Evaluation of soil fertility status for rice, corn, soybean on suboptimal land in West Java Indonesia

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Abstract. Rice, corn and soybeans are the main food commodities in Indonesia. The expansion of agricultural land in suboptimal areas has been carried out to increase the production of these commodities. However, with the limited suboptimal land conditions, the fit fertilizer engineering should be found. The purpose of this experiment was to evaluate the soil fertility status on suboptimal land in West Java, Indonesia. The research method used qualitative, descriptive, comparative and survey methods. The sampling area was carried out in each unit of land with determined by transect based on the results of environmental observations. It is sufficiently representative to represent the land in the area. The result from this experiment was there are four districts as a centre of rice, corn and soybean in West Java, Indonesia, such as Majalengka, Kuningan, Cirebon and Subang. In general, soil characteristics (N, P, K, pH, CEC, BS, cations and textures) for rice, corn and soybean centre in West Java are low, medium until high criteria based on analysis of nutrient content of soil samples. The characteristics of farmers (economic and social activities) in rice, corn and soybean centre in West Java, have good competence in the farming system, productive age of farmers and excellent organizational structure.

1. Introduction
Food security is a condition to fulfil of food which is reflected in the availability of food in quantity, quality, evenly and affordably. One of the strategic efforts an improving and maintaining sustainable local and national food security is to develop agricultural systems through improving the quality of land and see the potential locations such as suboptimal lands. However, this land has a big problem for the farming system that contains nutrient and water-deficient for plants. Generally, suboptimal lands, including the Ultisols and Inceptisols orders, have good prospects for develop in Indonesia. Because this land is widely distributed in this country, which is 45.79 million ha and 52.00 million ha from a total land area (188.20 million ha) [1]. Generally, in Indonesia this land is very large, including swamps and dry land. For wetlands, around 33.4 million hectares were starting from Sumatra, Kalimantan, Sulawesi and Papua. On the other side, from the total land area (58 million hectares), only 18 per cent of Indonesia's agriculture is classified as fertile and optimized. The rest is sub-optimal land with various agronomic constraints. Furthermore, the cultivation technology in Indonesia is dominated by optimal land use (almost 90% of the land is used as irrigated land). The government has a program to extensification of agriculture production on sub-optimal land which has abandoned, unproductive and marginal. To support this programme, the management of this land must balance between food self-sufficiency, improvement of farmers' live standard and preservation of a low-emission environment.
Sub-optimal land or marginal land has a potential to be optimized. In [2] and [3] reported various possibilities for improving the quality of suboptimal land through the amelioration process. This process using various materials, including application of organic matter derived from animal manure, green compost, rice straw, activated charcoal, humic acids and municipal waste [4, 5, 6]. Natural resources such as zeolites, natural phosphates, guano, and others [3, 7]. On the other side, the decreasing of main production commodities can happen naturally or through human activity [8].

2. Material and Methods
The study was conducted with qualitative, descriptive, comparative and survey methods. The survey method is carried out by a physiographic approach. Soil sampling is carried out in each representative land unit, which is determined by transect based on the results of environmental and mapping to represent the land in that area. The research location is in the rice, corn, and soybean centre on West Java Province. Analysis of soil properties (chemistry and physics) was conducted at the Laboratory of Soil Chemistry and Plant Nutrition. Mapping analysis was conducted at the Land Evaluation Laboratory of the Department of Soil Science, Universitas Padjadjaran. The map of sampling is represented in Fig.1 below.

![Figure 1 Observation point and soil sampling](image)

The research location is West Java Province with geographically located between 5°50'-7°50' south latitude and 104°48'-108°48' east longitude. West Java region is divided into 27 districts/cities, covering 18 districts consist of Bogor, Sukabumi, Cianjur, Bandung, Garut, Tasikmalaya, Ciamis, Pangandaran, Kuningan, Cirebon, Majalengka District Sumedang, Indramayu, Subang, Purwakarta, Karawang, Bekasi, West Bandung. Nine cities, they are the city of Bogor, Sukabumi, Bandung, Cirebon, Bekasi, Depok, Cimahi, Tasikmalaya and Banjar and consists of 626 subdistricts, 641 villages and 5,321 sub-villages. Geographic conditions of West Java have a strategic advantage for West Java province. Because, this land has fertile from volcanic deposits and fed by many stream rivers such as Cisadane, Ciliwung, Cisande, Cimandiri, Citarum, Cimanuk and Citanduy.

