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Abstract. This study were aimed to determine the effect of soil tillage and herbicide on earthworm populations. The experiment was designed by using completely randomize block design with two factors, i.e.; soil tillage systems consists of full tillage (T_1) and minimum tillage (T_0) and herbicide application (H) consists of herbicide (H_1) and non-herbicide (H_0). Herbicides with isopropylamine glyphosate + 2.4D active ingredient was application as treatment at level dosage 160 mL per 16 L of water. Soil sampling by using monolith and earthworm were collect by hand sorting methods. The data were analyzed by ANOVA and LSD test. The results showed that the soil tillage has no effect on the population and biomass of earthworms, but application of herbicide affected on earthworm population at one day after herbicide application. Earthworm population were higher in plot with no herbicide application (86 ind·m^{-2}) than that plot with herbicide application (33 ind·m^{-2}). However, at all combination treatment, earthworm population were increase followed by cassava growth. Population and biomass of earthworms found to be higher in the soil layer 0–10 cm than that 10–20 cm and 20–30 cm soil layers. Furthermore, soil water content had correlation with earthworm population.

1. Introduction

Earthworm is a soil macro fauna that presence in the soil is very important role in many soil functions such as nutrient availability, soil structure and organic matter dynamics [1]. However, earthworm distribution and activity are affected by soil moisture, organic matter, texture and pH [2]. Soil management likes soil tillage in agricultural soils can affect soil biota through changes in habitat [3],loss of organic matter [4], moisture and temperature dynamics [2]. Earthworm population change due to soil tillage depends on tillage intensity [2, 5]. Furthermore, reduced tillage intensity increased earthworm abundances and species diversity [3]. However, in reduce tillage systems, weeds become a problem [6], especially grasses and perennial weeds [7] and application of chemical herbicide have become the weed control strategy. Herbicide applications may reduce or maintain weed diversity [8, 9], but they can become a toxicological risk for earthworm. Earthworm are sensitive to the presence of chemical in the soil due to chemoreceptor distributed on their body surface [10]. Herbicides affect the feeding behavior of earthworms, which was reflected in the weight loss and reproductive capacity [11] and reduce cocoon production [12].

The mortality of earthworms in soils and excessive use of herbicide is still vague. Some herbicides are directly toxic to earthworm while others have virtually no effects [13]. Based on this condition, it's necessary to study the effect of soil tillage and chemical herbicide application on the existence of earthworm in cassava cultivation.

2. Materials and Methods

The research was conducted at the Integrated Field Laboratory, Agriculture Faculty University of Lampung (50°22'11.38" S, 1050°14'25.96" E) on May 2014. The experiment was designed by using completely randomize block design (RCBD) with two factors, i.e.; soil tillage systems consists of full tillage (T1) and minimum tillage (T0) and herbicide application (H) consists of with herbicide (H1) and without herbicide (H0). The Herbicides with active ingredient isopropylamine glyphosate + 2.4D was application as treatment at level dosage 160 mL per tank (16 L of water). Earthworm population sampling during cassava growth was done at 0, 3, 6, 11 month after planting cassava by using soil monolith and earthworm were collect by hand sorting methods. The data were analyzed by ANOVA and LSD test at 5% significant level and correlation between earthworm population and biomass with soil organic-C, soil pH, soil water content and soil temperature.

3. Results and Discussion

Based on statistical analysis effect of tillage and herbicides on the earthworm population and biomass could be seen in table 1. Table 1 shown that the tillage systems has no effect on the earthworm populations and biomass in each month of observation,whereas herbicide application affect on earthworm populations only at 0 MAP.

Table 1. Analysis of variant effect of soil tillage and herbicideapplication on earthworm populations and biomass.

Treatment	Month							
	0 MAP		3MAP		6 MAP		11 MAP	
	EP	EB	EP	EB	EP	EB	EP	EB
Tillage (T)	ns	ns	ns	ns	ns	ns	ns	ns
Herbicide (H)	*	ns	ns	ns	*	ns	ns	ns
TxH	ns	ns	ns	ns	ns	ns	ns	ns

Note: MAP= Months after planting; EP= earthworms population; EB= earthworm biomass; ns= non-significant; *= significant at 5% level.

3.1. Earthworm populations and biomass

Based on statistical analysis, tillage systems has no effect on earthworm populations and biomass. It is might be caused that the duration of experiment is too short. Many literature search revealed few studies that have assessed the effects of tillage systems on earthworms over the short and medium timescales simultaneously in both conventional (full) tillage and minimum tillage. However, it can be seen in figure 1, earthworm abundance on minimum tillage relatively higher than that earthworm population on full tillage due organic material content. Organic materials on minimum tillageare came from weeds and litter at surface layers, whereas on full tillage weeds and litter are cleared off from surface layer. Furthermore, earthworm distribution along soil depth was different. Earthwormpopulationper layer shows that neither the population nor the earthworm biomass was higher in the soil top layers (0–10 cm). This is caused by rich of organic material at top soil.Organic matter is one of the deciding factors that affect of macrofauna distribution on the below and above ground as well as a source of energy for soil fauna and microorganisms[14, 15].

