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Influence of Fertilization on Maize in Different Nutrient Classes on Jeneponto and Gowa District, South Sulawesi Regency, Indonesia

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Abstract

The field experiment was conducted on dry land in two location, that Jeneponto district and Gowa district, South Sulawesi regency by using single location approach. The aims of this research are (1) to determine the critical values of N, P and K for maize, and (2) to determine the rate of fertilizer on maize in the different classes of soil nutrient. Treatments were arrangement as a split-plot in randomized complete block design with three replications. Main plot were soil nutrient classes (low, moderate and high of N, P and K) and subplot were the rate of fertilizer of N, P and K. The results indicated that the critical values of total soil nitrogen for maize on Entisols (*Thypic Ustorthents*), Inceptisols (*Oxic Haplustepts*) and Vertisols (*Typic Haplusterts*) by using Cate-Nelson Method are 0.15, 0.15 and 0.11% N, respectively. Thus, the critical values of P and K for maize on Alfisols (*Typic Rhodustalfs*) are 0.32 ppm P, 85 mg P/100 g, 0.42 ppm P and 1.04 ppm P for each Mechlish, HCl 25 %, Bray-1 and Bray-2 extraction, respectively. 0.37 me K 100 g^{-1}, 0.55 me K 100/g, 178 ppm P, 213 ppm P for each NH_4OAc pH 4.8, NH_4OAc pH 7, Bray-1 and Olsen extractions, respectively. Rate of nitrogen fertilizer on Entisols, Inceptisols and Vertisols soil in Jeneponto district which gave the highest maize yield reached of fertilizer 180 kg N/ha for low class, 120 - 180 kg N/ha for moderate class, and 60 - 120 kg N/ha for high class of N total, while the rate of P fertlizer for the low and moderate P class of 160 kg P/ha and 40-80 kg P/ha for high P class. While the rate fertilizer of K for low K class of 80 – 160 kg K/ha, moderate K class of 40 – 80 kg K/ha, and high K class of 20 – 40 kg K/ ha on Alfisols soil in Gowa district.

Keywords: critical values, classes of soil nutrient, fertilizer dose, maize, dry land.

1. Introduction

Maize is the second most important cereal crop after rice, indicated by the percentage of area planted to maize. Maize has a very strategic role, both in food security system as well as its role as the driving wheel national economy. In addition to its role as food for some Indonesian society, also contribute to the availability of maize protein because maize to feed raw materials livestock. Demand of maize for food, feed, and industrial needs more in the five years forward is projected to increase along with continued population increase and also increased income and purchasing power (Director General for Food Crops, 2016).

The area planted to maize was about 19 % of the total area planted to food crop during 1970-2000 (Kasryno, 2002). The demand for maize for food and feed is steadily increasing. For the last three decades (1970-2000), production of maize in Indonesia steadily increased from 2.82 million tons in 1970 to about 9.34 million tons in 2000, growing at a rate of 4.07% per year (Swastika, 2002). This considerable production growth, however, failed to meet its domestic demand, causing a rapid increase in the net import since 1976.

Maize productivity in the last five years (2010-2015) increased by an average 1.14% per year, which in 2010 amounted to 4.57 t/ha to 4.89 t/ha in 2014 (Central Bureau of Statistics, 2015). According to Director General for Food Crops (2016), the target of maize production in the next 5 years (2015-2019) grew by 4.91- 5.12%, ie. from 19.83 million tons in 2015 to 27.80 million tons in 2019.

In the tropics, soil are often highly leached and acidic, and suffer multiple deficiencies of nutrients. Because of the low fertility status of such soils, productivity is quite low. Furthermore, environmental factors, such as the length of the day season and erratic rainfall, can have positive or negative interactions with nutrient elements, which complicate the situation considerably. Poor of inbalanced fertilizer practice can further exacerbate the problem. Because the crop may be suffering from a number of nutrient deficiencies, complicated by interactions with other controllable or incontrollable factors (Sumner and

Hylton, 1994).

Nitrogen, phosphorus, and potassium are the macro nutrients which became limited factor for increasing yield. Edmeades et al. (1994) reported that 90 % of maize planted in tropics area on dry land could increase of yield with use of nitrogen fertilizer. According to Halliday and Trankel (1992), nitrogen is generally needed of maize in large amount, it is 120 – 180 kg N/ha, however, on cultivate layer is a little amount (0.02 – 0.4 %) (Black, 1976) so must give nitrogen fertilizer for reach highest yield.

