DISCRIMINANT FACTORS IN THE CHOICES OF TEA PLANT CULTIVARS AMONG SMALLHOLDERS IN BADULLA DISTRICT: MULTIPLE DISCRIMINANT ANALYSIS

Thayaparan A.[1] and Muhandiram M.M.N.[2]

Abstract

This study employed multiple discriminant analysis to examine whether significant differences exist among the different group of tea smallholders in terms of their demographic and farming characteristics and to identify the significant factors influencing in the selection of different tea plant cultivars in Badulla district. The data were collected during the period November to December in 2019 and a sample of 108 tea smallholders has been randomly selected from three major tea producing regions namely Badulla, Haliela and Bandarawela divisions of the Uva region in the district. Frequency analysis reveals that, 43.5% of the tea smallholders chose VP 20/25 while 29.6% and 26.9% of them chose VP 20/23 and CY 9 cultivars respectively. Multiple discriminant analysis showed that, output from each tea plant cultivars and prices of each tea cultivar were the major discriminating variables as well as important influencing factors in selecting tea plant cultivars. Results of Fisher's linear discriminant functions revealed that as output increases, tea small holders are more likely to choose the cultivars VP20/25 and VP20/23 while less likely to select the CY9 cultivar. Similarly, as the price of the tea cultivar increases, they are more likely to adopt the CY9 cultivar than other two in the study. The classification results revealed that 56% of the respondents were correctly classified into three different groups of tea smallholders and the estimated discriminant functions for CY9 (96.6%) and VP 20/23(62.5%) were classified with better accuracy than another group in the study. The findings of the study may assist the tea smallholders in understanding the critical factors in the selection of tea plant cultivars and guide the policymakers to take effective measures in the tea sector in the future.

Keywords: Choices of Tea Plant Cultivars, Demographic and Farming Characteristics, Fisher's Linear Discriminant Functions, Multiple Discriminant Analysis, Tea Smallholders

[1] University of Vavuniya, Sri Lanka. Corresponding author. Email: aruppillaithayaparan@yahoo.com

[2] University of Vavuniya, Sri Lanka. Email: namalmuhandiram100@gmail.com

1. Introduction

Tea as a crop was first introduced to Sri Lanka in the middle of 19th century, when Coffee Leaf Rust disease was destroying the coffee plantations in the country. James Taylor, a Scot, started the first commercial tea plantation at Loolkandura Estate in 1867. Later more lands took over tea and as the demand was growing, the area of tea plantations expanded further into forest and other lands in the up country and finally to Uva and Low country of Sri Lanka. Sri Lankan tea ranks the best among world teas and over the 138 years, it faced many challenges and the Tea Research Institute (TRI) played a pivotal role in developing new technologies to stand against the competing forces both within and outside the country. (Ziyad Mohamed and Zoysa, 2006). The tea grown in Sri Lanka is classified into three different elevation zones: upcountry teas, low country teas, and middle-elevation zones. Teas grown in Badulla and Nuwara Eliya districts generally fall above 1200-meter elevation known as upcountry teas whereas, low country teas are generally cultivated below 600-meter elevation and found mainly in Galle, Matara, Ratnapura, Kegalle and Kalutara districts. Kandy and Matale districts fall in to the middle-elevation zone between 600 and 1200 meters and such teas are grown in mid-country(Tea exporters association, Sri Lanka, 2007). For more than a century, tea industry plays a significant role in the Sri Lankan economy in terms of the main employment provider and by providing employment opportunities and it is the main source of foreign exchange income of the country (Thushara, 2015).

There are many factors which were identified as the key contributors in tea production and among them, favourable weather conditions, adoption of better management agricultural practices and planting of vegetative propagated (VP) varieties in large extents and replacement of poor yielding seedling tea with high yielding VP varieties are important. An economically viable vegetative propagation method was discovered and established for the first time in tea in 1950s. Tea Research Institute of Sri Lanka has recommended and released several seminal series of tea varieties such as TRI 2000, 3000, 4000 and four TRI 5000 for different tea growing districts considering their ecological differences, growth and yield performance, pest and disease resistance etc. with the aim of increasing the productivity and the quality of tea plantations in the up-county. (The tea research Institute of Sri Lanka, 2021).

Even though, still a majority of the tea smallholders are adopting old and low yielding cultivars as they became familiarized to those and thus, they may be reluctant to adopt the latest and improved cultivars. Based on different clones or cultivars of tea plants, the quality and the taste of tea also differ from one another and different varieties of tea plants produce different tea yield. Each variety of tea may differ in terms of price, maturity period, and frequency of harvest, average yield and production techniques. Even though, most of the tea smallholders have chances to select different varieties of tea plants in their cultivation they may not prefer to practice them. Because of lack of financial facilities, skills and knowledge they had been unable to apply such new varieties properly but by adopting new tea cultivars they may produce more yield with productivity and high quality as well as they can compete with competitors in tea industry in the world.

In Sri Lanka, at present, smallholder tea cultivation is spread in fourteen districts in high, mid and low elevations and plantation company-owned large tea estates dominate in high and mid elevations. When comparing the tea production in various districts in Sri Lanka, it reveals that, Rathnapura district was ranked at the first place, with a production of 2.14 million kilograms in 2018 while Nuwara Eliya district registered as the second highest in tea production. Kegalle district improved significantly from 1.55 million kilograms to 2.73 million kilograms in 2018. However, the other two districts namely, Hambantota and Badulla registered 4.33% and 5.57% negative growth rate in tea production in 2018. (Future of work for Tea Smallholders in Sri Lanka, 2018). In Badulla district, the respondents are the small tea holders that were selected and they were adopting the conventional tea cultivars such as VP20/25, VP20/23 and CY9 in their cultivation.

