of age



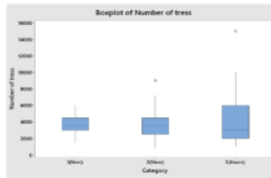
(b) Boxplot of education



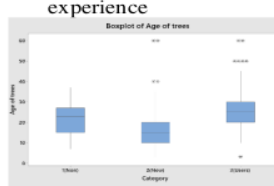
(c) Boxplot of length of farming experience



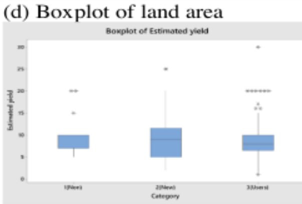
(d) Boxplot of land area



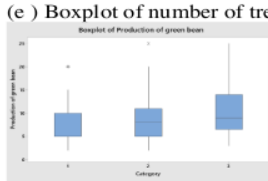
(e) Boxplot of number of trees



(f) Boxplot of age of trees

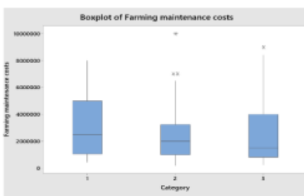


(g) Boxplot of estimated yield



(h) Boxplot of production of green bean

(i) Boxplot of total harvest

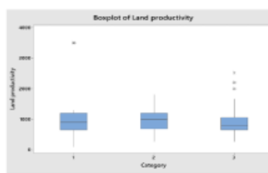


(j) Boxplot of farming maintenance cost

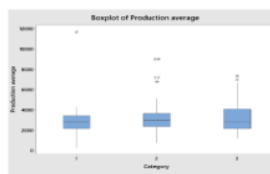
(k) Boxplot of gross income

(l) Boxplot of number of TL

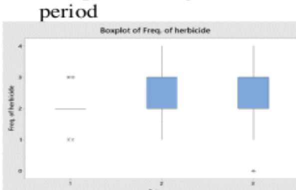
(m) Boxplot of length of harvest period



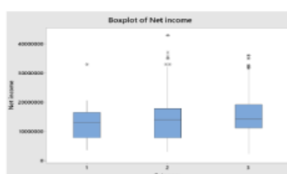
(n) Boxplot of land productivity



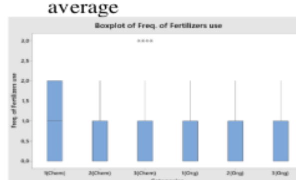
(o) Boxplot of production average



(p) Boxplot of freq. of herbicide use



(q) Boxplot of net income



(r) Boxplot of freq. of chemical and organic fertilizers use

Figure 1. Boxplot of 19 Variables Based on Reductant Herbicide Use

The boxplot in Figure 1 shows the median, Q1, Q3, the presence of data symmetry, and the presence of outliers for each category of respondents. If the median is around the middle of the box between Q1 and Q3, it can be said that the data is symmetrical with 25% of the data are between Q1 and the median and also 25% between the median and Q3. The plot represents that the data lies in the range (Q1 -1.5 (Q3-Q1)) to Q1 or lies in Q3 to (Q3+ 1.5 (Q3 -Q1)). Meanwhile, if the data is located less than (Q1 -1.5 (Q3-Q1)) or more than Q3+ 1.5 (Q3 -Q1), then the data are outliers. Box, plot, and outlier representations of the three categories can be compared. The largest box states that 50% of the range of variable values is greater. While, the comparison of the mean was using Equation (1). The recapitulation of the results of the mean difference test between each of the 2 categories of respondents can be seen in Table 2.