Phosphorus is the second important of macro nutrient after nitrogen (Otani dan Ae, 1996), and often called as prime key in sustainable agricultural. Phosphorus was added in the soil only small which using (about 10-20%) compared to N and K nutrient, and great which absorption, that is 100 - 1,000 times of P soluble (Mengel and Kirkby, 1978). Critical value of P for maize in soil is 20 ppm P (Fathan et al., 1988).

Potassium is an essential element for the plant growth, and it's required in large quantities for the metabolic processes of the plant. For produce 6 t/ha of grains, the maize plants have to absorb a total of 120, 20 and 150 kg/ha for nitrogen, phosphorus, and potassium, respectively.

According to Beringen (1980), potassium plays a very important role in biophysical and biochemical processes of the plants. Included in the biophysical processes the regulation of the osmotic potential, spesifically on the work mechanism of the guard cells of the stomata. While in the biochemical processes include the regulation of the enzyme activities, such those involve in starch formation, translocation of nutrients and protein synthesis (Wallingford, 1980). Commonly, the plants absorb, as much as1-2 % of the total available potassium from the soil (Pratt, 1965).

Critical values of N, P and K nutrient for maize are 0.10% and 0.17 %, 20 ppm P, and 0.30 me/100 g, respectively (Fathan et al., 1988; Baynes and Walmsley *in* Sanchez, 1976). According to Sirappa and Tandisau (2015), critical threshold values obtained with the K nutrient by Cate-Nelson graphical method are 0.3 me/100 g, 0.35 me/100 g, 178 ppm, and 213 ppm, respectively for extrantants NH_4OAc pH 4.8, NH_4OAc pH 7, Bray-1 and Olsen. Trehan et al. (2001) reported that the knowledge of nutrient deficiency symptoms is a prerequisite for balanced plant nutrition. Nutrient depletion of maize in South Sulawesi has limited the area's yield potential and profitability. This balanced fertilization study examines the impact of applied nutrients and provides recommendation that more closely match crop requirement.

The objectives of experiments were: (1) to determine critical values of N, P and K for maize, and (2) to determine the rate of N, P and K fertilizer on maize in the various classes of soil nutrient.

2. Materials and Methods

Field study was conducted on dry land during 2 years. Research of N nutrient was carry out in Jeneponto on the first years, while the experiments of P and K nutrient was carry out in Gowa on second years. The research was doing by single location approach. Treatments on each research were set as a split-plot in randomized complete block design with three replications. Main plots was soil nutrient class (low, moderate and high) of N, P and K, and subplots the rate of N, P and K fertilizer, ie. 0, 60, 120 and 180 kg N/ha and 0, 20, 40, 80 and 160 kg P and K/ha. Plant indicator was used on the study is a maize of Bisma variety. The critical values of N, P and K was determine by using Cate-Nelson method.

The dominant soil type which found is Regosol, Mediteran and Grumusol (Team Survey of South Sulawesi Agricultural, 1969). Results of profile description by using Keys to Soil Taxonomy are classified on Entisols (*Typic Ustorhents*), Inceptisols (*Oxic Haplustepts*) and Vertisols (*Typic Haplusterts*) in Jeneponto district, and Alfisols (*Typic Rhodustalfs*) in Gowa district, South Sulawesi regency, Indonesia.

3. Results and Discussions

3.1 Critical Values of N, P and K Nutrient for Maize

Critical values of N, P and K for maize by using Cate-Nelson Method showed in Table1. The critical values of N on Entisols, Inceptisols and Vertisols soil types in Jeneponto district are 0.15 % N, 0.15 % N and 0.11% N, respectively. In Gowa district, on Alfisols soil, the critical values of P by using several extraction methods are 0.32 ppm P; 85 me P/100 g; 0.42 ppm P and 1.04 ppm P for Mechlish, HCl 25 %, Bray-1 and Bray-2 extraction methods, respectively; and 0.37 me K/100 g, 0.55 me K/100 g, 178 ppm K and 213 ppm K, for respectively NH_4OAc pH 4.8, NH_4OAc pH 7, Bray-1, and Olsen extaction method. Fathan et al. (1988) reported that the critical values of N, P and K for maize were 0.10% N, 20 ppm P and 0.30 me K/100 g, respectively as per above mentioned extraction methods.