3. Result and Discussions

3.1. Characteristics of Soil Samples
The results of soil analysis for rice, corn and soybean centre in West Java showed the varied soil fertility conditions. The acidity of the soil starts from slightly acidic to neutral. These soil reactions indicate the acidity or alkalinity conditions expressed in pH values. This value is important to determine the elements are absorbed by plant roots in a neutral condition, because at that pH most elements are easily dissolved in water. The characteristics of pH, Organic C, Total N, C/N ratio, P, K and exchangeable H content were describe in Table.1 below.
Table 1. Content of pH, Organic C, Total N, C/N, P, K and exchangeable H on Soil Samples

| NO | DISTRICTS | PLANTS      | pH H₂O | pH KCl | Organic C (%) | TO T N (%) | C/N | P₂O₅ HCl 25% (mg/100g) | K₂O HCl 25% (mg/100g) | P₂O₅ BRAY (ppm P) | Exc-H (cmol/ kg) |
|----|-----------|-------------|--------|--------|---------------|-------------|-----|------------------------|----------------------|-------------------|-----------------|
| 1  | Majalengka| Rice Field  | 6.33   | 5.66   | 2.40          | 0.27        | 9   | 113.42                | 5.99                 | 34.42             | 0.09            |
| 2  | Majalengka| Rice Field  | 6.27   | 4.69   | 1.90          | 0.68        | 11  | 86.27                 | 4.38                 | 13.47             | 0.09            |
| 3  | Majalengka| Rice Field  | 5.80   | 4.46   | 1.65          | 0.18        | 9   | 90.55                 | 9.32                 | 6.53              | 0.18            |
| 4  | Majalengka| Rice Field  | 5.76   | 4.54   | 2.60          | 0.26        | 10  | 111.41                | 5.53                 | 5.15              | 0.09            |
| 5  | Majalengka| Corn        | 7.22   | 5.63   | 1.76          | 0.23        | 8   | 126.74                | 11.35                | 15.84             | 0.00            |
| 6  | Majalengka| Corn        | 7.18   | 5.60   | 1.61          | 0.20        | 8   | 130.76                | 10.37                | 24.16             | 0.09            |
| 7  | Majalengka| Soybeans    | 5.91   | 5.03   | 2.64          | 0.27        | 10  | 146.84                | 15.40                | 12.63             | 0.09            |
| 8  | Cirebon   | Rice Field  | 6.19   | 4.93   | 1.79          | 0.20        | 9   | 152.62                | 23.84                | 7.23              | 0.27            |
| 9  | Cirebon   | Rice Field  | 6.10   | 4.99   | 1.80          | 0.20        | 9   | 153.88                | 23.16                | 8.61              | 0.09            |
| 10 | Cirebon   | Rice Field  | 6.60   | 5.12   | 1.65          | 0.17        | 10  | 150.61                | 20.17                | 33.59             | 0.14            |
| 11 | Kuningan  | Corn        | 6.57   | 5.08   | 2.33          | 0.24        | 10  | 190.32                | 6.39                 | 77.97             | 0.00            |
| 12 | Kuningan  | Corn        | 7.30   | 6.18   | 1.66          | 0.23        | 7   | 175.75                | 17.37                | 67.98             | 0.18            |
| 13 | Subang    | Rice Field  | 6.77   | 5.19   | 1.72          | 0.18        | 10  | 141.56                | 16.00                | 33.59             | 0.09            |
| 14 | Subang    | Rice Field  | 5.88   | 4.75   | 1.86          | 0.18        | 10  | 95.57                 | 3.84                 | 10.00             | 0.09            |

The moderate to low organic C and total N, P (moderate to high) and K (moderate to low) gives variation of nutrients in sub optimal land. For the low content indicates that land as a centre of rice, corn, soybeans need efforts to increase the soil productivity in West Java. The content of soil organic matter describes the balancing of the humification and mineralization processes. The soil activity such as post-harvest, lost crops are directly affected by the intensity of the soil as an agricultural system [9,10]. In Table 2 below, we can see the contents of CEC (Cations Exchangeable Capacity), BS (Base Saturation) and cations that contain on soil on rice, corn and soybeans centre in West Java.

