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Application of Eco-cycle Model on Improving Sustainable Maize Productivity of Marginal Soil in South Sulawesi-Indonesia

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Introduction

South Sulawesi Province as the nation's largest maize producer in Indonesia which have maize production in 2010 as many as 1.34 million tons of dry grain, obtained from the harvested area of 303.38 thousand ha and the productivity of 4.43 t/ha (Sunanto et al., 2012). Maize cultivation was high dependent to chemical fertilizer, pesticide, and organic material nearly absent. This practice had been effect to decreasing of soil quality and high production cost. Eco-cycle model had been created to improve this cultivation system for sustainability of maize productivity. This model structure is based on close interaction between agriculture production system with plant, husbandry, and environmental system involved. Organic material from maize production system is processed become feed for animal or it decomposed to be organic fertilizer. Then, organic material from husbandry/cow-stalls is use through biogas production system. Liquid (sludged) of biogas is applied to be source of microorganism isolate. Both sources are potential material in producing soil bio-ameliorant. These materials can be used to produce liquid soil bio-ameliorant through anaerobic fermentation process (Setiawan, 2010). The model applied in this experiment is more specific related to management of the bio-physico-chemical environment and the implementation of appropriate cultivation technology. This study objective is to obtain maize cultivation technology in order to improve sustainable maize productivity through eco-cycle model.

Materials and Methods

Field experiment was carried out in Teaching Farm, Faculty of Agriculture, Hasanuddin University. Two planting season of maize with factorial experimental design replicated three times in 2x2 m field plots was set up in this experiment. On the first planting season, treatments were arranged in three factors as: (1) planting space with two type spaces ($P_1=75 \times 25$ cm and $P_2=50 \times 20$ cm); (2) liquid bio-ameliorant (LBA) with three concentrations ($B_0=0$ ml/l; $B_1=100$ ml/l; and $B_2=300$ ml/l); and (3) urea fertilizer with three levels ($N_0=0$ kg/ha; $N_1=300$ kg/ha; and $N_2=240$ kg/ha). The second planting season, treatments were arranged in two factors as: (1) liquid bio-ameliorant (LBA) with four concentrations: ($B_0=0$ ml/l; $B_1=150$ ml/l; $B_2=250$ ml/l and $B_3=350$ ml/l); and (2) compost with four levels: ($K_0=0$ ton/ha; $K_1=2$ ton/ha; and $K_2=5$ ton/ha; and $K_3=10$ ton/ha). In this season, planting space of 75 x 25 cm was applied.

Results and Discussion

Soil Quality Improvement

Application of inorganic fertilizer for long term tend to decreased soil quality which were direct affect to environment and plant production. A combination method to maintain sustainability production could be achieved by supplementing crop production environment using organic material such as liquid bio-ameliorant and compost. Clear result as shown in Table 1, that liquid bio-ameliorant could be applied to reduce utilization of chemical fertilizer. In single or combination treatment, high concentration of bioameliorant and low level nitrogen had highest increase of nutrient content compare to the other treatment. Improvement soil quality could be related to the increasing of mineralization and transformation of organic material with activation of microbial activity.

Influence on Plant Performance

Plant density and fertilizer management are two components could be improve using product of organic matter in eco-cycle model. In the first season, plant height was shown significant response in the treatment of liquid bio-ameliorant, nitrogen fertilizer, and planting space on single or combination treatment (Table 2). The highest

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result was performed in the treatment 100 ml/l LBA with 300 kg/ha urea. However, statistically it was not significant effect with treatment 300 ml/l LBA and 240 kg/ha urea. In the second season, liquid bioameliorant and compost was observed significant effect on single treatment, however combination treatment was no significant effect to plant height. Increasing plant production showed in both season. The highest production was shown in combination treatments between 300 ml/l LBA and 240 kg/ha nitrogen fertilizer with 50 x 20 cm planting space (1st), (Table 3). Incorporation 10 ton/ha compost or addition 350 ml/l LBA was recommended to increase maize production in marginal land. The result was found also that LBA improving environmental production as reducing nitrogen fertilizer. The result could be used to confirmed the usefulness of liquid bio-ameliorant as material in improving maize production especially in sub-optimal soil.