Adoption of newly improved cultivars in tea sector is a vital investment to enhance the productivity and to sustain the yield stability under different environmental stress conditions (Jayasinghe**,** W.S., & Alwis, L.M.H.R., 2016).

Improved tea varieties are important for increased productivity (Kamunya et al., 2012). The quality of seed indicates the potential crop yield and consequently the potential gains from the investment (de Roo et al., 2016). In this background, this study contributes to the tea smallholders to choose the appropriate tea cultivars in their cultivation, Government bodies, policy makers and research institutions also can identify how demographic and farming characteristics help to classify the tea smallholders into three different groups based on the choices of different tea cultivars. Even though there are many tea cultivars available in tea farming, there is a need to classify the smallholders based on the major three cultivars across their demographic and farming characteristics in Badulla district. This may be useful for tea estate owners and tea smallholders to consider necessary strategies for the improvement of different cultivars in tea cultivation. Because of this reason, this study is taken up to know the significant factors that discriminate the tea smallholders in to three groups and identify how the demographic and farming characteristics influence in selecting tea cultivars in the study area.

1.1 Research problem

There are many factors influencing the choices of tea plant cultivars and based on the factors the planters need to find the best variety to get more yield and income. New tea plant cultivars reported better economic performances such as high yield and high product price, maximum utilization of resources, and low cost of production compared to conventional tea cultivars. In general, the planters adopt conservative practices and they may resist to adopt new farm techniques. Based on that, it is important to encourage them to adopt newly released cultivars which have better characteristics than the existing ones. Adoption of modern tea plant varieties is often cited as one of the key factors to increasetea production and in this background, this study is important in the selection of tea plant cultivars among tea smallholders. Because of the predominance of more than 20 years old tea plants which comprise seedlings and old cultivars and certain lands have become marginalized as they do not produce economic yields. The technical solution would be to replant the lands with high-yielding cultivars and thus, there is a need for survey to understand the tea

smallholders' practice in farming, their opinions and perceptions of the new tea cultivars and awareness creation on technologies. (Daily news, May 24, 2021).

1.2 Objectives

The main objectives of the study are,

- To examine the significant differences which exist among different groups of tea smallholders in terms of their demographic and farming characteristics in Badulla district.
- To identify the significant factors influencing the selection of different tea plant cultivars in the study area.

To attain the above objectives, the researcher classified the tea smallholders based on their choices of tea cultivars across their demographic and farming characteristics. This would be useful for tea estate owners and tea smallholders to make their future strategies in tea cultivation.

1.3 Literature Review

Numerous studies have investigated the influence of various factors on the selection of improved seed varieties across various crops. Most of the scholars had investigated the choices of seeds and crop varieties than tea cultivars nationally and internationally. They had used socio – economic and farming characteristics as well as environmental factors are the main determinants in the choices of the seed or crop varieties but, a small number of empirical studies exist in the literature that have focused on whether significant differences exist among the different group of tea smallholders in terms of their demographic and farming characteristics and had tried to identify the significant factors influencing in the selection of different tea plant cultivars. Further, for this type of research, most of the previous researchers had applied multinomial regression and probit models to analyse the data and very few are applied discriminant analysis in the study. Also, most of the previous studies related to tea focused on consumer preferences towards tea branded or tea packets not from tea smallholder context and their selection of tea cultivars. Thus, the researcher found a limited review of literature on the selection of tea plant cultivars among tea smallholders in Sri Lanka as well as other countries.

To fill the research gap, different tea cultivars adopted by tea smallholders were considered as the sample and the discriminant analysis was taken to identify the determinants of selecting tea cultivars in the Badulla district.

Kumar et al., (2010), examined the characteristics and determinants of contract design of wheat seed farming in India on the basis of decision making. They employed discriminant and logit regression model and the results of discriminant analysis revealed that, the ratio of the contract price and open market price became the most alluring attribute for inducing the farmer to nudge into contract farming followed by technology back up, timely certification of seed crop by the support of sponsoring seed firm, adequate financial support, physical quantity of produce, and the mode of payment acquired importance in descending order and became next pressing attributes in discriminating the contract designs of public and private sectors in the study. This study is not related directly with the objective of the current study, the method that is used by the research is aligned with the current study to find the

discriminating factors in wheat farming. Yigezu et al., (2015) examined on modelling farmers' adoption decisions of multiple crop technologies in the case of barley and potatoes in Ethiopia. They applied multivariate Tobit and multivariate Probit models and the results revealed that decisions on the area shares of barley and potatoes in total farm size and the plot or field level decision on the adoption of improved varieties of the two crops are independent in the barely and potato cultivation.

Alhassan et al., (2016) employed quadratic classification function to examine the influence of farmer's socio-demographic and varietal characteristics of maize on adoption of improved maize varieties in Wa Municipality, Upper West Region of Ghana. The results showed that, farm labour, information availability on variety, weed resistance, low yielding variety, early maturity and water stress resistance are the major discriminating variables in classifying farmers in the Municipality. Another study done by Jayasinghe & Alwis (2016) related to the determinnats of adoption decision of newly improved tea cultivars by tea smallholders in Uva region. Their findings of the study revealed that, education, awareness and knowledge level, extension service contact, experienced with drought, membership of agricultural association, field affected by pest and deceases are the factors affecting to increase the adoption decision of newly improved tea cultivars by tea small holders. Nguyen-Van et al., (2017) analysed the farmers' decisions on tea varieties in Vietnam applying a multinomial logit analysis and they found that income, age, household size, farming contract, and use of organic fertilizers, also membership of professional associations such as the tea association and the farmers union are the important factors which influence the decision to adopt types of tea varieties in Vietnam.

