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Ascertainment of K Nutrient Availability Class for Maize by Several Methods

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ABSTRACT

Research was conducted in Gowa, South Sulawesi at dry land farmer during two years. The aims of the research was to get the best method in ascertainment of availability class of potassium (K) for maize in dry land. The research used a single location approach, which made some of K nutrient artificial. Result of this research indicated that K nutrients class which reached by several methods are: (1) by Cate-Nelson method : two class, ie low and high class, (2) by curve continue method: two until three classes, ie very low to moderate class, low and moderate, and low to high class; and (3) by analysis of variance modified method: three classes, ie low to high class. Ascertainment of K nutrient availability classes by modified analysis of variance method was the best methods compared to other methods. Critical level of K nutrient for maize according to modified analysis of variance method by several extractant is: 0.40 me K 100 g^{-1} for NH_4OAc pH 4.8 extractant; 0.40 to 0.60 me K 100 g^{-1} for NH_4OAc pH 7 extractant; 200-300 ppm K_2O for Bray-1 extractant, and 215-250 ppm K_2O for Olsen extractant.

Keywords: Ascertainment, critical level of K nutrient, maize, Cate-Nelson method

INTRODUCTION

Potassium fertilizer plays an important role in improving crop production because of its role in physiological processes, such as cell division, photosynthesis, nitrate reduction and protein synthesis, and enzyme activity (Leiwakabessy and Sutandi 1996). Therefore, potassium is often referred to as a catalyst in the process of ensuring the life because the reaction in the plant life. Potassium is one of the macro nutrients that plants need quite a lot of early corn growth before flowering plants even 30% of the potassium they need is absorbed by plants (Laddong 1988). However, the use of K fertilizer on crops are generally not rational and balanced because fertilization has not been based on the status and dynamics of nutrients in the soil as well as the needs of the plant optimum. Therefore, nutrient status and plant nutrient dynamics are needed to be known through soil testing approach (Sabiham 1996).

Estimate of nutrient availability in the soil can be done through soil testing, chemical analysis is an activity that is simple, fast, inexpensive, accurate, and reproduceable (Leiwakabessy and Sutandi 1996; Leiwakabessy and Koswara 1985). Ascertainment the status of nutrients in the soil through a soil test can be used as a guide the land's ability to provide nutrients for plants. However, the ability of plants to absorb nutrients from the soil is determined by the nutrient status of the soil, and it is also influenced by the availability of water, infiltration rate, drainage, salinity, exchangeable cations, and the presence of compounds that are toxic as well as the plant it self (Soepartini *et al*. 1994). Thus, the status of nutrients in the soil can not be used as a probe response to fertilization and crop fertilizer requirements for crops in question before calibrated with experimental results fertilization (Widjaja-Adhi 1993; 1996; Voss 1998).

Several methods can be used to ascertainment the class of the availability of nutrients such as Cate-Nelson graphical method (Widjaja-Adhi 1996). In this method, the critical threshold values obtained indicate that the nutrient status of the soil nutrients that have a soil test value is lower than the critical threshold value considered low class, whereas greater than the critical threshold value including high class. Cate-Nelson graphical method only provides two classes (categories) soil test, which is a low class (response to fertilizers) and high class (no response to fertilizer). Another method that gives the class of nutrient availability more than two classes is a continuous curve method (Leiwakabessy 1996; Dahnke and Olson 1990) or analysis of variance modified method (Widajaja-Adhi 1986).

Ascertainment of K nutrient availability class with some methods are very important in terms of getting the best method in the preparation of fertilizer recommendations for maize. K soil test calibration studies conducted with a single location to remember the way the approach is relatively inexpensive, easy and fast, but to obtain more accurate data needs to be done through a multi-site approach.

The aims the research was to get the best method in determining of K nutrient class for corn in dry land.

MATERIALS AND METHODS

Nutrient soil test calibration study K for corn conducted on dry land by using the approach of a single location, that is by making artificial soil nutrient status of very low to very high and subsequently implement fertilization experiment in each nutrient status.