Table 2. Comparison of the mean and the results of the mean difference test

Variable	Category	Mean	StDev	Comparison	Z value	Test result
Ages	1	49.13	10.33	1 and 2	1.65	*Accept H_0
	2	44.12	11.98	2 and 3	-0.40	Accept H_0
	3	44.86	10.57	1 and 3	1.47	Accept H_0
Education	1	7.533	3.815	1 and 2	-2.96	**Reject** H_0
	2	10.739	3.776	2 and 3	5.05	**Reject** H_0
	3	7.259	4.658	1 and 3	0.25	Accept H_0
Length of farming experience	1	23.07	10.99	1 and 2	0.49	Accept H_0
	2	21.51	12.43	2 and 3	-1.24	Accept H_0
	3	23.91	11.07	1 and 3	-0.27	Accept H_0
Land area	1	1.167	0.523	1 and 2	-0.09	Accept H_0
	2	1.1812	0.5572	2 and 3	-1.51	Accept H_0
	3	1.3426	0.7494	1 and 3	-1.11	Accept H_0
Number of tress	1	3600	1391	1 and 2	-0.18	Accept H_0
	2	3675	1769	2 and 3	-0.73	Accept H_0
	3	3933	2512	1 and 3	-0.73	Accept H_0
Age of trees	1	21.80	8.07	1 and 2	1.74	*Accept H_0
	2	17.51	10.97	2 and 3	-4.58	**Reject** H_0
	3	26.00	11.73	1 and 3	-1.71	*Accept H_0
Estimated yield	1	10.47	4.58	1 and 2	0.86	Accept H_0
	2	9.300	5.537	2 and 3	-0.37	Accept H_0
	3	9.623	5.154	1 and 3	0.64	Accept H_0
Freq. of herbicide use	1	2.000	0.535	1 and 2	-0.70	Accept H_0
	2	2.1159	0.7580	2 and 3	-2.00	**Reject** H_0
	3	2.3580	0.7125	1 and 3	-2.25	**Reject** H_0
Freq. of chemical fertilizer use	1	1.200	0.862	1 and 2	2.31	**Reject** H_0
	2	0.6522	0.6823	2 and 3	-0.77	Accept H_0
	3	0.753	0.916	1 and 3	1.83	*Accept H_0
Freq. of organic fertilizer	1	0.467	0.743	1 and 2	0.89	Accept H_0
	2	0.2899	0.4570	2 and 3	-3.59	**Reject** H_0
	3	0.6420	0.7299	1 and 3	-0.84	Accept H_0
Production of green bean	1	9.13	4.47	1 and 2	-0.02	Accept H_0
	2	9.159	5.403	2 and 3	-0.92	Accept H_0
	3	9.951	5.012	1 and 3	-0.64	Accept H_0
Total harvest	1	10.24	4.98	1 and 2	-0.57	Accept H_0
	2	11.069	5.499	2 and 3	-0.01	Accept H_0
	3	11.077	5.542	1 and 3	-0.59	Accept H_0
Farming maintenance costs	1	3140667	2507835	1 and 2	1.13	Accept H_0
	2	2361957	1961376	2 and 3	-0.53	Accept H_0
	3	2541198	2212602	1 and 3	0.87	Accept H_0
Gross income	1	16600000	8570381	1 and 2	-0.45	Accept H_0
	2	17742754	10412349	2 and 3	-0.75	Accept H_0
	3	18970370	9624369	1 and 3	-0.96	Accept H_0
Pendapatan bersih	1	13459333	7021972	1 and 2	-0.82	Accept H_0
	2	15211071	9347568	2 and 3	-0.56	Accept H_0
	3	16012259	7959745	1 and 3	-1.27	Accept H_0
Number of TL	1	3.47	4.49	1 and 2	1.03	Accept H_0
	2	2.232	2.702	2 and 3	-2.64	**Reject** H_0
	3	3.938	5.031	1 and 3	-0.36	Accept H_0
Length of harvest period	1	3.067	0.458	1 and 2	5.69	**Reject** H_0
	2	2.3043	0.5231	2 and 3	-5.88	**Reject** H_0
	3	2.8272	0.5655	1 and 3	1.79	*Accept H_0
Land productivity (kg/10,000 m^2)	1	1018	757	1 and 2	0.16	Accept H_0
	2	986.0	354.6	2 and 3	1.19	Accept H_0
	3	912.8	397.1	1 and 3	0.53	Accept H_0
Production average	1	3237	2532	1 and 2	-0.08	Accept H_0
	2	3289	1626	2 and 3	-0.06	Accept H_0
	3	3305	1442	1 and 3	-0.10	Accept H_0