Table 2. Content of CEC, Base Saturation (BS), Cations on Soil Samples

| CEC (Cmol/kg) | BS (%) | CATIONS (Cmol/kg) |
|---------------|--------|-------------------|
|               | Exc-K  | Exc-Na  | Exc-Ca  | Exc-Mg  |
| 27.117        | 49.21  | 0.20    | 0.45    | 3.74    | 8.98   |
| 21.82         | 39.14  | 0.10    | 0.45    | 2.78    | 5.21   |
| 31.49         | 35.85  | 0.17    | 0.45    | 3.34    | 7.32   |
| 30.28         | 35.7   | 0.11    | 0.57    | 3.29    | 6.85   |
| 25.42         | 48.78  | 0.28    | 0.50    | 3.63    | 8.00   |
| 25.82         | 47.83  | 0.27    | 0.46    | 3.76    | 7.86   |
| 31.17         | 45.39  | 0.45    | 0.49    | 3.75    | 9.46   |
| 43.80         | 54.68  | 0.43    | 0.59    | 6.38    | 16.55  |
| 43.23         | 58.47  | 0.47    | 1.02    | 6.68    | 17.11  |
| 42.72         | 59.17  | 0.35    | 1.10    | 6.79    | 17.16  |
| 29.77         | 30.56  | 0.19    | 0.69    | 3.37    | 4.85   |
The capacity of cation exchange in the rice, corn and soybeans centre is known from moderate to very high. This Cation Exchange Capacity (CEC) is an important chemical characteristic on soil that is related to soil fertility. The cation exchange capacity is defined as the ability of the soil to absorb and exchange cations. Furthermore, the land with high CEC is able to absorb and provide nutrients better than land with low CEC. Many factors that influence the level of CEC such as the content of organic matter, clay content and types of clay minerals. The contain of texture on rice, corn, soybeans centre can be seen in Table.3 below.

**Table 3. Contents of Textures on Soil Samples**

| Textures (%) | Sand | Dust | Clay |
|--------------|------|------|------|
| 29           | 37   | 34   | Clay Loam |
| 55           | 17   | 28   | Sandy Clay Loam |
| 10           | 34   | 56   | Clay |
| 28           | 33   | 39   | Clay Loam |
| 21           | 44   | 35   | Clay Loam |
| 23           | 42   | 35   | Clay Loam |
| 16           | 38   | 46   | Clay |
| 1            | 31   | 68   | Clay |
| 2            | 30   | 68   | Clay |

Soil fertility is important for counting the nutrients from media to plant. This process also calculating the amount of plant residue returning to the ground [10,11,12]. The residual process in quantity, quality, time and method of crop residues returned to the soil and the factors that affect their transformation, can be managed through cultivation techniques, post-harvest combinations or both combinations [9]. The map fertility status of rice, corn and soybeans centre in West Java can be seen in Fig.2 below.
3.2. Characteristics of Farmers

Characteristics farmers in centre of rice, corn and soybeans in West Java is interesting to study. The characteristics can be seen from economic and social activity. The economic activity is related to farming activity, while the social activity is correlated with age, farmer experience, population movement patterns, leadership patterns and other activity. Characteristics of farmers and farm competence is a picture of the ability of farmers to manage a farming system with good planning (industrial cultivation). It also shows the performance and responsibilities of farmers in running the farm activity with better and more sustainable. Based on the results of a survey that has been conducted generally, farmers do not have special education, especially formal education to young age. This experience shows that the average farmer comes from hereditary. Most farmers have ages between 30 and 50 years (productive age). Also the farmer in Majalengka, Cirebon, Kuningan and Subang district as a centre of rice, corn and soybeans generally have a good organizational structure as a farmer group.

3.3. Characteristics of Rice, Corn and Soybeans

Rice cultivation in Majalengka, Cirebon, Kuningan and Subang (Fig. 3, Fig. 4, Fig. 5 and Fig. 6) above are generally cultivated on irrigated land and some small cultivated in rainfed. Usually, paddy rice farmers in that district have the advance farming system, because they have been doing it for years. In this area, the concept of good fertilizer as one of important factor is already understood. However, this application is one factor that affects the productivity of paddy rice.

Figure 3 Irrigation of Paddy

Figure 4 Rainfed Rice Fields

Figure 5 Corn Land

Figure 6 Paddy Rice Land

Based on the results of the survey and evaluation that has been done in Majalengka, Cirebon, Kuningan and Subang districts, the farming system for paddy rice in that area is not new for the farmers. It is because the paddy rice farming has been done for some generations. Furthermore, it shown from age of farmers with the average between 10-40 years. However, the technique of rice production in the region is not performed in modern cultivation techniques. Because, farming in that area is still in a simple, not using agricultural machines. But some already have irrigation channels to supply the water needs in the paddy fields. For fertilizer understanding, the composition of inputs, such as fertilizer use in that area is still not balanced. Inorganic fertilizer still dominates in agricultural system in that area. Characteristics of paddy rice farming in rice, corn and soybeans centre can be seen in Table.4 above.
Table 4. Characteristics of paddy rice farming