Type of soil in the experiment at the level of orders include Alfisols and at the level classified as Typic Rhodustalfs family. Average rainfall at the site is 291 mm/month with 18 days the number of rainy days. The highest rainfall occurs in February which reached 1,008 mm while the lowest rainfall occurs in August. The event was doing in Gowa, South Sulawesi during two years.

The experiment consisted of two stage, namely the first stage of making artificial soil nutrient status K, and the second stage K fertilization experiments were placed in locations that have been conditioned of K nutrient status.

Stage I: Preparation of Artificial K Nutrient Status

K fertilizer was given at a dose of 0X (K status is very low), 1/4X (low), 1/2X (medium), 3/4X (high), and X (very high), where X is the number of K fertilizer given that K in the soil solution reached 0.02 mg K/l (Widjaja-Adhi *et al.* 1990), defined by the absorption curve of K according to Fox and Kamprath method (1970). K dose used in the first stage is based on K maximum absorption, ie 200 kg ha^{-1} of Potassium Clorida (KCl).

Potassium clorida is given to the respective main plots in accordance with the treatment before planting. Evenly spread fertilizer and soil stirred until completely homogeneous. Urea and ZA, respectively at a dose of 300 kg (3 times application) and 50 kg ha^{-1} given bolt spread on crops, while the SP-36 at a dose of 250 kg ha^{-1} provided with Potassium Clorida.

Experimental plots were 30 m × 20 m. The experimental design was in a randomized completely block design with three replications. The experiment consisted of five treatments, namely: (1) very low K nutrient, (2) low K nutrient, (3) moderate K nutrient, (4) high K nutrient, and (5) very high K nutrient status. Indicator plants are maize with a spacing of 75 cm × 20 cm. In the first phase of the experiment (incubation experiments), in addition to soil is expected to reach reaction equilibrium constant (steady stage) or K nutrients from manure turned into the soil nutrient K, is also the basis for fertilization experiment in the second stage at various K nutrient status of the soil.

StageII : K Fertilization on Corn in Dry Land

After the completion of the first stage of the experiment, soil samples were taken from each plot treatment by composite about 1 kg for ascertainment of soil K levels with 25% HCl, NH_4OAc pH 7, pH 4.8 NH_4OAc, Bray-1 and Olsen method.

Further experimental plots in stage I, split into plots measuring 6 m × 4 m. The experimental design used in the second stage is a split plot with three replications. In the main plot is K nutrient status of the soil (which acquired the activities of stage I), namely: very low K nutrient (A), low K nutrient (B), moderate K nutrient (C), high K nutrient (D), and very high K nutrient (E), while the subplot is K fertilizers, namely: 0 kg K ha^{-1} (K0), 20 kg K ha^{-1} (K1), 40 kg K ha^{-1} (K2), 80 kg K ha^{-1} (K3), and 160 kg K ha^{-1} (K4). Total number of treatment is 60 treatments.

Plant indicators which using are corn of Lamuru variety. Potassium clorida is given prior to planting at a dose of 0, 20, 40, 80, and 160 kg K ha^{-1} for the treatment consecutive K0, K1, K2, K3, and K4. Whereas urea, ZA and SP-36, respectively at a dose at 300 kg urea (3 times applications), ZA 50 kg, and 250 kg SP-36 ha^{-1} given the same as in the first stage. The parameters measured in the experiment is the result of the second stage of the maize plant.

Ascertainment of Nutrient Availability

Several methods can be used in the ascertainment of K nutrient availability, including by Cate-Nelson graphical method (Widjaja-Adhi 1996), continuous curve (Leiwakabessy 1996; Dahnke and Olson 1990), and analysis of variance were modified (Nelson and Anderson 1977).

Cate-Nelson Graphical Method

Ascertainment procedures of nutrient availability class with this method are as follows: (1) make the distribution diagram of the relative percentage yield on the Y axis and K soil test values on the X axis, (2) the distribution diagram put the two lines intersect (cross axis) which divides quadrant into four parts, the lower left quadrant and right upper quadrant as positive, and the left upper quadrant and lower right quadrant as a negative, (3) the cross slide axis in a fixed position until the number of points in the positive quadrant as much as possible, while at the quadrant negative as little as possible, and (4) the intersection of the cross axis with X axis is a critical level nutrient value of K. Areas that are to the left of the critical threshold is low class and the area to the right of the critical threshold is high class (Figure 1).

