Land management on soil physical properties and maize (\textit{Zea mays} L. var. BIMA) growth (An adaptation strategy of climate change)

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Abstract. Water deficit is a problem on rainfed maize production but can be solved by proper land management. The objective of the study to determine the soil physical properties and maize yield affected by land management to adapt to drought. The experimental design was a randomized complete block using 5 treatments with 4 repetitions, including: (i) Control (KO), (ii) Rice Straw Mulched (MC), (iii) Compost Fertilizer (CF), (iv) In-Organic Fertilizer (AF), (v) Legume Cover crop (CC). Soil physical and maize growth properties namely soil moisture, soil texture, soil bulk density, plant height, biomass, and yield were investigated. The results showed that composting land increased soil water availability and provided nutrient to crops and thus increase soil physical properties, maize growth and yield. Although inorganic fertilizer also increased plant growth and yield, but it did not improve soil physical properties.

1. Introduction
Climate change is a natural phenomenon occurs nowadays due to global warming. In natural, it occurs due to the increase of solar intensity and the rotation of the Earth’s orbits approaching the sun [1]. In addition, climate change caused by global warming occurs due to the increased carbon dioxide concentration in the air. One of the global climate changes is the increasing frequency and intensity of extreme climates such as storms, floods, and droughts [2].

Drought is a natural phenomenon related to the climate especially insufficiency of rainfall that affects agricultural, environmental, and socioeconomic conditions [3]. Drought is divided into meteorological, hydrological, agronomic, and socio-economic droughts. Meteorological droughts are defined as rainfall deficit; agronomic drought is a drought occurs due to low groundwater, high evapotranspiration and water scarcity [4]. Drought is an important issue for rain-fed agriculture, because of the dependency of water availability to rainfall. This leads to drought threat during the dry season.

Various efforts have been made to anticipate the occurrence of drought on the rain-fed land, due to rainfall irregularity such as the utilization of Nino 3.4 surface temperature data to predict monthly rainfall [2], as well as the implementation of various land management, monitoring soil moisture to
determine cropping pattern [5]. This study aims to investigate the effects of land management to anticipate drought by employing organic, inorganic fertilizer and cover crop on soil physical, properties, maize growth and yield.

2. Method
This research was conducted in the experimental field of Faculty of Agriculture, Sebelas Maret University, Surakarta. Administratively the research area is located in Central Java, Indonesia (110°56'51" S and 07°37'48" E) with elevation 191 meters above sea level. Soil type at research site is Alfisols. The condition of research land as shown in Figure 1.

![Figure 1. Land preparation condition in Jumantono district with Alfisol soil.](image)

The research was designed using Randomized Block Design with 4 treatments (single factor), including 1) Control or no treatment (K0), 2) Composting (CF), 3) Straw mulch giving (MC), 4) An-organic fertilizer (AF), and 5) Use of cover crop (CC) with 4 repetitions. Each treatment consists of 4 repetitions. Soil moisture was observed with the gravimetric method, soil bulk density with pycnometer method and soil texture with hydrometer method. The observation of maize growth and yield occupied volumetric method. Analysis of variance (F-test) and advance test (Duncan Multiple Range Test) were employed to analyze the data, at α =0.05.

3. Results and discussions

3.1. Soil physical properties

3.1.1. Soil moisture. Water in soil acts as a solvent and a binder element between soil particles that will affect the structure and strength of the soil. Chemically, water acts as a transporting agent of solutes involved in soil development and degradation. Soil moisture at each treatment is shown in Figure 2.

Figure 2 shows that soil moisture content under all treatments are similar to control, but managing rain-fed farmland with compost and inorganic fertilizer resulted in significant different soil moisture. Applying compost on rain-fed farmland can significantly maintain soil moisture remains high (18.1%) than implementing just inorganic fertilizer (14.5%). Thus it is important to control inorganic fertilizer usage in order to minimize drought risk at rain-fed farmland.
Figure 2. Soil moisture at each treatment

3.1.2. Soil texture. The soil texture shows the fraction comparison between sand (2mm - 50μ), silt (2μ-50 μ), and clay (<2μ) in the fraction of fine soil [6]. The relative size of soil particles is expressed in terms of texture that refers to the fineness or roughness of the soil [7]. The soil texture result under treatments as presented in Table 1.

