Selecting land characteristics affecting local flash sweet potato production levels based on production indicator of consumer preference

M A Solihin¹, A Setiawan¹, A Nurbaity¹, Widiatmaka²

¹ Soil Science and Land Resources Department, Universitas Padjadjaran, Indonesia
² Soil Science and Land Resources Department, IPB University, Indonesia

m.amir.solihin@unpad.ac.id

Abstract. Rancing sweet potato is one of preferred local flash sweet potatoes in Indonesia. The interesting thing about Rancing is on its sweetness taste that meet on common consumer’s preference. So, production indicator of Rancing should be consider the sweetness levels in addition of yield. The study aimed to selecting land characteristic affecting Rancing production levels based on combination of yield and sweetness indicator. Sampling units were research plot in actual production site in West Java. Sweet potato tuber samples were collected at harvest time, whereas the soil samples were taken by composite soil sample at each sampling unit. Rancing production indicator was measured in total sugar weight (kg ha⁻¹). Total sugar weight was determined by multiplication of weight of yield (t ha⁻¹) and total sugar content (%) of Rancing at harvest time at same sampling units. Selecting land characteristics were affecting Rancing production were determined using stepwise multiple discriminant analysis. Results showed that there were soil and climate properties affecting Rancing production levels. These land characteristics can be considered in determining land use requirements of Rancing.

1. Introduction
Sweet potato (Ipomoea batatas L.) is one of important commodity for food source, raw material of industry and feed source in Indonesia. Indonesia is a one of largest sweet potato producer in the world [1]. One of production center of sweet potato is West Java. Sweet potato cultivation in West Java has orientation for trade commodity. As trade commodities, sweet potatoes cultivation that can meet qualifications and demands of market is importance. One of preferred local flash sweet potatoes that has high market demands in Indonesia is Cilembu sweet potato. The interesting thing of Cilembu sweet potato is on its sweetness taste that meet on common consumer’s preference. The sweetness of the Cilembu tuber comes from sugary liquids [2]. The majority farmers have been cultivated Rancing as dominant varieties of Cilembu sweet potato in West Java.

An increase in market demand requires Rancing’s farmers to expand their cultivation area to outside of the Cilembu origin areas. However, land characteristics of the new areas may be not necessarily appropriate for Rancing production. The influence of the growing environment on plant growth is an external factor that affects plant life and development [3]. Land is not only related to soil, but also relates to climate, relief and existing land use on land which affects its potential use [4]. The combination of land characteristics will results in variations in the land properties from one place to another. As a result, the influence of varying land characteristics will affect the growth and level of crop production.
Previous study was done by [2]. He revealed that Cilembu sweet potato which was planted in outside of origin areas had variation in yield and lower in sugar content than others. The differences of biophysical characteristics of land affecting sweet potatoes yield [5, 6, 7, 8, 2], and sugar content [9, 10, 11, 12, 2].

The expansion of Rancing cultivation area to new areas requires land suitability evaluation. Common land evaluation activities in Indonesia have been done indirectly using matching table method. This method requires land use requirements to evaluate land data. The land use requirement is land suitability criteria for optimal plant growth and production [13, 14, 15]. Land suitability criteria consist of diagnostic criteria and their range of land suitability criteria [2]. [2] Stated that diagnostics criterion is discriminate land characteristic which differentiates the level of crop production. The range of land suitability criterion is the range of land value in relation to land suitability classes of specific crop or land use type.

The crop production indicator which used in land suitability evaluation for Rancing is different from common sweet potato criteria. The Rancing production is usually based on yield and sweetness taste degree, whereas common sweet potato is generally based on yield only. The yield and sweetness of Rancing depend on different land characteristics that differentiate their production level [2]. Therefore, to determine land use requirement of Rancing must be based on the single production indicator that considers combination of actual yield and sweetness degree.

Previous study was showed that discriminant analysis capable to determine land characteristics which differentiates Cilembu yield and sweetness degree classes, separately based on specific characteristics [2]. Specific characteristics to be investigated in this study are land data, yield and sweetness degree of Rancing in the actual production centers in West Java. This study was conducted to selecting land characteristics affecting Rancing production using production indicator of consumers’ preference.

2. Material and Method
2.1. Location study description
Rancing production center at this study were: Sumedang Regency (Cilembu Pamulihan, Rancakalong, Tanjungsari, Sukasari, Jatinagar, Situraja), Bandung Regency (Cileunyi, Cicalengka, Banjaran, Cimaung), and Kuningan Regency (Jalaksana). Planting areas were located on Inceptisol [16], and based on geomorphology aspect were located in volcanic soil parent material, except Nagreg was located in igneous rock parent material [17]. The annual rainfall average in the study area is 2105.17 mm yr\(^{-1}\). The location study was presented in figure. 1.