Continuous Curve Method

Ascertainment of availability class K nutrient by this method are as follows: (1) pair of points mapped relative to the value of the results of the soil test K, (2) create a curve through the points, (3) for the curve into several classes according to the criteria of Cope and Rouse (1973), namely: (a) very low: <50%, (b) low: 50-75%, (c) are: 75-100%, (d) high and very high:> 100% relative yield, as in Figure 2.

Analysis of Varians were *Modified*

Ascertainment procedures of availability K nutrient class with a analysis of modified varians method (Nelson and Anderson, 1977) are as follows:

(1) Calculate DY_{max}.,namely: $DY_{max} = (Y_{max} - Y_0) / Y_{max}$, where Y_{max} is the maximum dry seed yield and Y_0 is dry seed yield on the treatment without fertilizer.

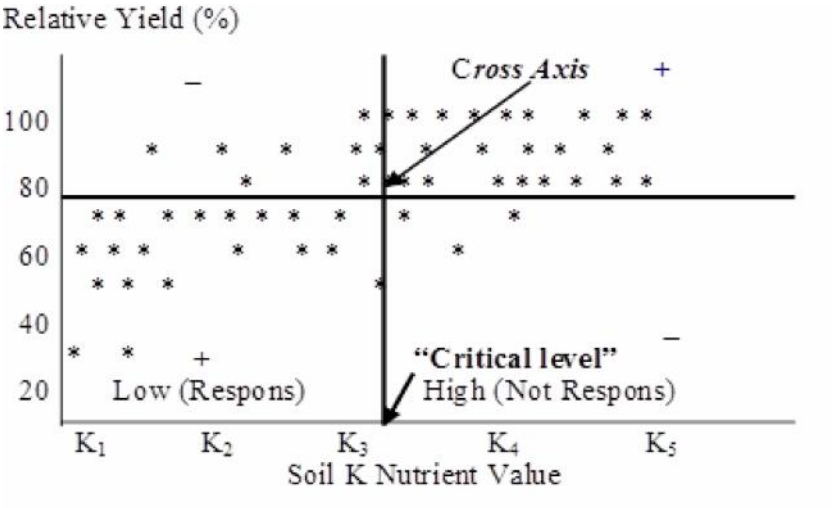

Figure 1. Graph Method of Cate-Nelson for Ascertainment of Availability K Nutrient Class

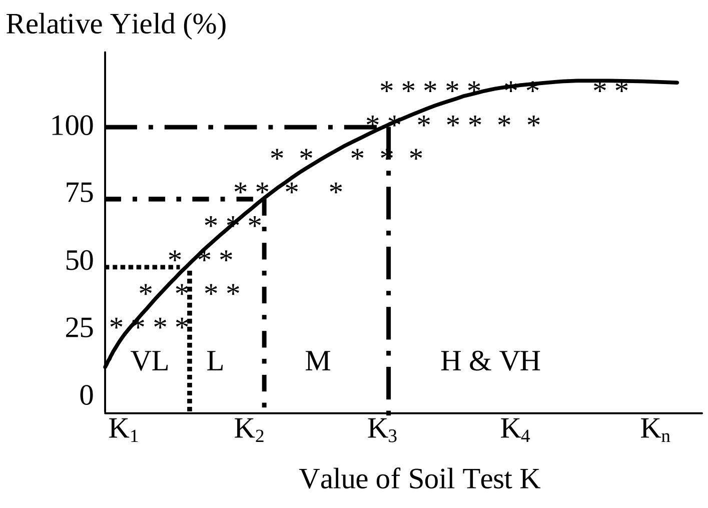

Figure 2. Continuous Curve Method for Ascertainment of Availability K Nutrient Class. VL: Very Low, L: Low, M: Moderate, H: High, VH: Very High.

(2) Arrange the data by increasing the value of soil testing.