*Note: The critical Z for α/2 = 5% is 1.65; α /2=2.5% is 1.96. The critical F value uses α = 5%. *Meaningly reject H_0 if α = 10% is used. The two-tailed hypothesis test on H_0 states that the mean of the two populations is the same. StDev: Standard deviation.*

By using a significance level of α = 5%, New users have the highest education, but the average length of harvest is the lowest compared to non-users and users. New users also have a significantly lower frequency of chemical fertilizer use than non-users. In addition, age of tree, frequency of organic fertilizers used, and the number of TL use on new users are lower than users. Users have the highest frequency of herbicide use significantly from non-users and new users. The age of tree, the use of organic fertilizer, the use of the number of TL and the length of harvest period for users were significantly higher than new users. Similarly, it can also be interpreted that non-users have significantly lower education than new users and also lower frequency of herbicide use than users. However, non-users had a significantly higher frequency of chemical fertilizers use and length of harvest time than new users.

Furthermore, by using a significance level of α= 10%, it means that non-users have the highest frequency of chemical fertilizers use and the longest harvest period, new users have the lowest length of harvest period, and users have the highest age of tree. Factors that can distinguish the characteristics of the three categories of respondents can be seen on the variables of education, age of tree, frequency of chemical fertilizers use, length of harvest, frequency of herbicide use, frequency of organic fertilizers use, and number of TL. The recapitulation of the results of the mean difference test can be seen in Table 5. The relationship of the variables studied with the factor of the use of reductant herbicide was further analyzed using correspondence analysis. These variables are divided into several categories as shown in Table 3.

Table 3. Categories of research variables

No.	Variable name	Measurement Scale	Category
1.	Age of respondent	Ordinal	1 : ≤ 30 years old 2 : (30, 40] years old 3 : (40, 50] years old 4 : > 50 years old
2.	Education	Ordinal	1 : ≤ SD (Elementary school) 2 : SMP (Junior High School) 3 : SMA (Senior High School) 4 : Undergraduate
	…		
19.	Production average (kg/10,000 trees)	Ordinal	1 : ≤ 1.500 Kg 2 : (1500, 3000] Kg 3 : (3000, 4500] Kg 4 : > 4500 Kg

Simple correspondence analysis was carried out to determine the relationship of each factor studied with the factor of the use of reductants graphically. The initial step is to make a contingency table as in Equation (2). Respondent data on the relationship between the age of respondent and the factor of the reductant herbicide use is presented in the two-way contingency table in Table 4.

Table 4. Contingency table of respondent age and the factor of reductant herbicide use

Age of respondent (in years)	Categories			Sum of rows
	Non-Users	New users	Users	
A1: ≤ 30	0	11	6	17
A2: (30, 40]	2	15	24	41
A3: (30, 40]	8	26	32	66
A4: > 50	5	17	19	41
Sum of columns	15	69	81	165

The expected value of observations can be obtained according to Equation (3). The value of χ^2 in Equation (4) is obtained at 7.412. The value of Nilai $\chi^2_{count} < \chi^2_{table\,(0.05,\ df=6)}$ (= 12.59) and p-value 0.284 > 0.05, so that the independence test results on the test statistic χ^2 is accepted H_0. In this case, there is no relationship between the age of respondent and the factor of the reductant herbicide use. Furthermore, with the same way was carried out on the relationship of other variables with the category of reductant herbicide use, so that the independence test results recapitulation was obtained as shown in Table 5.

Table 5. Recapitulation of the results of the mean difference test and chi-square test on variables related to the use of reductant herbicide