![Figure 1](image-url)

**Figure 1.** Area of sampling plot for Rancing Cultivation Areas

2.2. Land use type of Rancing
Land use types of Rancing describes by the cultivation technical specifications which was applied by farmers in origin cultivation areas. The technical specifications of Rancing cultivation are: the Cilembu sweet potato variety used Rancing, production inputs, land management, and cultivation techniques applied undertaken by common local sweet potato farmers, and production orientation was for commercial. Fresh tubers of Rancing were harvested at 4.5 months after planting.

Production indicators of Cilembu sweet potato is according to the demand and consumer preferences which are include both the yield and the level of sweetness. For practical purposes, the production indicator of land suitability criteria of Cilembu sweet potato which used in this study was based on the total sugar weight (kg ha⁻¹). The total sugar weight is multiplication of the yield (t ha⁻¹) and total sugar content (%) of each sample plot. Therefore, production classes which was used in the determination of discriminate land characteristics are based on the the total sugar weight of Cilembu sweet potato. The level of total sugar weight of Rancing was following the classification of production in [2].

2.3. Soil sample and analysis
Land characteristics include in this study are soil, climate and topography properties. Soil samples were taken from 80 plots. Composite soil samples were collected from 5-10 locations in the plot diagonally, mixed and taken with quarter methods about 1 kg. Soil analysis was followed the technical procedures of soil analysis of [18]. Soil characteristics were measured, include: pH, total N, organic C, P, K, Ca, Mg, CEC, KB, and soil texture. Soil analyses were performed in the soil laboratory of Indonesia Horticulture Research Agency. Some characteristics have been measured in the field, include: elevation, effective depth of soil, rock surface, rock outcrops. Climate data were obtained from the closest weather stations, include: air temperature and rainfall throughout the growing period of local flasah sweet potatoes. Planting location elevation data were obtained from topographic maps and measurement locations with GPS coordinates. Sampling sites of Rancing tuber and soil samples were done purposively on existing origin and new cultivation areas.

2.4. Sweet potato sample and analysis
Tuber samples were taken from 80 plots of Rancing planting areas and harvested at the age of 4.5 months from planting. Weight of the raw tuber (t ha⁻¹) was measured on each plot. For the measurement of the sweetness degree, six raw tubers were collected from each sampling area. Tuber samples were healthy and uniform size tubers. Measurements of the sweetness degree of raw tubers were done as soon after at harvest time. Sweetness degree was measured in terms of total sugar content (%) using Luff school method in accordance standard measurement of sugar in Indonesia (SNI 01-2892-1992) [19]. Total sugar weight (kg h⁻¹) was measured by multiplication total sugar content (%) and yield (t ha⁻¹) of raw tuber samples.

2.5. Statistical analysis
Selecting land characteristics affecting Rancing production method was refers to [2]. This method were used discriminant analysis which was determined land characteristics affecting the total sugar weight classes of Rancing. This method was carried out through analysis of potential discriminate variables, discriminant loading and standardized discriminant coefficient.

The total sugar classes were determined based on criteria of the decreasing production was applied by [2]. The difference between typical and non typical areas was analyzed through t-test comparison of the mean at α = 0.05. Potential discriminate variables were determined by equality of means analysis of each classes (groups) at a significance level α = 0.05. That can be used on multiple discriminant analysis. Potential discriminate variables were used on multiple discriminant analysis by stepwise estimation and Mahalanobis Distance method [20]. On the basis stepwise multiple discriminant analysis, the criteria to enter the variable in the discriminant function with α = 0.05 and for removing it from the discriminant function at α = 0.1 [20].

Multiple discriminant analysis generated discriminant loading and standardized discriminant coefficient. Discriminant loading is the correlation of variable value with the discriminant Z score of
each discriminant function. Discriminant loading determines the predictor variables that discriminate each group or classes. In addition, standardized discriminant coefficient shows strength of differentiator (discriminant power) of each corresponding land characteristics. It can be seen from the highest value (as strong discriminator) to lowest (as weak discriminator) on the value of the standardized discriminant coefficients [20]. Strong discriminator and weak discriminator but remains closely linked to the function of differentiate the classes can be considered as the certain land characteristic which affecting local flash sweet potato. For data processing and statistical analysis was used Microsoft word and excel applications.