Table 1. The critical values of N, P and K nutrient for maize on selected soil type in South Sulawesi Regency

Nutrient	Soil Type/Location	Extraction Method	Unit	Critical Value
N	Entisols/Jeneponto district	Kjeldahl	%	0.15
	Inceptisols/Jeneponto district	Kejldahl	%	0.15
	Vertisols/Jeneponto district	Kejldahl	%	0.11

P	Alfisols/Gowa district	Mechlish	ppm	0.32
		HCl 25 %	me P/100 g	85.00
		Bray-1	ppm	0,42
		Bray-2	ppm	1,04
K	Alfisols/Gowa district	NH_4OAc pH 4.8	me K/100 g	0.37
		NH_4OAc pH 7	me K/100 g	0.35
		Bray-1	ppm	178.00
		Olsen	ppm	213.00

3.2 Response of Maize to N, P and K Fertilization

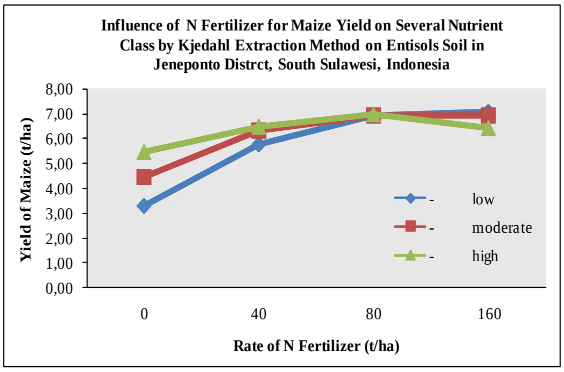
Response of maize to nitrogen fertilizer on each nitrogen class showing significant effect to means of dry shell yield of maize, showed in Table 2. Nitrogen fertilizer on Entisols, Inceptisols and Vertisols in Jeneponto district which gave the higher maize yield reached of fertilizer 180 kg N/ha for low class, 120 -180 kg N/ha for moderate class, and 60 - 120 kg N/ha for high class of N total.

Result of research Sirappa et al. (2002) found that nitrogen fertilization at a rate of 120 kg N/ha, equivalent to 260 kg urea/ha on dry land with a concentration of total N was very low to moderate and soil types Inceptisols, able to deliver results shelled 6-7 t/ha. Furthermore Sirappa et al. (2003) and Sirappa and Tandisau (2004) reported that corn yields highest in three types of soil (Entisol, Inceptisols and Vertisols) respectively obtained at fertilization with a rate of 120 kg N, 80 kg P_2O_5 and 80 kg K_2O/ha, equivalent to 260 kg urea, 220 kg SP-36 and 130 kg KCl/ha, see in Figure 1 (a), (b) and (c).

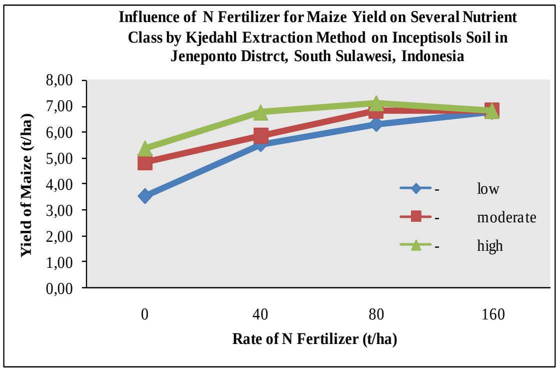
Table 2. Mean of maize yield on several rate of N fertilizer and total N class on Entisols, Inceptisols and Vertisols in Jeneponto district, South Sulawesi regency

Soil type/ Nutrient status	Maize yield w.c 12% (t/ha)			
	0	60	120	180
	.... (kg N/ha)			
Entisols :				
- low	3.31	5.79	6.98	7.11
- moderate	4.45	6.35	6.93	6.95
- high	5.49	6.51	7.00	6.45
Inseptisols :				
- low	3.53	5.54	6.32	6.79
- moderate	4.85	5.88	6.83	6.84
- high	5.39	6.77	7.13	6.83
Vertisols :				
- low	3.08	5.56	6.73	7.33
- moderate	4.40	6.11	7.05	7.14
- high	5.30	6.75	6.95	6.64