Ashoori et al., (2019) investigated the determinants of modern rice cultivars among smallholders of northern Iran. They applied logistic regression model and its results showed that perceived profitability and perceived importance of modern varieties, background in rice farming, and the size of livestock holdings were positively associated with the adoption of improved cultivars.

In a study done by Ahmed & Anang (2019), they analysed the impact of improved variety adoption on farm income in Tolon District of Ghana. Their results indicated that men have lower probability of adoption while adoption increased with extension contact, access to fertilizer subsidy and cattle ownership but decreased with the cost of adoption. Discriminant factors in selecting groundnut varieties for cultivation was done by Kumari & Vasanthi (2020) in India. They used 150 groundnut farmers selected randomly and the collected data were evaluated by using discriminant analysis. They found that, seed availability, market demand and high yield are the major factors that discriminate the farmers into becoming the adopter and the non – adopter in the study.

Nidamanuri (2020), analysed the hyperspectral discrimination of tea plant varieties using machine learning and spectral matching methods in Munnar, Western Ghats of India. Canopy level hyperspectral reflectance measurements acquired for tea and natural plant species were analysed using several statistical methods, including linear discriminant analysis. The results of the study indicated that, six out of nine tea plant varieties could be discriminated with accuracies between 75% and 80% while the presence of natural plant species decreased the inter-species spectral variability for a few tea plant varieties. As mentioned earlier, there is a research gap which is

that most of the studies considered seed or crop varieties as the sample and the studies focusing on tea cultivars are very rare. From this literature, the current study tried to fill the gap considering how the demographic and farming characteristics are important in selecting the tea cultivars in the current research.

2. Material and Methods

In Sri Lanka, Badulla district is areawhere tea is produced by many tea estate owners and mainly, they engaging in tea cultivation. Because of this reason, Badulla district was selected purposely which has 15 Divisional Secretariat (DS) Divisions and out of them three DS divisions namely Badulla, Haliela, Bandarawela were selected as a sample in the study. The total number of tea smallholders operating in Badulla district is 28,101 and there are 9,020ha of tea smallholdings available. (Tea Smallholdings Development Authority (TSHDA), 2015)).

A questionnaire survey was conducted with 200 tea farmers who were selected randomly in data collection to cover the respondents who adopt to conversational cultivars such as VP 20/25, VP 20/23 and CY9. Primary data was collected through a field survey using a structured questionnaire which was designed to capture the basic information on demographic characteristics of tea smallholders such as age and family size whereas farming characteristics related to farm experience, land size, yield from each tea plant variety, price of each tea plant variety and frequency of harvest from each tea plant in the study. Thus, the questionnaire consisted mainly of two parts including demographic and farming characteristics and the choices of tea plant cultivars selected by the respondents in the study. From 200 samples, finally, 108 tea smallholders were selected from the above divisions during the period from November to December, 2019 which included the above three cultivars adopted by the tea smallholders in the study area. There are different tea cultivars such as series of TRI 2000, 3000 and 4000 cultivars which are released by the tea research institute in the countrybut in the study area, there is still a certain number of smallholders engaged in tea cultivation using the conversational cultivars such as VP 20/25, VP 20/23 and CY9. These three cultivars were taken as dependent variable with the coding of 1,2 and 3 respectively. The respondents who chose these cultivators requested to give their details related to demographic and farming characteristics and the measurements are given in Table 1.

Table 1: Operationalisation of the variables

Variables	Measurements
Age of the respondent	Measured in number of years
Family size in the household	Measured in numbers
Farming experience	Measured in number of years
Size of land	Measured in Ha
Yield from each tea plant variety	Measured in Kg
Price of each tea plant variety	Measured in Rupees
Frequency of harvest from each tea plant	Number of times harvested from each tea cultivars

Source: Developed by the researcher based on previous literature

2.1 Multiple linear discriminant analysis

Multiple discriminant analysis is a technique for analysing data when the criterion or dependent variable is categorical with more than two and the predictor or independent variables are interval in nature. Thus, when there are more than two groups which are different from each other, multiple discriminant analysis is more applicable to classify them into different groups than simple discriminant analysis. In this study, there are three different tea cultivars chosen by the three groups of smallholders and thus they were classified into three groups in terms of their socio – economic and farming characters in the study. Discriminant analysis is a useful statistical technique to classify an observation into one or several priori groups that is dependent upon the individual's characteristics. When the criterion variable has two categories, the technique is known as two-group discriminant analysis whereas three or more categories are involved, the technique is referred to as multiple discriminant analysis. In multiple discriminant analysis, more than one function may be computed. Thus, multiple linear discriminant analysis is a technique for analysing the data when the criterion or dependent variable is categorical and the predictors or independent variables are measured on at least interval scales.

Multiple linear discriminant analysis is used to identify the attributes of tea estate owners towards the adoption decision on three varieties of tea plants among the tea smallholder owners and examine how socio- economic, economic related and farming characters discriminating them into three different groups in the study.

The multiple discriminant analysis was employed with three groups of tea estate owners for scale data using stepwise method. Step wise method is applied to remove the independent variables that are not significant and try to find the best set of predictors based on their discriminating power.