3. Result And Discussion

3.1. Total sugar weight classes of Rancing

Total sugar weight classes were presented in table 1. The total sugar weight classes were varied among cultivation areas. Total sugar weights were had variation among cultivation areas. Variation of total sugar weight classes were showed significant different between typical and non typical cultivation areas (table 2). This fact may result from differences of land characteristics both typical and non typical cultivation areas as revealed by [2]. One or more land characteristics may differentiate total sugar weight of Rancing in different influence. Therefore, one land characteristic will influence in high effect to total sugar weight, so the total sugar weight became low. Otherwise, others land characteristics will influence in moderate to very low effect, so the total sugar weight become moderate to high. This result congruent to [2] that discriminate land characteristics were distinguished local flash sweet potato yield and sugar content classes. [6] revealed that differences Cilembu Nirkum yield related to variation of soil properties.

Table 1. Classes of total sugar weight of Rancing in existing cultivation areas

| Cultivation Areas | Range    | Average | Class         |
|-------------------|----------|---------|---------------|
| Typical           |          |         |               |
| Pamulihan         | 311.14 - | 463.15  | Low – Moderate|
|                   | 650.15   |         |               |
| Nagarawangi       | 163.08 - | 254.50  | Low – Very Low|
|                   | 329.44   |         |               |
| Rancakalong       | 378.00 - | 481.99  | Low – Moderate|
|                   | 544.32   |         |               |
| Sukasari          | 327.60 - | 559.10  | Low – High    |
|                   | 825.33   |         |               |
| Tanjungsrari      | 426.38   | 426.38  | Low           |
| Non Typical       |          |         |               |
| Situraja          | 384.69 - | 431.70  | Low           |
|                   | 478.71   |         |               |
| Jatinangor        | 276.32 - | 412.20  | Low – Moderate|
|                   | 498.96   |         |               |
| Banjaran          | 360.05 - | 384.65  | Low           |
|                   | 425.25   |         |               |
| Cicalengka        | 183.14 - | 248.41  | Low           |
|                   | 305.90   |         |               |
| Cimasuk           | 54.40 – 250.90 | 146.70  | Low – Very Low|
|                   | 250.90   |         |               |
| Dangdeur          | 387.07 – 779.11 | 601.72  | Low – High    |
|                   | 779.11   |         |               |
| Jalaksana         | 89.00 – 282.85 | 182.76  | Low – Very Low|
|                   | 282.85   |         |               |
| Cileunyi          | 174.18 – 454.90 | 273.41  | Low           |
|                   | 454.90   |         |               |
| Nagreg            | 102.06 – 364.50 | 248.14  | Low – Very Low|
|                   | 364.50   |         |               |

Table 2. Result of compare means t test of total sugar weight of Rancing in existing cultivation areas

| Variable               | Cultivation areas | N | Average | Standard deviation | T test for equality of means |
|------------------------|-------------------|---|---------|--------------------|------------------------------|
|                       |                   |   |         |                    | T test | Df  | Sig. (2 tailed) |
| Total sugar weight     | Typical           | 34| 461.22  | 148.51             | 3.91  | 78   | 0.00           |
|                        | Non Typical       | 46| 324.22  | 159.36             |        |      |                |

Remarks: N=Number of samples; Df=Degree of Freedom; Sig.=Significance
3.2. **Discriminate land characteristics of total sugar weight classes of Rancing**

The stepwise multiple discriminant analysis assessed 21 land characteristics (pH, Nitrogen, Soil organic carbon, P, K, Ca, Mg, CEC, BS, soil texture, depth effective, rock surface, rock outcrops, elevation, temperature, rainfall and planting period). Land characteristics that had significant differences of average means of total sugar weight classes, were: pH, SOC, CEC, T maximum, ΔT, T mean, rainfall 3rd to 5th month in planting period (RF3, RF4, RF5). The land characteristics are potential discriminate variable (table 3). The potential discriminate variable as the predictor variable data had normal distribution, which have done based on test results of Kolmogorof-Smirnof with α = 0.05. These results reinforce the result of previous research [2] that land characteristics had different influences to sweet potato production in different degree.

Predictor variables differentiated each total sugar weight classes which figured as discriminant loading. From discriminant loadings were shown in table 4, that several land characteristics were having higher correlation to functions 1, 2, or 3 than others. Function 1 was play a role in differentiate the high class of total sugar weight from other classes, which were correlated strongly with soil organic carbon and rainfall at 3rd month (RF3) in planting period. Soil chemical properties are: CEC and pH, which were correlated to the function 2 and play a role in differentiating the moderate class of total sugar weight from other classes. Climatic factors are: maximum temperature and rainfall at 5th month (RF5) in planting period which were correlated strongly with function 3 and play a role in differentiate the low class of total sugar weight from very low class. This result indicate that to achieve minimum total sugar weight of sweet potato that is profitable, it’s need to have suitable maximum temperature and rainfall at harvest time. To get higher profitable production of Rancing, favourable soil properties and sufficient rainfall until maximum tuber formation are importance. This result was congruent with the result of the study of [8] and [2].