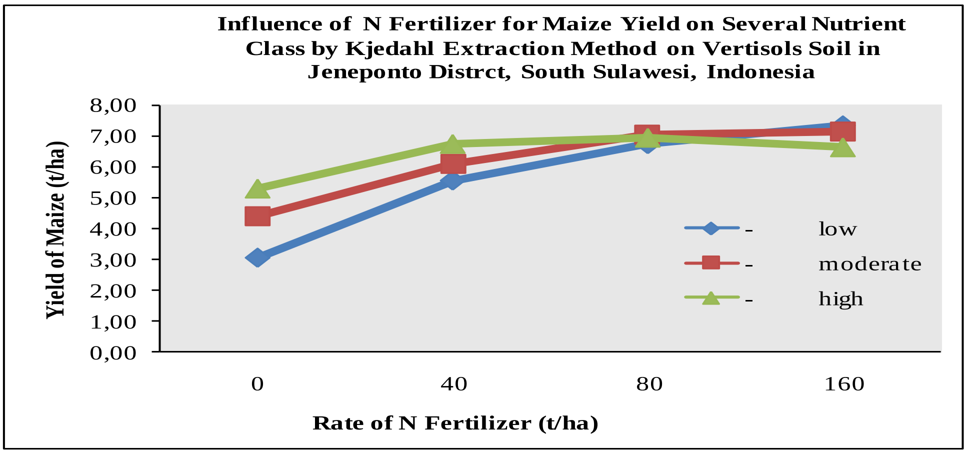
Remarks: low : < 0.12 %; moderate : 0.12 – 0.15 %; high : > 0.15 %



(a)



(b)



(c)

Figure 1. Influence of N fertilizer for maize yield on several nutrient class by Kjedahl Extraction method on Entisols (a), Inceptisols (b) and Vertisols (c) soils in Jeneponto District

Maize yield response to phosphorus and potassium fertilizer on each P and K classes showed in Table 3. This table indicated that the higher yield of maize was reached on rate of P fertilizer for the low and moderate P class of 160 kg P/ha and 40 – 80 kg P/ha for high P class (Figure 2). While for K nutrient status, the the rate of K fertilizer which give the higher yield of maize for low K claas of 80 – 160 kg K/ha, 40 – 80 kg K/ha for moderate K class, and 20 – 40 kg K/ha for high K class in Alfisols soil in Gowa District (Figure 3). Sirappa and Tandisau (2015) was reported too that K fertilization for Lamuru variety on low class nutrient is 80 kg K/ha is sufficient.

Table 3. The rate of P and K fertilizer effect for maize yield on several nutrient class on Alfisols soil in Gowa District, South Sulawesi Regency

P and K extraction/ P and K nutrient status	Maize yield w.c. 12% (t/ha)				
	0	20	40	80	160
	.... Rate of P and K fertilizer (kg P/ha, K/ha)				
- *HCL 25%* [a] *:*					
- Low-P	0.45	0.85	1.71	2.75	3.64
- Moderate-P	1.25	2.07	3.21	4.03	4.12
- High-P	2.02	3.14	4.88	4.81	4.25
- *Bray-2* [b] *:*					
- Low-P	0.74	1.32	2.35	3.46	3.80
- Moderate-P	1.26	2.15	3.43	3.85	4.10
- High-P	1.98	2.94	4.46	4.72	4.28
- *NH_4OAc pH 7* [c] *:*					
- Low-K	3.57	4.01	4.89	5.05	4.55
- Moderate-K	4.24	4.69	4.79	4.85	4.49
- High-K	5.13	5.27	5.27	5.25	4.78

- Olsen [d] *:*					
- Low-K	3.48	3.93	4.77	5.03	4.53
- Moderate-K	4.44	4.88	5.06	4.87	4.50
- High-K	5.14	5.31	4.83	5.05	4.78

Remarks: [a] low : < 65 mg P/100g; moderate : 65 – 90 mg P/100 g; high : > 90 mg P/100 g

[b] low : < 0.6 ppm; moderate : 0.6 – 1.2 ppm; high : > 1.2 ppm

[c] low : < 0.4 mg K/100 g; moderate: 0.4 -0.6 mg K/100 g; high : > 0.6 mg K/100 g