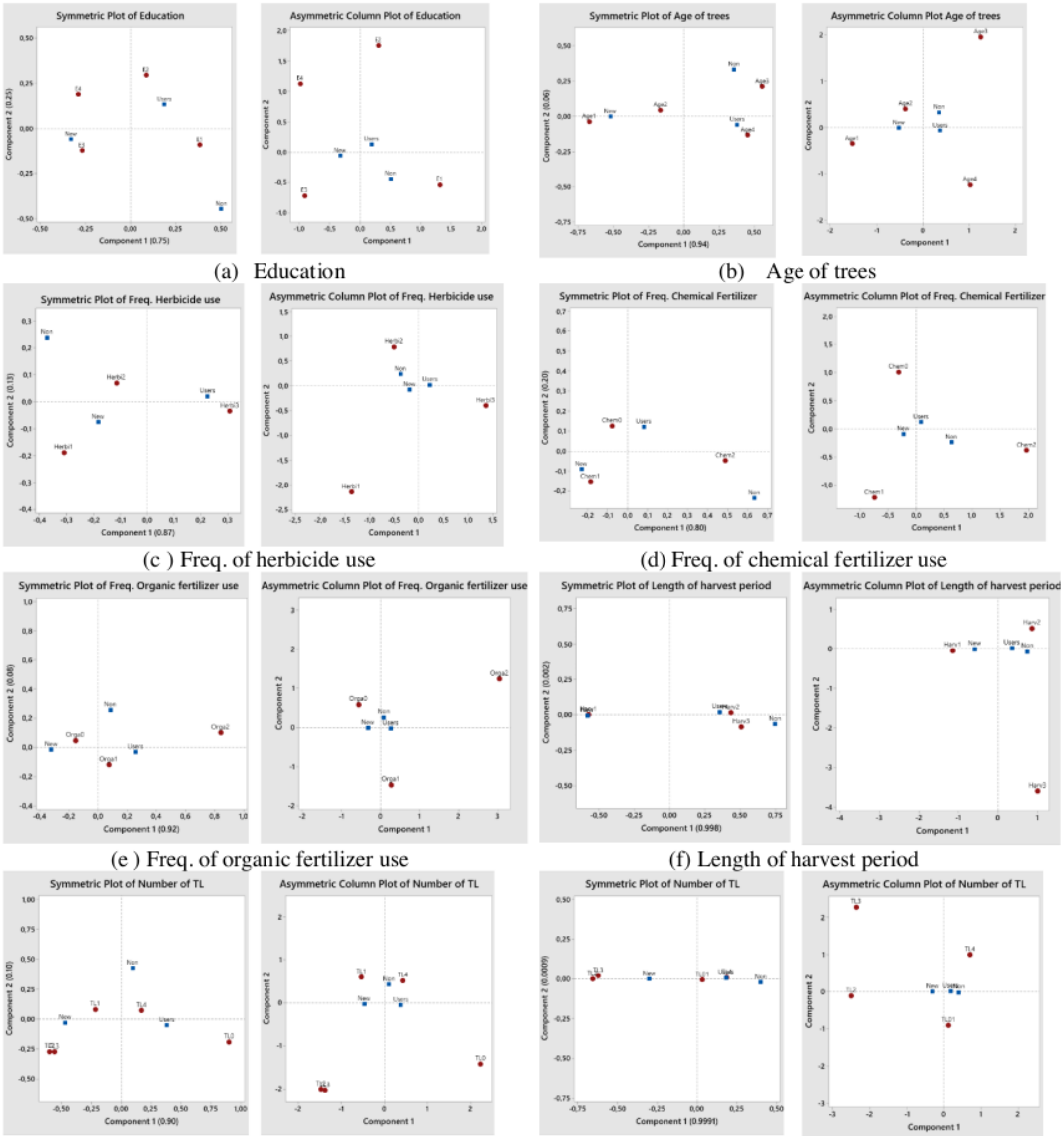
No.	Variable	Reject H_0 on mean difference test			χ^2_{count}	*df* (*a*-1)× 2	*p* value	Result of χ^2 test
		1 and 2	2 and 3	1 and 3				
1.	Age of respondent				7.41	6	0.284	Accept H_0
2.	Education	-	+		18.84	6	0.004	**Reject** H_0
3.	Length of farming experience				4.305	6	0.635	Accept H_0
4.	Land area				3.323	2 (conv.)	0.190	Accept H_0
5.	Number of trees				7.991	6	0.239	Accept H_0
6.	Age of tree		-		34.14	6	0.000	**Reject** H_0
7.	Estimated yield				10.35	6	0.111	Accept H_0
8.	Green bean production				5.377	6	0.496	Accept H_0
9.	Total harvest				1.931	6	0.926	Accept H_0
10.	Farming maintenance costs				8.650	8	0.373	Accept H_0
11.	Gross income				8.306	8	0.404	Accept H_0
12.	Number of workers outside family (TL)		-		30.05 24**	8 6 (conv.)	 0.000	* **Reject** H_0
13.	Length of harvest period	+	-		42.13	4	0.000	**Reject** H_0
14.	Land productivity				5.885	6	0.436	Accept H_0
15	Production average				2.420	4 (conv.)	0.659	Accept H_0
16.	Freq. of herbicide use		-	-	9.736	4 (conv.)	0.045	**Reject** H_0
17	Frequency of chemical fertilizer use	+			12.83	4 (conv.)	0.012	**Reject** H_0
18	Frequency of organic fertilizer use		-		13.76	4	0.008	**Reject** H_0
19	Net income				7.004	6	0.320	Accept H_0