**Table 3.** Result of equality of means analysis of each classes and F test in predictor variable individually

| No | Variable | F   | Wilks’ λ | df1 | df2 | Sig. |
|----|----------|-----|----------|-----|-----|------|
| 1  | RF5      | 7.87| 0.76     | 3   | 76  | 0.00 |
| 2  | RF3      | 7.04| 0.78     | 3   | 76  | 0.00 |
| 3  | CEC      | 6.94| 0.79     | 3   | 76  | 0.00 |
| 4  | ΔT       | 4.43| 0.85     | 3   | 76  | 0.01 |
| 5  | RF4      | 4.42| 0.85     | 3   | 76  | 0.01 |
| 6  | T max    | 4.27| 0.86     | 3   | 76  | 0.01 |
| 7  | SOC      | 3.53| 0.88     | 3   | 76  | 0.02 |
| 8  | pH H2O   | 3.28| 0.89     | 3   | 76  | 0.03 |
| 9  | T Average| 3.06| 0.89     | 3   | 76  | 0.03 |

Remarks: RF3, RF4, RF5=Monthly rainfall during Rancing growth periods at 3rd, 4th, and 5th months from planting; ΔT=The difference of maximum and minimum temperature; T Max= The Maximum Temperature; T Average=The average of Temperature; CEC=Cation exchange capacity; SOC=Soil Organic Carbon; F= F test value; Df=Degree of Freedom; Sig.=Significance

**Table 4.** Correlation between discriminate variabel of total sugar weight of Rancing and discriminant function coefficient

| Variable | Function 1 | Function 2 | Function 3 |
|----------|------------|------------|------------|
| RF3      | 0.451*     | 0.406      | -0.001     |
| RF4     | 0.436*     | -0.018     | 0.211      |
| SOC     | -0.348*    | 0.114      | 0.202      |
| CEC     | 0.364      | 0.512*     | 0.419      |
The power of discriminate variable of total sugar weight classes of Rancing based on coefficient of standarized discriminant function

| Variable   | Function 1 | Function 2 | Function 3 |
|------------|------------|------------|------------|
| pH H₂O     | -0.852     | 0.392      | 0.486      |
| SOC        | -0.558     | 0.466      | 0.084      |
| CEC        | 0.478      | 0.613      | 0.289      |
| T max      | 0.579      | -0.279     | -0.584     |
| RF3        | 0.476      | 0.721      | -0.172     |
| RF5        | 0.260      | -0.625     | 0.637      |

Remarks: CEC=Cation exchange capacity; SOC=Soil Organic Carbon; RF3, RF5=Monthly rainfall during Rancing growth periods at 3rd and 5th months from planting; T Max= The Maximum Temperature; F= F test value; Df=Degree of Freedom; Sig.=Significance

The other result of stepwise multiple discriminant analysis was standardized discriminant coefficient. The coefficient shows strength of differentiator or discriminant power of each corresponding preditor variables. The standardized discriminant functions were presented from the highest to lowest coefficient value in table 5. In the first function were obtained pH H₂O, and the soil organic carbon (SOC) as strongest discriminate variable, which differentiates a high class of the total sugar weight from other classes, significantly. In function 2 were obtained CEC and rainfall at 3rd month (RF3) in planting period, which were discriminator of moderate class from lower classes. The functions 3 were obtained the maximum temperature (T max) and Rainfall at 5th month (RF5) in planting period which were differentiates low and very low class. Land characteristics which were strong and weak discriminator as land characteristics affecting total sugar weight of Rancing classes.

The role of soil properties, as: pH, SOC, and CEC relates to yield of Rancing, which was consistent with the results of previous study [6, 5, 7, 8, 2], and to sugar content [9, 10, 11, 12, 2]. Climate factors are related to the growing environment that is suitable for photosynthesis, water availability, and biochemical processes in plants. [21] stated that natural external factors that influence crop yields include solar radiation, temperature, evapotranspiration and precipitation. The availability of water for sweet potato plants, including from rainfall, contributes to changes in physiology, anatomy and plant morphology and subsequently affects sweet potato productivity and yield [22, 23, 2]. Related to temperature for sweet potato growth, [2] revealed that vegetative growth requires optimal sunlight during the day, while the accumulation of photosynthesis in the roots of sweet potato plants of when respiration occurs, requires cold night temperatures.

4. Conclusion
This study was find out production indicator criteria of local flash sweet potato that meet consumer’s preference. The production of Rancing which based on considerations of quantity and quality of production is total sugar weight. Land characteristics affecting total sugar weight classes of Rancing are are: pH H₂O, soil organic carbon, CEC, maximum temperature, rainfall at 3rd and 5th from planting period.
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