The tea smallholders can be divided into three categories based on their choices of three tea plant cultivars. The group 1 represents the smallholders who choose the tea cultivar VP 20/25, group 2 represents the smallholders who select the VP 20/23 and group 3 represents third choice of smallholders who adopt the CY9 cultivar in the study area. These three categories are the dependent variables of the discriminant function and the independent variables or predictors are demographic and farming characteristics. The variables related to demographic and farming characteristics were taken based on the previous reviews of literature and the availability of data which are relevant in the study.

These characteristics include the seven independent variables in multiple discriminant analysis which can be written as,

$$D = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + \varepsilon$$

Where,

D = Discriminant score

b'_s = Discriminant coefficient or weight

X_1 = Age in years

X_2 = Number of family size

X_3 = Farming experience in years

X_4 = Land size in Ha

X_5 = Yield from each tea plant variety in Kg
X_6 = Price of each tea plant variety in Rs
X_7 = Frequency of harvest from each tea plant
e = Error term

Further, descriptive statistics and frequency was also applied as the basic analytical techniques in the study.

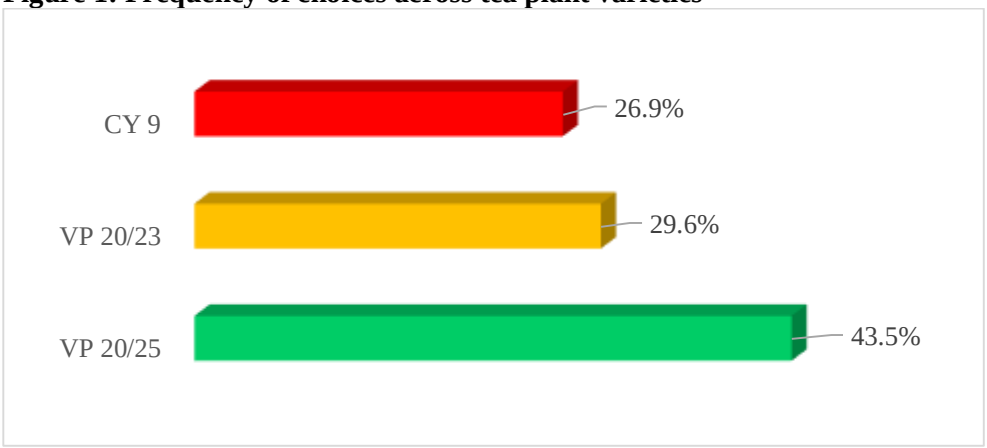
3. Results and Discussion

The collected data were analysed using different analytical tools such as frequency, descriptive statistics and multiple discriminant analysis. The results derived from each analytical tools are described in the following section.

3.1 Frequency of the variables used in the study

Figure 1 shows the frequency of choices towards three different tea plant cultivars and according to that, nearly 44%of the respondents chose the VP 20/25 variety while 30% and 27% of them chose VP 20/23 and CY9 varieties respectively. Even when there are three varieties of tea plants available, most of the smallholders prefer to select VP 20/25 variety followed by VP 20/23, while there is less preference in selecting CY9 variety in the study area. Results derived from frequency analysis may help the policy makers to identify the reasons for the choices of tea plant cultivars differ across tea smallholders and according to that, they can take necessary steps to improve the selection of other tea plant cultivars in the future.

Figure 1: Frequency of choices across tea plant varieties

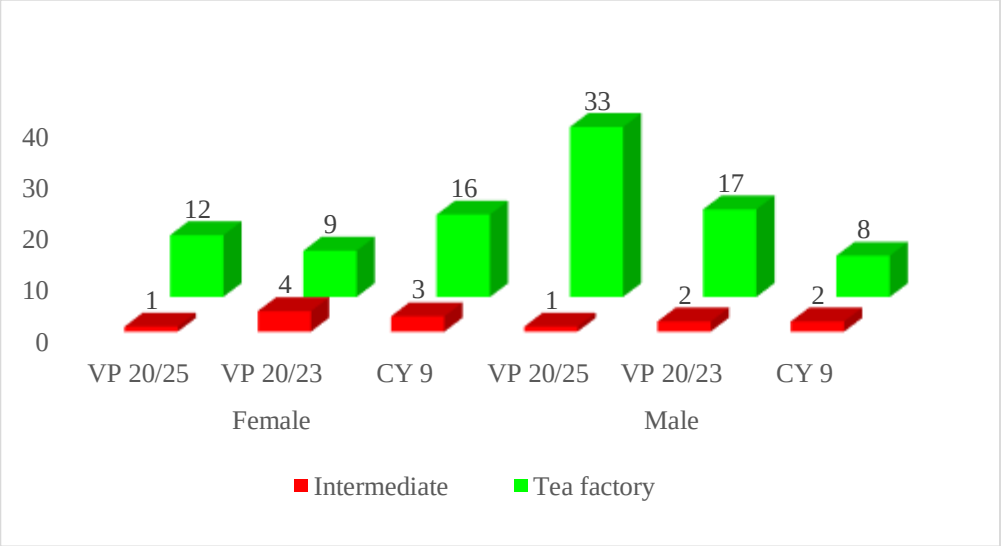


Source: Compiled by authors

In addition to the above frequency of tea plant cultivars, another analysis which represents the number of smallholders who select their cultivars across gender and their choice of two marketing channels is because they sell their tea yield by an intermediate or sell them directly to the tea factory. By analyzing this, it is useful to identify the link between the choice of tea plant cultivars and the choice of marketing

channels which are related to attain the first objective of the study. It can be illustrated in the following figure.