*Note: The + and - signs indicate that the variables are significantly different in the mean difference test between the 2 categories of respondents. The + sign indicates that the mean of the first category of respondents is greater than the mean of the second category of respondents. The – sign is the other way around. Notation 1 as Non-Users; 2 as New Users; and 3 as Users. Conv. states that on the contingency table, categories are converted by merging the row variable categories (because of the cell frequency is less than 5). The * sign indicates that there is an amalgamation of respondent categories, i.e. non-users are merged with new-users.*

Based on the results of the chi-square test in Table 5, there are 7 factors that reject H_0, so that these factors are related to the use of reductant herbicide, namely the respondent's education, age of tree, number of TL, length of harvest period, frequency of herbicide use, frequency of chemical fertilizer use, and frequency of organic fertilizer use. In the frequency of use of herbicides variable there is a merging of categories 0 and 1. In the frequency of chemical fertilizer use variable there is a merging of categories 2 and 3. While for the number of TL variable there is a merging of categories 0 and 1.

There are as many as 12 factors whose chi square test results in accepting H_0, so that these factors had no relationship with the use of reductant herbicide. These factors are the age of the farmer, length of farming experience, land area, number of trees, estimated yield, green bean production, total harvest, land maintenance costs, gross income, net income, land productivity and production average. The variables related to the category of reductant herbicide use are the same as the results of the mean difference test. These variables become factors that differentiate the characteristics of the respondent categories based on the use of reductant herbicide.

Furthermore, by doing Step 7 and by using Minitab 19 software, a simple correspondence analysis output graph is obtained. Because the row variable has an ordinal scale, the category of each row is denoted in the order starting from 0 or starting from 1. While the respondent category notations are denoted as Non for non-users, New for new users, and Users. Figure 2 represent the output of symmetric and asymmetric plots of the variables significantly related to the use of reductant herbicide. The contribution by the first and second dimensions of the plot is expressed as the proportion between the sum of the squares of the first two inertia and the total inertia. The percentages of the first two inertia represent the amount of information from the representation of row and column profiles in two-dimensional Euclidean space.



(a) Education (b) Age of trees

(c) Freq. of herbicide use (d) Freq. of chemical fertilizer use

(e) Freq. of organic fertilizer use (f) Length of harvest period

(g) Number of TL (h) Number of TL after TL0 and TL1 are merged

Figure 2. Outcome Plots of Simple Correspondence Analysis

The total inertia of all plots in Figure 2 represents 100% of the information from the data. Based on Figures 2a to 2g, for symmetric plots, the categories of variables related to the use of reductant herbicide tend to spread from the center of the coordinates. While the symmetric plot of the Number of TL in Figure 2h tends to be parallel, because the total inertia of the first dimension is 99%.

In Figure 2a, the asymmetric column plot describes the relationship between the points of row categories (i. e. categories of education) and the points of column variables (ie categories of reductant herbicide use). Categories E3 and Non are adjacent and located in the same quadrant. Likewise, the position of Non and E1 and also the position of Users and E2. It can be interpreted that non-users tend to have level 1 education, i. e. up to elementary school level. New users tend to have level 3 education, namely up to high school level. Meanwhile, users tend to have level 2 education, which is up to junior high school level. Subsequent interpretations are carried out in the same way, so that the trend of the relationship between row variable categories and categories of reductant use can be recapitulated as shown in Table 6.