[d] low : < 215 ppm; moderate : 215 – 250 ppm; high : > 250 ppm

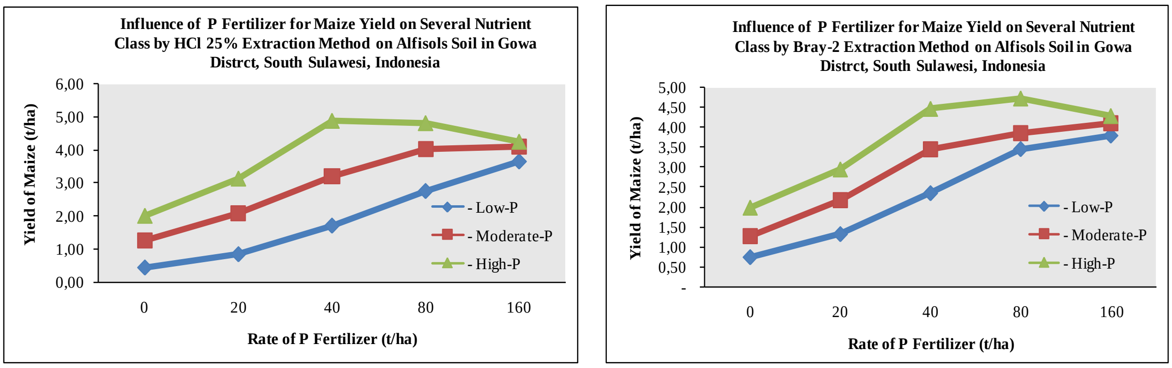


Figure 2. Influence of P fertilizer for maize yield on several nutrient class by HCl 25% and Bray-2 extraction methods on Alfisols soil in Gowa District

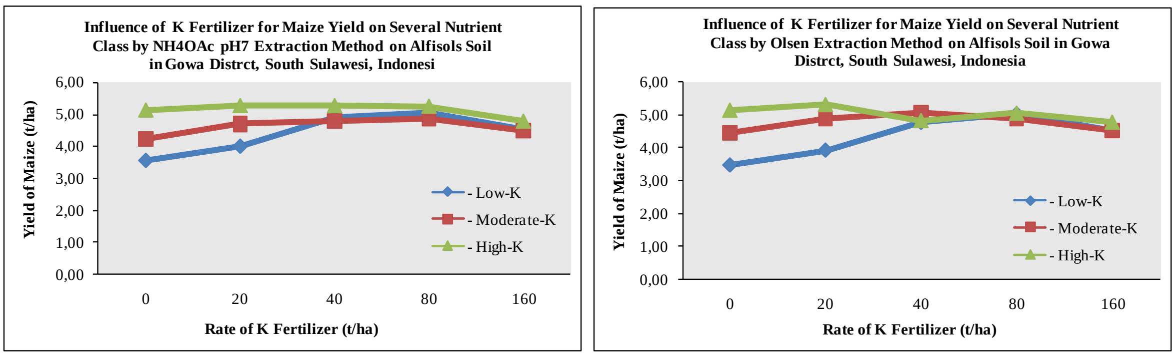


Figure 3. Influence of K fertilizer for maize yield on several nutrient class by NH_4OAc pH 7 and Olsen extraction methods on Alfisols soil in Gowa District

Sirappa and Nurdin (2010), Sirappa et al. (2012) reported that N, P and K fertilization with rate 300 kg urea, 200 kg SP-36 and 50 kg KCl/ha combined with 2 ton manure was give the hihgest yield of maize about 4,5 – 8.6 t/ha. According to Widjaja-Adhi (1993, 1996), to determine the optimum dose of the preparation needs to be done recommended rate using response curve fertilization. Based on this curve, optimum K fertilizer is determined by following the laws of economics. Recommended rate of fertilizer is fertilizer to achieve optimum results. Optimum fertilizer usually occur when crop reaches 90% maximum yield (Affandi et al., 2001).

4. Conclutions

- The critical values of total soil nitrogen for maize on Entisols (*Thypic Ustorthents*), Inceptisols (*Oxic Haplustepts*) and Vertisols (*Typic Haplusterts*) by using Cate-Nelson Method are 0.15, 0.15 and 0.11% N, respectively. The critical values of P and K for maize on Alfisols (*Typic Rhodustalfs*) are 0.32 ppm P, 85 mg P/100 g, 0.42 ppm P and 1.04 ppm P for each Mechlish, HCl 25 %, Bray-1 and Bray-2 extraction, respectively, and 0.37 me K/100 g, 0.55 me K/100 g, 178 ppm P, 213 ppm P for each NH_4OAc pH 4.8, NH_4OAc pH 7, Bray-1 and Olsen extractions, respectively.
- Rate of nitrogen fertilizer on Entisols, Inceptisols and Vertisols soil in Jeneponto district which gave the highest maize yield reached of fertilizer 180 kg N/ha for low class, 120 -180 kg N/ha for moderate class, and 60 - 120 kg N/ha for high class of N total, while the rate of P fertlizer for the low and moderate P class of 160 kg P/ha and 40-80 kg P/ha for high P class, while the rate fertilizer of K for low K class of 80 – 160 kg K/ha, moderate K class of 40 – 80 kg K/ha, and high K class of 20 – 40 kg K/ha on Alfisols soil in Gowa district .

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