Table 1. Soil texture of each treatment (0-30 cm)

| Treatments          | Texture (%) |
|---------------------|-------------|
|                     | Sand        | Silt       | Clay        |
| control             | 29.07       | 7.98       | 62.93       |
| compost             | 28.55       | 5.26       | 66.63       |
| cover crop          | 34.05       | 11.72      | 56.97       |
| straw mulch         | 26.68       | 6.68       | 66.17       |
| inorganic fertilizer| 27.94       | 20.99      | 48.30       |

Table 1 shows that the sand content ranges from 26.68 to 35.05%, silt ranges 5.26 – 20.99% and clay ranges from 48.30 to 66.63%. Soil fraction which strongly correlates with soil moisture is clay. The clay content at each treatment is shown in Figure 3.

Figure 3. Clay content at each treatment

Figure 3 shows that clay content under all treatment were not significantly different with control. This is the same result as shown by soil moisture in Figure 2 that the soil moisture under all treatments were not different as that performed by control. It is shown in Figure 3 that compost treatment had higher clay content than that under cover crop and inorganic fertilizer treatments. That is probably
because compost donated clay to the soil, but not much compare to control. Soil texture requires very long time to be affected by treatments, and thus it will be too early to determine the effects of this study on soil texture. However, compost played role in contributing clay than inorganic fertilizer.

3.2. Maize growth and yield

3.2.1. Plant height. Plant height is an indicator of plant growth that is easily observable and measured. The result of maize height measurement is presented in Figure 4.

![Figure 4. Plant growth at each treatment](image)

Figure 4 shows that the cover crop treatment significantly resulted in the lowest plant height (117.76 cm), while other treatments are nearly similar to control (157.25 cm). That is may be due to the nutrient competitiveness of maize with cover crop during the growth. This result shows that plant height is regardless of soil moisture, nutrient plays more role in determining plant height than water availability.

3.2.2. Leaf width. Leaf width is an indicator of plant growth that is easily observed. Leaf width is one component of leaf area. Sitompul and Guritno [8], said that the leaves function organ that plays a role in photosynthesis. Leaf width is the main parameter for determining leaf area and rate of photosynthesis of plant unity. The result of leaf width observation shown in Figure 5.

![Figure 5. Leaf width at each treatment](image)
Figure 5 shows that leaf width under compost (8.24 cm) and inorganic fertilizer (8.32 cm) were significantly higher than control (6.79 cm). That is probably because compost and inorganic fertilizer provide nutrient than other treatments, and thus leaf width growth seemed to in correspondence with nutrient supply from the soil.

3.2.3. Cobs weight. The result of cobs weight measurement is performed in Figure 6.

![Figure 6. Cobs weight at each treatment](image)

Based on Figure 6, it can be seen that the cobs weight were significantly higher under compost (74.55g) and inorganic fertilizer treatment (83.48 g), compared with control (39.62gr). This is similar pattern as shown in leaf width growth, that nutrient availability probably plays more role in determining the cob weight.

3.2.4. Biomass. Figure 7 shows biomass at each treatment.

![Figure 7. Biomass at each treatment](image)

Figure 7 displays that the highest biomass reached by inorganic fertilizer (316.15g), followed by compost treatment (221.85 g), with the lowest is undercover crop treatment (166.90 g). It shows that biomass determined by nutrient availability and competitiveness with other crops included cover crop.

4. Conclusion
Rain-fed land management to anticipate climate change adverse effect on drought by conditioning soil with compost, cover crop, mulching and conventionally (only implementing chemical fertilizer),
resulted in different effects. Composting land will increase soil water availability and provide nutrient to crops and thus increase soil physical properties, maize growth and yield. Although inorganic fertilizer also increased plant growth and yield, but it did not improve soil physical properties.

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