Figure 2: Number of tea smallholders and their choices across gender and marketing channels



Source: Compiled by authors

The above figure revealed that, 33 male smallholders prefer to select VP 20/25 cultivar and they like to sell their tea yield directly to the tea factories while 16 females chose CY9 cultivar and they liked to sell the yield through intermediaries in the study. The respondents whether they were male or female, mostly they liked to sell their tea yield directly to the factories at any tea plant cultivars chosen by them.

3.2 Results of descriptive statistics

In addition to the frequency statistics, descriptive statistics are also used to describe the basic features of the selected variables related to the average yield derived from three varieties of tea plants, some selected demographic and farming characteristics of the respondents in terms of mean and standard deviation.

Table 2: Descriptive statistics of yield among tea plant cultivars

Type of tea cultivars	N	Average yield/Ha	Standard deviation
VP 20/25	47	140.00	88.231
VP 23/23	32	133.50	77.726
CY9	29	87.93	34.396
Total	108	124.09	76.803

Source: Calculated by author, 2019/2020

Based on the average value of yield among three tea plant varieties, the highest yield is derived from VP 20/25 while the variety of CY9 gives the lowest yield. The findings of these results coincided with the frequency of choices of tea varietiesbecause the highest yield was obtained from the variety VP 20/25 which is mostly chosen by the tea smallholders. On the other hand, the variety CY9 provided on average lower yield and due to that, nearly 27% of them preferred to choose CY9 variety in their cultivation.

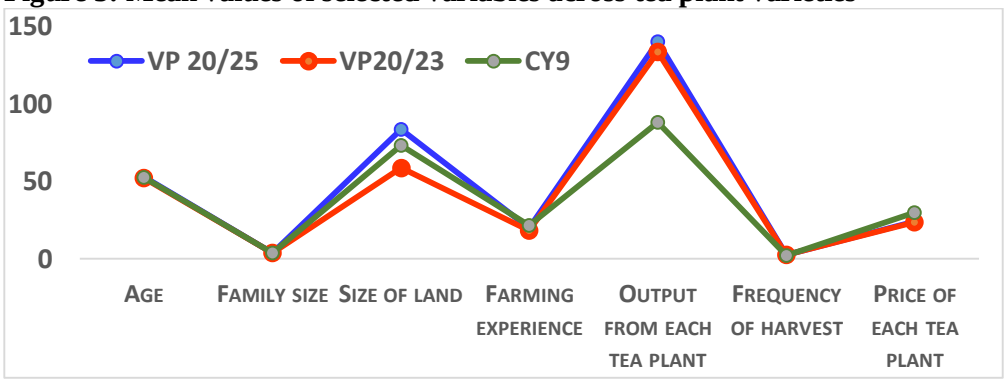
Table 3: Descriptive statistics of the sample

Variables	Maximum	Minimum	Mean	Standard deviation
Age	78	27	52.57	10.98
Family size	6	1	3.85	1.17
Farming experience	50	1	19.85	10.87
Output of tea yield	350	12	124.09	76.80
Frequency of harvesting	4	1	2.51	0.69
Price of the tea plant	36	10	25.48	4.90

Source: Calculated by author, 2019/2020

The above table summarizes the basic statistics of the samples which showed that the average age of the tea estate holders is nearly 53 years old with the minimum and maximum ages of 27 and 78 respectively. On average, they have 73 acres of tea estate land with a standard deviation of 56 and nearly they have 20 years of experience in tea cultivation. Furthermore, on average 124.09 Kg of tea leaves were produced by them from all three tea plant varieties with three times harvest per month. Finally, the average price of tea plant is Rs 25/= per Kg with a standard deviation of 4.9 in the sample. Mean values for the selected variables related to demographic and farming characteristics across three tea plant varieties are shown in Figure 3.

Figure 3: Mean values of selected variables across tea plant varieties



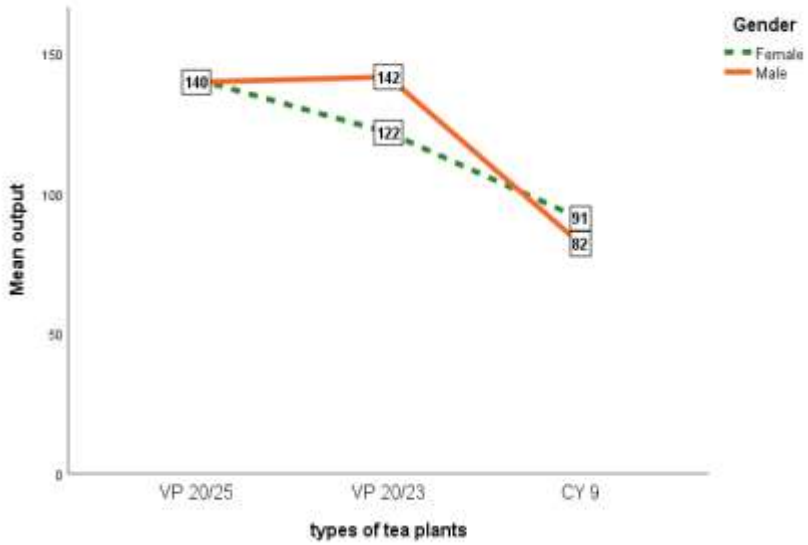
Source: Compiled by authors

The above figure reveals that, age-wise there was no difference among the people who chose the three different tea plant varieties of VP 20/25, VP 20/23 and CY9. Similarly, family size, and farming experience also did not much differences among them and the other variables significantly differed from one another. The

average experience in farming for the varieties of VP 20/25 and CY9 were nearly 20 and 22 years respectively but the experience of the smallholders who chose the variety VP 20/23 was 18 years. The average size of land for the varieties of VP 20/25 and CY9 were 83.45 and 73.21acres respectively while the size of cultivated land for CY9 variety was 58.5 acre which was lower than the other two cultivars.