(3) Groupping the data into several groups DY_{max} with basic considerations in drawing boundaries subgroups as follows: (a) there must be a considerable reduction of DY_{max} between values either side of the separation barrier and the average DY_{max} should up, (b) dividing line is not drawn between the two soil test values are the same or nearly the same, and (c) members of at least two.

(4) Calculated data pairs (ni), deviation standard (Si), and the average DY_{maxi} of the group to-1 and pooled S of all groups.

(5) Test the difference between two D Y max median of consecutive groups with Student's t-test one-way by the formula:

$t = (DY_{max\ i} - DY_{max\ i+1}) / S\ (1/n_i + 1/n_{i+1})^{0.5}$

When the difference D Y max on average between two successive groups are not real, then the two groups merged into one. Based on the number of new groups, the procedure returns to step 4 and continue to step 5. This is repeated until the value of the average difference between the two groups were sequentially real (Nelson and Anderson 1977).

RESULTS AND DISCUSSION

Statuss of Soil K Nutrient

Data experiment of K nutrient which obtained through experiments in the first step on the field is very irregular (erratic). One of the suspected causes for the land has not reached equilibrium constant (steady stage) or in other words K fertilizer nutrients has not changed completely into nutrient soil K during incubation in the field in a state of drought. Other causes are factors beyond the ability of management experiments, both in the field and in the laboratory.

Availability Class of K Nutrient

Cate-Nelson Graphical Method

Availability class of K nutrient which obtained by Cate-Nelson graphical method with various extractans consist of two classes, namely low class and high class (Table 1). Low K class is obtained in the area to the left of critical level values, while the high K class areas that are on the right of the critical level value. Boundary between low K class and high K class referred to as the "critical level".

Table 1. Availability class of K nutrient for maize based on Cate-Nelson graphical method.

Soil Test Extractants	Unit	Availability Class of K nutrient	
		Low	High
NH_4OAc pH 4.8	me K 100 g^{-1}	< 0.30	> 0.30
NH_4OAc pH 7	me K 100 g^{-1}	< 0.35	> 0.35
Bray-1	ppm K_2O	< 178	> 178
Olsen	ppm K_2O	< 213	> 213

Critical threshold values obtained with the K nutrient by Cate-Nelson graphical method are 0.3 me 100 g^{-1}, 0.35 me 100 g^{-1}, 178 ppm, and 213 ppm, respectively for extrantants NH_4OAc pH 4.8, NH_4OAc pH 7, Bray-1 and Olsen, as presented in Figure 3.

Ascertainment of availability class of K nutrient with Cate-Nelson graphical method (Figure 3) is very weak because it only consists of two classes, low and high, or response and no response to fertilizer K. But according to Dahnke and Olson (1990), the class categories are located in the critical level value. Cate-Nelson graphical method has disadvantages as well, also has the advantage, that it can know the critical value of a nutrient in relation to whether or not to do an act of fertilization. Critical threshold values obtained with the K nutrient Cate-Nelson graphical method can be used as a reference in the act of fertilization on a soil type.

Continuous Curve Method

Ascertainment of availability class of K nutrient with continuous curve method at various extractors K are presented in Figure 4. Based on the continuous curve method, extracting NH_4OAc pH 7 provides two classes of nutrient availability, ie low and medium K class, while the other extractors generate three classes, namely the class K is very low to moderate (NH_4OAc pH 4.8 and Olsen), and low K class to high class (Bray-1), as in Table 2. Only extractors Bray-1 that provides high-class categories K, while the other extractors obtained through the class K is very low to moderate.