Table 6. Recapitulation of the tendency of the relationship between row and column variables in the plot results

No	Row Variable	Row variable category that related to the category of		
		Non-Users	New users	Users
1	Education	E1	**E3**	**E2**
2	Age of trees	Age3	Age2	**Age4**
3	Freq. of herbicide use	**H2**	**H1**	H3
4	Freq. of chemical fertilizer use	C2	**C1**	
5	Freq. of organic fertilizer use	Orga2	**Orga1**	**Orga0**
6	Length of harvest period		**Harv1**	**Harv2**
7	Number of TL	**TL4**	TL2 TL3	TL0
	Number of TL (converted)		TL2	**TL4**

Description: The bolded notation is the row category that is very close to the column variable

Table 6 interprets the closeness between the categories of row and column variables. Respondents who are non-users tend to be educated at the elementary level, have the age of coffee trees 20-25 years, the majority use herbicides 2 times in 1 harvest season (in 1 year), use chemical fertilizers and organic fertilizers each 2 times a year, and use TL greater than or equal to 4 people.

Respondents who are new users tend to be educated at the high school level, have coffee trees that are 10 to 20 years old, the majority use herbicides less than or equal to 1 time in 1 harvest period, have length of harvest period for less than or equal to 2 months, the majority use chemical fertilizers and organic fertilizers each once a year, and use 2 to 3 workers outside the family (that are called as TL).

Respondents who are users tend to be educated at the junior high school level, have coffee trees that are more than 25 years old, the majority use herbicides 3 times in 1 harvest period (in 1 year), have harvest period for 3 months, the majority do not use organic fertilizers, and do not use workers or can also use more than or equal to 4 workers outside the family (that are called as TL).

Overall, the three categories of respondents have an age range, length of coffee farming experience, land conditions (i. e. land area and number of trees), coffee production, maintenance costs and income which tend to be the same. However, the level of education and the age of coffee trees owned can affect the way of land care which are different. The land care includes frequency of activity in fertilizing and controlling weed. These are also related to the length of harvest period, so that they also affect the number of workers needed in carrying out land maintenance and harvesting activities. Old coffee trees certainly require intensive care, because if the culture or habit of farmers in using herbicides and chemical fertilizers inappropriately will also affect coffee production. So, the decision to use reductant herbicide can be an effort for the sustain coffee production.

4. Conclusions

Based on the results of the chi square test, there are 7 factors that have relationship with the factor of the use of reductants, namely education of respondents, age of tree, length of harvest period, frequency of herbicide use, frequency of chemical fertilizers use, frequency of organic fertilizers use, and the use of workers outside the family (that are called as TL). These variables have significantly different means according to the results of the mean difference test. The three categories of respondents have age, length of coffee farming experience, land conditions (i.e. land area and number of trees), coffee production, maintenance costs and income which tend to be the same. The proximity of the categories of the row and the column variables points in the results of the correspondence analysis plot can show differences in the characteristics of the respondent categories according to the use of reductant herbicide.

The category of non-users is dominantly characterized by the use of herbicides ≥ 2 times a year and the use of workers outside the family ≥ 4 people. New user category is dominantly characterized by the majority of respondents having high school education, the majority using herbicides $\leq$ once a year, using chemical fertilizers and organic fertilizers each once a year, and the harvest period ≤ 2 months. While, the dominant characteristics of user category are the majority of respondents having junior high school education, having tree age > 25 years, tend not to use organic fertilizer, and having 3 months on length of harvest period.

For further research, it is recommended to use other methods such as discriminant analysis and logistic regression to analyze the factors that influence the different categories of respondents in using reductant herbicide. The results of this study recommend that land maintenance is very important for farmers to maintain the sustainability of coffee harvests and optimal green bean production, especially if the trees are relatively old. Therefore, education to farmers about land care which includes proper fertilization and weed control, and plant care including pruning and rejuvenation is very important. This can also be supported by the use of reductant herbicide introduced through the education process to farmers.

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