An average output from each variety also significantly differs from one another and according to that, outputs from VP20/25 and VP20/23 were found to be around 140 and 133Kgs respectively whereas, from CV9, it is nearly 88Kg which is lower than the first two varieties. Even the frequency of harvest across the three varieties is the same and the prices of each tea plant variety were significantly different among them. Thus, the above comparative analysis suggests that, only average yield from each tea plant variety and average prices from each plant were significantly different among the three varieties and the rest of the other variables were the same in the study.

Figure 4: Average production of each tea plant variety across the male and female smallholders



Source: Compiled by authors

An average yield of tea derived from different tea plant varieties among male and female smallholders was shown graphically and according to that, average yield of VP 20/25 is nearly the same among the male and female tea smallholders whereas there is a little difference in average yield in CY9 variety but, in the case of VP 20/23, the average yield derived by the males are higher than the females in the study.

Table 4: Custom table for average tea yield

						Average output
Training	*No*	Gender				
			Female	Types of tea cultivars	VP 20/25	137
					VP 20/23	115
					CY 9	87
			Male	Types of tea cultivars	VP 20/25	151
					VP 20/23	141
					CY 9	83
	Yes	Gender	Female	Types of tea cultivars	VP 20/25	144
					VP 20/23	138
					CY 9	108
			Male	Types of tea cultivars	VP 20/25	119
					VP 20/23	141
					CY 9	80

Source: Calculated by author, 2019/2020

The table depicts that an average yield of 151Kgs tea is obtained from the variety VP20/25 which is the highest one cultivated by the male respondents without training, which is followed by the next highest average yield, which is 144 Kg obtained from the same variety of tea plant cultivated by females with training in the study. When comparing the average output derived from the three varieties, the yield derived from the variety VP 20/25 is the highest while the average yield is very low from CY9 variety compared to the other two varieties which is cultivated by male or female.

3.3 Results of multiple discriminant analysis

The first part of the multiple discriminant analysis results compares socio-economic and farming characteristics between three groups of smallholders who chose three tea cultivars in terms of the mean and standard deviation. From the Table 5, it is observed that, average ages of the smallholders who chose the three cultivars are the same. This indicates that those three groups are homogeneous while their average size of tea land is significantly different from each other groups. Average value of the other variables are nearly the same across three groups of adopters except farm experience, yield derived from each tea plant cultivar and their prices.

Table 5: Descriptive statistics across different tea plant cultivar adopters

Types of tea plant cultivars	Variables	Mean	Standard deviation
VP 20/25	Age	52.85	10.948
	Family size	4.06	1.111
	Land	83.45	66.329
	Experience	19.81	9.582
	Output	140.00	88.231
	Harvest	2.64	.673
	Price	24.09	5.085
VP 20/23	Age	52.25	11.728
	Family size	3.66	1.066
	Land	58.56	37.322
	Experience	18.25	12.150
	Output	133.50	77.726
	Harvest	2.53	.718
	Price	23.75	4.127
CY 9	Age	52.48	10.582
	Family size	3.72	1.360
	Land	73.21	54.758
	Experience	21.69	11.440
	Output	87.93	34.396
	Harvest	2.28	.649
	Price	29.66	2.439

Source: Calculated by author, 2019/2020

Further, multiple linear discriminant analysis is conducted using seven factors that distinguish the smallholders into three groups such as VP 20/25 adopters, VP 20/23 adopters and CY9 adopters. The tests of equality of group means are illustrated in the following table and according to that, the variable which has smaller the Wilks' Lambda, that is the more important factor to discriminate the function.

Table 6: ANOVA: Tests of Equality of Group Means

Variables	Wilks' Lambda	F - value	df_1	df_2	Significant
Age	0.999	0.029	2	105	0.971
Family size	0.974	1.391	2	105	0.253
Land size	0.965	1.878	2	105	0.158
Farming experience	0.986	0.759	2	105	0.471
Output from each tea cultivar	0.917	4.778	2	105	0.010
Number of harvests	0.953	2.568	2	105	0.082
Price of each tea plant cultivar	0.731	19.302	2	105	0.000

Source: Calculated by author, 2019/2020

Wilks' Lambda is significant by the F - test only for two independent variables viz price of each tea plant cultivar and the output derived from each cultivar at 1% level. Thus, these two are the significant discriminant factors to classify the small tea holders as three groups while the number of harvests is a significant factor at 10% level.

Basic results of discriminant analysis on selected demographic and farming characteristics that have an impact on the choices of tea plant varieties among smallholder tea estate owners in Badulla district are shown in the tables below.

Table 7: Summary results of Eigen value

Functions	Eigen value	percentage of variance	Canonical Correlation
1	0.619	99.7	0.618
2	0.002	0.3	0.043

Source: Calculated by the author, 2019/2020

Table 8: Summary results of Wilk's' Lambda

Test of functions	Wilk's' Lambda	χ^2	df	Sig
1 through 2	0.616	50.55	4	0.000
2	0.998	0.19	1	0.657

Source: Calculated by the author, 2019/2020

The larger the Eigen value, there is more of the variance in the dependent variable which is the choice of tea plant cultivar explained by that function. Since the dependent variable has three categories, there is two discriminant functions available in the study. As indicated by the above table it shows that function 1 has the highest Eigen value than function 2 and also function 1 accounts for 99.7% of the variance while function 2 accounts only for 0.3%. These results suggest that, the first function is the best ability to separate between three groups of small tea holders towards three different tea varieties in the study. Also, Wilk's Lambda is another test to measure the overall significance of the linear discriminant function which measures how well each function separates cases into groups. Smaller values of Wilk's Lambda indicate the greater discriminatory ability of the function and function 1 has the smallest value which is significant at 1% level and it concludes that only the first function has a discriminatory ability than the second function in the model.