Analysis of Variance Modified Method

Ascertainment of availability class of K nutrient by using analysis of variance modified methods (Nelson and Anderson 1977) showed that a class of nutrients K obtained by extracting NH_4OAc pH 4.8, NH_4OAc pH 7, Bray-1 and Olsen, each

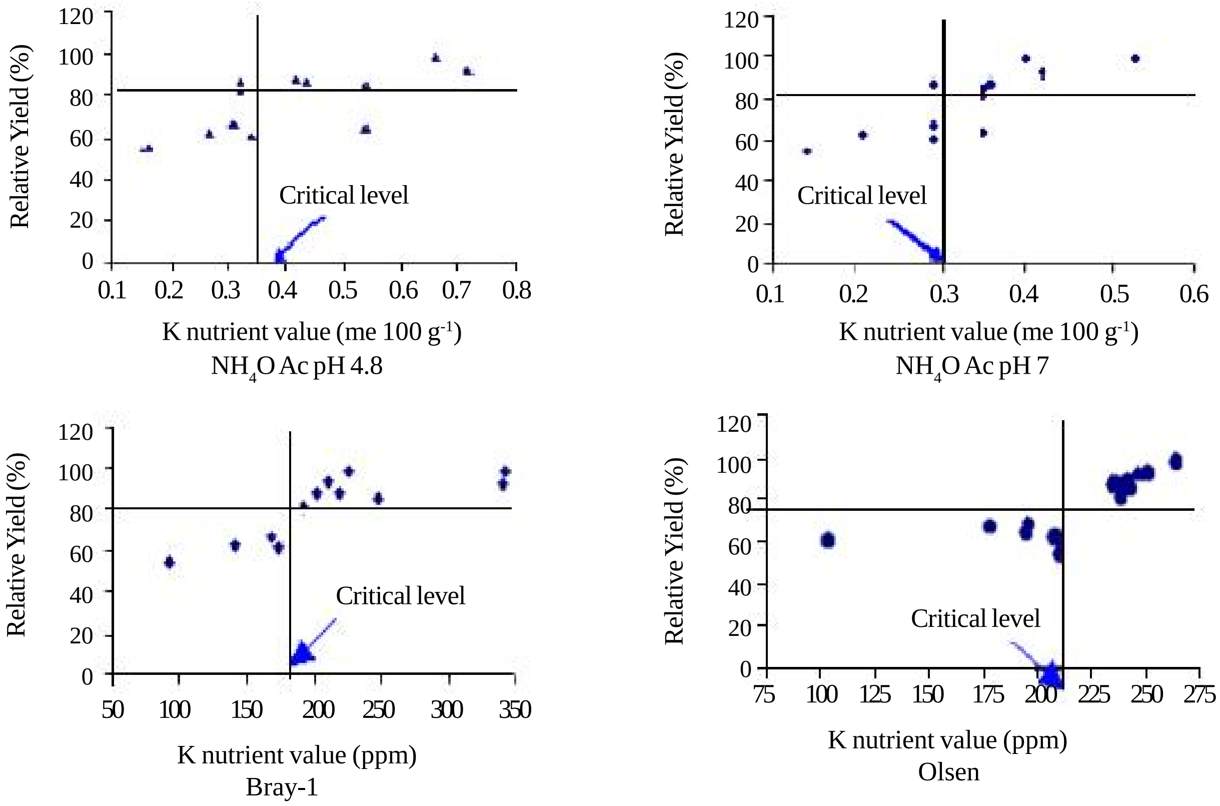

Figure 3. Critical level of K nutrient with graphs Cate Nelson and various K extractants.