| No  | Descriptions                                      | Majalengka       | Cirebon       | Kuningan       | Subang       |
|-----|---------------------------------------------------|------------------|---------------|----------------|--------------|
| 1   | Experience in Rice Farming                        | 10-20 years      | 10-20 years   | 10-30 years    | 10-40 years  |
| 2   | Land Ownership                                    | 0.1 - 5 ha       | 1-5 ha        | 0.1 - 3 ha     | 1 - 5 ha     |
| 3   | The form of exploitation of paddy fields is intercropped with other plants | corn             | no            | corn           | No           |
| 4   | The pattern of management of agriculture          | farmers          | farmers       | farmers        | farmers      |
| 5   | The type of fertilizer used                       | Organic and chemical fertilizer | Organic and chemical fertilizer | Organic and chemical fertilizer | Organic and chemical fertilizer |
| 6   | Ease of getting fertilizer                        | Easy             | Easy          | Easy           | Easy         |
| 7   | Handling of agricultural waste products           | Made compost     | Made compost  | Made compost   | Made compost |
| 8   | Maintenance system                                | Integrated       | Integrated    | Integrated     | Integrated   |

The factors that can affect corn production are land area, selection of seeds, the dose of fertilizer, management (cultivation-harvest) and use of labour. The seed selection will affect the commodity would be planted, and the size of the crop that will be generated. Comparison of the use of production farming on corn with technology shows that the application of factors production is technically still not following the recommendation. Because, most of the use of production inputs such as the number of seeds, fertilizers, labour and cultivation patterns exceed the amount suggested. In addition, the experience of farming became an important factor in supporting the success of the farming system. The characteristics of corn farming system can be seen at Table 5 above.

Table 5. Characteristics of Corn Farming System

| No  | Descriptions                                      | Majalengka       | Kuningan |
|-----|---------------------------------------------------|------------------|----------|
| 1   | Experience in Corn Farming                        | 5-20 years       | 5-10 years |
| 2   | Land Ownership                                    | 0.1 - 2 ha       | 0.1 - 1 ha |
| 3   | The form of exploitation of corn is intercropped with other plants | Paddy and Vegetables | Paddy and Vegetables |
| 4   | The pattern of management of agriculture          | Farmers          | Farmers   |
| 5   | The type of fertilizer used                       | Organic and chemical fertilizer | Organic and chemical fertilizer |
| 6   | Ease of getting fertilizer                        | Easy             | Easy      |
| 7   | Handling of agricultural waste products           | Made compost     | Made compost |
| 8   | Maintenance system                                | Integrated       | Integrated |

Farming experience is a learning process that can facilitate the adoption and application of technology which is dynamically developed. Continuity of farming is also determined by how big area is managed by farmers. The average farmer has a land area with a range of 0.1 ha to 2 ha. The cropping
system that applied by farmers has variations between regions. In general, the pattern of farmers planting of corn in the West Java, grow on dryland, upland, or irrigated rice. This system using different technology applied by four factors, namely: (1) regional development, (2) consumer tastes, (3) the farming land, and (4) the availability of capital farming. Soybean cultivation in Majalengka generally cultivated on irrigated land and some small cultivated in rainfed and dryland.

**Tabel 6. Characteristics of Soybeans Farming System**

| No | Descriptions | District         |
|----|--------------|-----------------|
| 1  | Experience in Soybean Farming System | Majalengka      |
| 2  | Land Ownership | 5 - 10 years    |
| 3  | The form of exploitation of soybean is intercropped with other plants | Corn            |
| 4  | The pattern of management of agriculture | Farmers         |
| 5  | The type of fertilizer used | 0.1 – 0.5 ha    |
| 6  | Ease of getting fertilizer | Organic and chemical fertilizer |
| 7  | Handling of agricultural waste products | Made compost    |
| 8  | Maintenance system | Integrated      |

Prospect of soybean production in Indonesia to reduce imports is quite good. The availability of land resources are quite extensive, suitable climate and technology that has been generated can open commodity market in Indonesia. Government as facilitator, motivator, and creating a conducive environment in the development of a commodity is technically, socially and economically very important and strategic. Scope of discretion in the program is very complex. This program includes the procurement and distribution of production (seeds, fertilizers, pesticides and business loans farmer), education and business administration. All part of this program through institutional systems results and guidance from the central to the village level. Policy in research increased production, and trade (prices) are interconnected to one another. Price protection will have a positive impact on increasing production and income of farmers when supported by the potential of technology and business administration systems are efficient.

4. Conclusions
There are four districts as a centre of rice, corn and soybean in West Java, Indonesia, such as Majalengka, Kuningan, Cirebon and Subang. In general, soil characteristics (N, P, K, pH, CEC, BS, cations and textures) for rice, corn and soybean centre in West Java are low, medium until high criteria based on analysis of nutrient content of soil samples. The characteristics of farmers (economic and social activities) in rice, corn and soybean centre in West Java, have good competence in the farming system, productive age of farmers and excellent organizational structure.

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