Another part of the discriminant analysis is the standardized discriminant coefficients which serve the same purpose as beta weights in multiple regression. They imply the relative importance of the independent variables in predicting the dependent variable. They allow to compare the variables measured on different scales and where the coefficients with large absolute values correspond to variables with greater discriminating ability.

Table 9: Standardized canonical discriminant function coefficients

	Functions	
Items	1	2
Price of each tea plant	.969	.398
Output from each tea plant	-.669	.806

Source: Calculated by author, 2019/2020

In the above table, the first function has a discriminatory ability with the highest coefficient value of price followed by the coefficient of output derived from tea cultivars. It shows that nearly 96% and 67% of the contributions is given by the price and output respectively to the selection of tea plant cultivars.

Table 10: Results of structure matrix

	Functions	
Items	1	2
Price of each tea plant	.770*	.638*
Output from each tea plant	-.380*	.925*
Land size [b]	-.195	.366
Frequency of harvest [b]	-.068	.162
Family size [b]	-.088	.146
Age [b]	.035	.073
Experience in farming [b]	-.024	.044

Notes:
*. Largest absolute correlation between each variable and any discriminant function.
b. This variable is not used in the analysis.

The structure matrix table shows the correlations of each variable with each discriminant function. The correlations serve like factor loadings in factor analysis that is, by identifying the largest absolute correlations associated with each discriminant function. According to the results in structure matrix, the price of each tea plant and output derived from each tea plant were the significant factors in both functions 1 and 2. According to the results in Table 6, among the seven explanatory variables only price and output of each tea plant variety are the major factors and they best discriminate among the three groups in the sample.

Table 11: Unstandardized canonical discriminant function coefficients

	Functions	
Items	1	2
Price of each tea plant	.229	.094
Output from each tea plant	-.009	.011
Constant	-4.711	-3.743

Source: Calculated by the author, 2019/2020

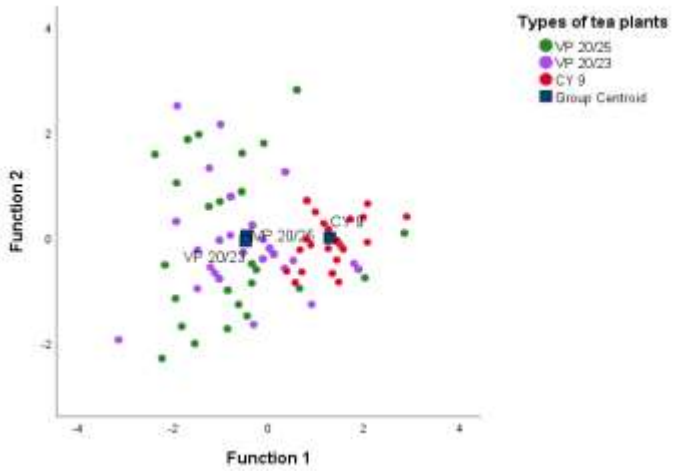
Results in Table 11 contain the unstandardized canonical discriminant function coefficients would be used like unstandardized beta coefficients in multiple regression. Based on the selected function 1, the coefficients can be used to construct the actual prediction equation which is used to classify the new cases. The significant

variables illustrated in the above table represents the discriminant function in the first function which can be written as:

$$D_i = -4.711 + 0.229\ price\ of\ each\ tea\ plan - 0.009\ output\ from\ each\ tea\ plant$$

Since the function 1 has the best ability to separate among three groups and the first function shows that, price of each tea plant and output from each tea plant have the most contribution in the classification of the choice of tea plant cultivars. Since, the value of Wilk's' Lambda is insignificant as indicated in Table 6, discriminant model using second function is not important in the study. Since there are two discriminant functions, the charts below are scatter plots showing the discriminant scores of the cases on the two discriminant functions.

Figure 5: Canonical discriminant functions and combined group plot



Source: Compiled by authors

The closer the group centroids, the more errors of classification will be likely and the three groups of tea smallholders were clustered based on their choices of tea plant varieties.

In order to identify the factors which, discriminate the smallholder tea farmers into 3 groups, stepwise method of discriminant analysis was applied in the study. Since there are three groups, two discriminant functions were derived and out of them, function 1 was selected where it has the ability to discriminate the groups. Based on the standardized discriminant coefficients indicated in Table 12, socio - demographic characters and farming characters did not discriminate the different choices of tea plant varieties.

Table 12: Results of standardized canonical discriminant function coefficients function

Variables	Function 1	Function 1
Output from each tea plant variety	-.669	.806
Price of each tea plant variety	.969	.398

Source: Calculated by author, 2019/2020

Among economic related characters, only two of them namely, the price of each tea plant and output from each tea variety were the significant factors which discriminated them in the study. The price of each plant has the coefficient of 0.969, which indicates that it has the highest partial contribution to discriminate the tea small holders based on three different tea plant varieties in the study. Next one is the output derived from each tea plant variety, which is another character which classifies the tea smallholders into three adaptors and the rest of other economic related characters were not important to categorize them in the sample.

Classification function coefficients provide another way of studying the importance of the variables in the discriminant function and its results are displayed in the table below.