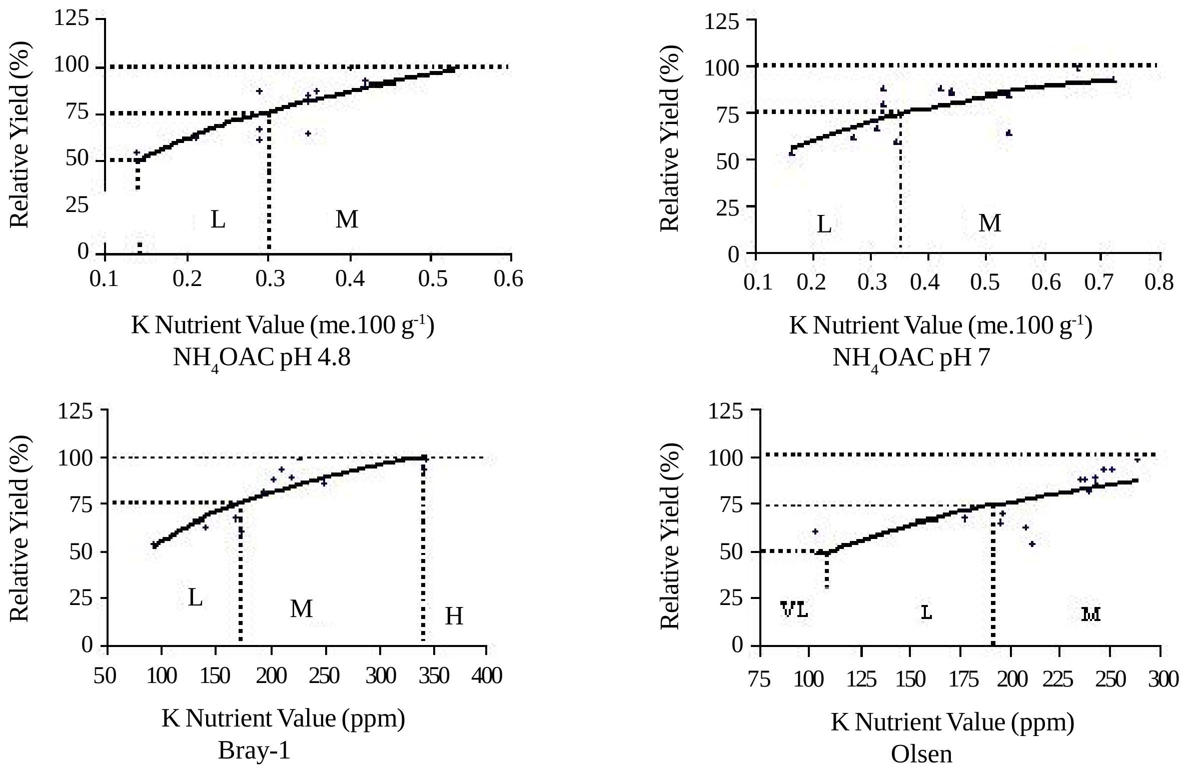

Figure 4. Availability class of K nutrient by continuous curve method on various extractans.

producing three groups, namely K low, moderate, and high class.

The third methods of determining the availability class of K nutrient to corn in dryland is known that the analysis of variance modified method gives three classes of K nutrients, and other methods are generally reach two or three classes, so that analysis of variance modified method can be used as a reference in determining the nutrient availability of K class.

Table 2. Availability class of K nutrient for maize based on continuous curve method.

Soil Test Extractans	Unit	Availability Class of K nutrient			
		Very Low	Low	Moderate	High
NH_4OAc pH 4.8	me K 100 g^{-1}	< 0.15	0.15 – 0.03	> 0.30	--
NH_4OAc pH 7	me K 100 g^{-1}	--	< 0.35	> 0.35	--
Olsen	ppm K_2O	< 110	110 – 190	> 190	--
Bray-1	ppm K_2O	--	170	170 – 340	> 340

Effect of Fertilization for Maize

Grain yield drying of maize obtained in the second stage of the experiment. From this data will be seen that in general, the average of the yield highest maiz obtained on fertilization at 80 kg K ha^{-1} for K nutrient very low class to moderate class, and the fertilization at 20-40 kg K ha^{-1} for high K nutrient class.

K fertilization until dose 80 kg K ha^{-1} at different K nutrient classes increased yield, but if the dose increased until to 160 kg K ha^{-1} the decreasing of yield. Thus, K fertilization for Lamuru variety on Alfisol type is 80 kg K ha^{-1} is sufficient. To determine the optimum dose of the preparation needs to be done recommended dose using response curve fertilization (Widjaja-Adhi 1993; 1996). Based on this curve, optimum K fertilizer is determined by following the laws of economics. Recommended dose of fertilizer is fertilizer dose to achieve optimum results. Optimum fertilizer usually occur when crop reaches 90% maximum yield (Affandi *et al*. 2001)

CONCLUSIONS

Ascertainment of K nutrient class for maize by some of the methods are as follows: (a) Cate-Nelson graphical method provides two classes of nutrient K, the low-and high-K classes, (b) continuous curve method gives two to three classes, namely the class K very low and moderate, and low-to high-K class, and (c) a modified method of analysis of variance gives three classes, namely low-to high-K class.