Table 1. Soil chemical properties after application of liquid bio-ameliorant treatment

Treatments	Soil Chemical Properties								
	C	N	P ₂ O ₅	K	Ca	Mg	Na	CEC	BS
	%	%	ppm	cmol/kg				%	
N ₀ B ₀	1.94	0.06	10.99	0.22	6.36	2.67	0.33	18.34	52
N ₀ B ₁	1.75	0.34	36.87	0.25	8.38	4.87	0.41	22.33	62
N ₀ B ₂	2.49	0.36	37.82	0.36	7.90	3.50	0.38	24.33	50
N ₁ B ₀	2.14	0.31	18.48	0.17	6.83	4.63	0.33	28.51	42
N ₁ B ₁	2.59	0.08	34.99	0.25	7.78	3.03	0.42	22.13	52
N ₁ B ₂	2.59	0.28	35.74	0.22	7.48	2.79	0.61	24.13	46
N ₂ B ₀	2.71	0.22	10.00	0.22	6.83	2.85	0.35	22.53	46
N ₂ B ₁	2.24	0.24	34.99	0.24	8.49	0.42	0.52	21.34	45
N ₂ B ₂	2.70	0.21	34.04	0.33	8.08	1.60	0.41	21.14	49

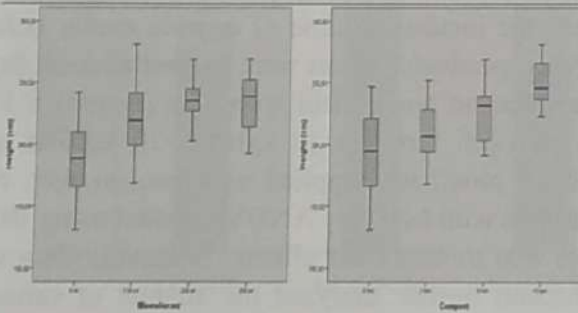


Fig. 1 Treatment effect to plant height (2nd)

Table 3. Plant production in the first season

Treatments	Prod. (kg plots)	Production (ton/ha)
P ₁ B ₁ N ₁	5.40	5.32
P ₂ B ₂ N ₂	7.92	9.00
P ₂ B ₀ N ₁	3.24	3.12
P ₁ B ₀ N ₀	2.64	3.00

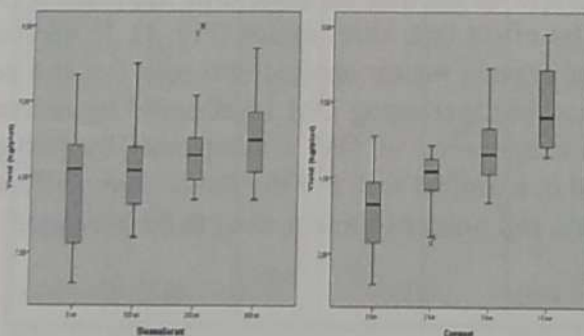


Fig.2 Plant production in the second season

Table 2. Significant difference of plant height (1st)

Treatments	Height (cm)	Note*
P ₁ B ₁ N ₁	198,07	a
P ₂ B ₁ N ₁	185,60	a
P ₂ B ₀ N ₁	184,64	a
P ₁ B ₂ N ₂	183,57	a
P ₂ B ₂ N ₂	183,55	a
P ₂ B ₁ N ₂	183,00	a
P ₂ B ₂ N ₁	178,86	ab
P ₂ B ₀ N ₂	177,90	b
P ₁ B ₁ N ₂	177,33	b
P ₁ B ₀ N ₁	176,03	b
P ₁ B ₀ N ₂	171,43	b
P ₁ B ₂ N ₁	167,90	b
P ₂ B ₁ N ₀	157,65	bc
P ₂ B ₀ N ₀	153,19	c
P ₂ B ₂ N ₀	150,55	c
P ₁ B ₂ N ₀	143,50	c
P ₁ B ₁ N ₀	137,77	c
P ₁ B ₀ N ₀	134,37	c

*Sig. different (p<0.001) by MRT Duncan's test

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