Table 13: Results Fisher's linear discriminant functions

Variables	Types of tea plant varieties		
	VP 20/25	VP 20/23	CY9
Output from each tea plant cultivar	.003	.002	-.013
Prices of each tea plant cultivar	1.327	1.314	1.722
Constant	-17.282	-16.824	-26.047

Source: Calculated by author, 2019/2020

As depicted in the above table, only output from each tea plant variety and the price of each plant variety discriminated the small tea holder's adoption decision towards tea plant varieties in the study.

Fisher's classification function coefficients are used to classify the cases between the groups. The coefficients of the independent variables which are shown in Table 13 are used to construct a discriminant function for each group, say G_1 named as (VP20/25), G_2 named as (VP20/23) and G_3 named (CY9) as below.

$$G_1 = -17.282 + 0.003\ Output\ from\ each\ tea\ plant\ cultivar + 1.327\ Price\ of\ each\ tea\ plant\ cultivar$$

$$G_2 = -16.824 + 0.002\ Output\ from\ each\ tea\ plant\ cultivar + 1.314\ Price\ of\ each\ tea\ plant\ cultivar$$

$$G_3 = -26.047 - 0.013\ Output\ from\ each\ tea\ plant\ cultivar + 1.722\ Price\ of\ each\ tea\ plant\ cultivar$$

As the output increases, tea small holders are more likely to choose the varieties VP20/25 and VP20/23 while they are less likely to select the CY9 variety. Similarly, as the price of the tea variety increases, they are more likely to adopt the CY9 variety than other two varieties in the study. Thus, the results of this discriminant analysis confirmed that, the economic related characters such as, the price and the output of each tea plant variety were discriminating the small tea holders into three adaptors based on three tea varieties in the study. Finally, to examine whether the cases were classified correctly or not, classification results were obtained and it is indicated in Table 14.

Table 14: Classification results

			Predicted group membership			
Original	Count	Tea plant varieties	VP 20/25	VP20/23	CY9	Total
		VP 20/25	13	27	7	47
		VP 20/23	8	20	4	32
		CY9	0	1	28	29
	Percent	VP 20/25	27.7	57.4	14.9	100
		VP 20/23	25.0	62.5	12.5	100
		CY9	.0	3.4	96.6	100

Note: * indicates that 56.5% of original grouped cases correctly classified
Source: Calculated by the author, 2019/2020

The above results were used to assess how well the discriminant function works, and if it works equally, it is well for each group of the dependent variable. The above classification results revealed that 56% of the respondents were correctly classified into three different groups of tea smallholders. As results of the estimated discriminant functions, the cases are classified as given in the above Table 14. According to that 27.7 % of cases were classified into the first group who selected the VP 20/25 cultivar, 62.5 % of cases were classified into the second group who selected VP 20/23 cultivar and 96.6% of cases who chose the CY9 cultivar. This indicated that, the estimated discriminant functions for CY9 (96.6%) and VP 20/23(62.5%) were classified with better accuracy than another group.

4. Conclusion

This study aimed to discriminate the factors in the selection decision of tea plant cultivars among tea smallholders in Badulla district. The study concludes that , 43.5% of the tea smallholders chose VP 20/25 while 29.6% and 26.9% of them chose VP 20/23 and CY 9 cultivars respectively. Further, multiple discriminant analysis showed that among the various factors related to the demographic, economic and farming characteristics, only farming related characters such as, output of tea from each tea plant cultivar and the prices of each tea plant cultivar were the classifying factors which discriminate the tea smallholders into three groups of adopters in the study. These findings reveal that, tea smallholders prefer to select their tea cultivar based on the above two farming related characters than other demographic and economic characters in the study. Based on these findings, the results of the study

will be useful for tea research institute and policy makers to design their upcoming policies and necessary arrangements to improve the tea industry focusing on these aspects in the future. Tea smallholders can easily identify different groups of adopters in tea plant cultivars in terms of farming characters which help them to make their collaborative decision in the future.

Results of classification function coefficients show that as the output increases, tea small holders are more likely to choose the cultivars VP20/25 and VP20/23 while less likely to select the CY9 cultivar. Similarly, as the price of the tea cultivar increases, the tea estate owners are more likely to choose the CY9 cultivar than other two cultivars in the study. The classification results revealed that 56% of the respondents were correctly classified into three different groups of tea smallholders and the estimated discriminant functions for CY9 (96.6%) and VP 20/23(62.5%) were classified with better accuracy than another group in the study. Previous studies considerd to identify the factors on the selection of different seed varieties or crops from producer context and most of the other studies focused on consumer point of view in selecting various tea brands. Most of the studies focused on factors affecting adoption of improved agricultural technologies among smallholder tea farmers, but they did not take the choices of tea plant cultivars into account in their study (Carren ekwang, 2021). Some other studies were done by the researchers in the same district in Sri Lanka on determinants of adoption decision of newly improved tea cultivars by tea smallholders in uva region but they mainly focused on whether the tea smallholders prefer to adopt newly improved tea cultivars or not and they did not consider the different types of tea cultivars while the tea growers were making their choices (Jayasinghe**,** W.S., & Alwis, L.M.H.R., 2016).

However, this study clarified the specific contributions on the selection decision towards different tea plant cultivars in the producer context and will contribute to the existing body of knowledge on the factors that determine the choices of different tea plant cultivars among smallholder farmers in Badulla district.

Thus, this research will fill the knowledge gap in the existing scholarship and literature and describe the different context which is unexplained by the previous research in terms of choices towards different tea plant cultivars and its discriminant factors. From this research context, it helps to identify how the demographic and farming characteristics influence in the selection of different tea plant cultivars and how they contribute to classify the tea smallholders into three different groups in the study.

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