The average highest yield of maize obtained at fertilization rate 80 kg K ha^{-1} for very low K class through moderate class, and fertilization rate 20 kg - 40 kg K ha^{-1} for high K nutrient class.

Analysis of variance modified method give the best yield for determination of availability class K soil nutrient for corn in dry land.

To obtain the nutrient availability of class K is more accurate for a certain soil-plant system is recommended with multi-location approach.

REFERENCES

Affandi DN, Sri Rochayati and Sulaiman. 2001. Technical Guidelines for Soil Test Calibration Hara P and K in Dryland of Maize (*Zea mays* L.). Research and Development Center of Land and Agro-climate.

Cope JT and RD Rouse. 1973. Interpretation of soil test results. pp.35-54. In L.M. Walsh and J.D. Beaton (ed). Soil Testing and Plant Analysis.Revised Edition.SSSA, Madison, WI.

Dahnke WC and RA Olson. 1990. Soil Test Correlation, Calibration, and Recommendation. In Soil Testing and Plant Analysis. 3rd ed. SSSA, Madison, WI, pp. 45-71.

Fox RL and FJ Kamprath. 1970. Phosphate Sorption Isotherms for Evaluating the Phosphate Requirements of Soils. *Soil Sci Soc Am Proc* 34: 902-907.

Laddong Abu. 1988. Seasonal Corn Crop Science. Plant Cultivation Department, Faculty of Agriculture, Hasanuddin University.

Leiwakabessy FM. 1996. Interpretation of data soil testing and fertlizer recommendation basalt. In Fertilization Optimization Training Institutional Development Project in collaboration with the Faculty of Agriculture Agricultural Research IPB, Bogor, 19 to 31 January 1996.

Leiwakabessy FM and A Sutandi. 1996. Fertilizer and fertilitization. Soil Department, Faculty of Agriculture, Bogor Agricultural University.

Leiwakabessy FM and O Koswara. 1985. Methods and techniques collection, analysis, and data interpretation of soil fertility. Material Preparation Course Environmental Impact Assessment-II to PPSML-UI. Soil Department, Faculty of Agriculture, IPB, Bogor.

Nelson LA and RL Anderson. 1977. Partitioning of Soil Test-Crop Response Probability, pp. 19-38. *In* Soil Testing: Correlating and Interpretating the Analitycal Results. ASA Special Publication 29. ASA, CSSA, SSA, Madison, WI.

Sabiham S. 1996. Basic Principles of Soil Testing. *In* Fertilization Optimization Training Institutional Development Project in collaboration with the Faculty of Agriculture Agricultural Research IPB, Bogor, 19 to 31 January 1996.

Soepartini M, Nurjaya, A Kasno, S Ardjakusumah, Moersidi S and J Sri Adiningsih. 1994. P and K nutrient status and soil properties as estimate fertilizer needs of rice on Lombok Island. *Comm Soil Fertil Res*. 12: 23-35.

Voss R. 1998. Fertility recommendations: Pest and Present. Commun. *Soil Sci Plant Nutr* 29: 1429-1440.

Widjaja-Adhi IPG. 1986. Determination of Nutrient Availability Class with a Modified Diversity Analysis Methods. *Soil Fertil Preach* 5: 23-28.

Widjaja-Adhi IPG. 1993. Formulating Soil Testing and Fertilizer Recommendation. IARD Journal 15: 71-80. IARD, Ministry of Agriculture.

Widjaja-Adhi IPG. 1996. Use of Soil Testing and Analysis Leaves as Fertilizer Recommendation Base. *In* Fertilization Optimization Training.Institutional Development Project Agricultural Research and Development in collaboration with the Faculty of Agriculture, Bogor Agricultural University, 19 to 31 January 1996.

Widjaja-Adhi IPG, JA Silva and RL Fox. 1990. Assessment of the External Requirement of Maize on Paleudults and Eutrustox. The preaching of Soil Research. *Pemberitaan Peneliti an Tanah dan Pupuk* 9:14-20.