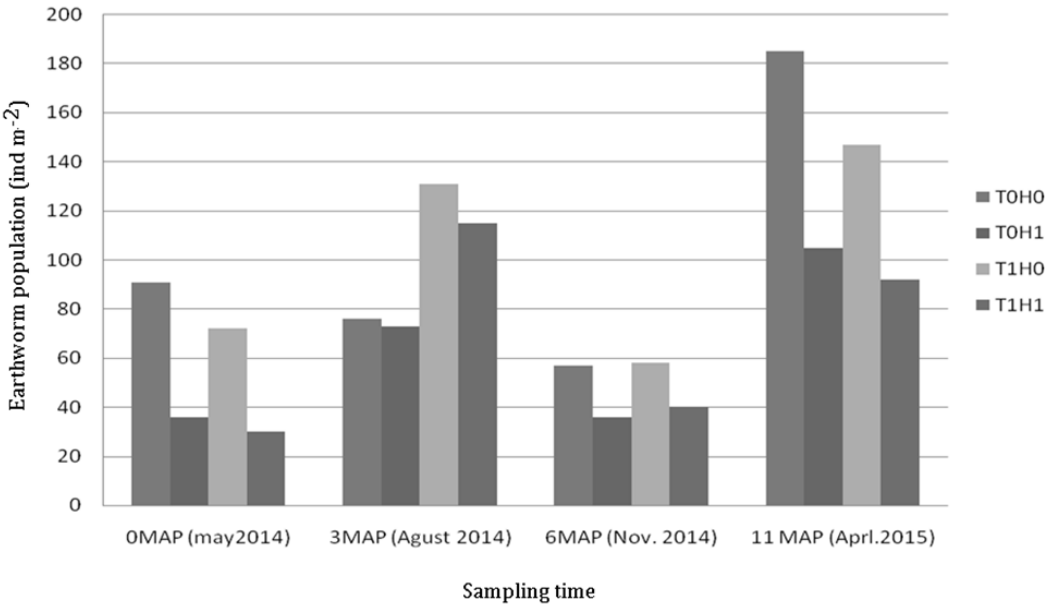

Figure 1. Earthworm population at sampling time 0, 3, 6, and 11 MAP (MAP: Months after planting); T0: minimum tillage; T1: full tillage; H0: without herbicides; H1: herbicide application).

Figure 1 shows that earthworm population at 11 MAP was higher compared to others observation and the highest number of earthworm is in minimum tillage without herbicide application (T_0H_0) 190 ind·m^{-2}. The highest number of earthworm at 11 MAP might be caused by the full canopy of cassava make the soil microclimate, such us soil temperature and moisture are comfortable to earthworm living [2].

Based on ANOVA at table 1, herbicide application had significant effect on earthworm populations only at 0 MAP (before planting). Based on LSD test, weed control using herbicides has an earthworm population lower than that without application of herbicides (table 2), however at 3, 6 and 11 MAP herbicide application had no effect on earthworm number. The active ingredient glyphosate was eaten by earthworms can have an effect on earthworm breeding [16].

Table 2. The effect of herbicides application on earthworm population at 0 MAP.

Treatment	Population (ind·m^{-2})
Without Herbicides (H_0)	86 a
Herbicide Applications (H_1)	33 b
LSD $_{0.05}$	37

3.2. The relationship between earthworm's population and biomass with some soil properties

Other factors that have an effect on earthworm populations i.e. soil properties such as soil organic carbon, soil pH, soil temperature and soil moisture content (humidity).The relationship between earthworm's population and biomass with some soil properties were shown in table 3. Based table 3, soil organic-C, and soil pH, have no correlation with earthworm populations and biomass. However, soil water content had positively correlated with earthworms population, it is caused by earthworms are extremely sensitive with soil humidity. Soil water content is needed by earthworms to keep his skin in order to function normally i.e. for respiration. Earthworm's biomass consists of 75–90% water, so the humidity is very important to earthworm life cycle. When the soil water content is too high, earthworms will move to find a suitable and then their skins could be normally functioning. The

optimum range of soil humidity for earthworm's growth is 15–50% [17]. Furthermore, temperature had positive correlation with earthworm populations. Earthworm is soil biota that very sensitive to the temperature, however the earthworms can still tolerate in temperatures above 30°C with high humidity. A temperature that is too low is also not preferred by earthworms, as it will affect hatching cocoon earthworms.

Table 3. Correlation between earthworms population (ind·m^{-2}) and earthworm biomass (g·m^{-2}) with soil properties.

Variable/Sampling time	The correlation coefficient (r)	
	The number of earthworms	Earthworm biomass
Soil analysis Before Cassava Planting 0 MAP		
C-organic	0.39^{ns}	0.49^{ns}
soil pH	0.21^{ns}	0.51^{ns}
Water content of soil	0.18^{ns}	0.31^{ns}
Soil temperature	0.36^{ns}	0.01^{ns}
Soil Analysis at 3 MAP		
C-organic	0.25^{ns}	0.03^{ns}
soil pH	0.19^{ns}	0.21^{ns}
Water content of soil	0.46^{ns}	0.15^{ns}
Soil temperature	0.29^{ns}	0.01^{ns}
Soil Analysis at 6 MAP		
C-organic	0.02^{ns}	0.26^{ns}
soil pH	0.37^{ns}	0.24^{ns}
Water content of soil	0.79*	0.41^{ns}
Soil temperature	0.51*	0.41^{ns}
Soil Analysis at 11 MAP		
C-organic	0.31^{ns}	0.16^{ns}
soil pH	0.28^{ns}	0.49^{ns}
Water content of soil	0.03^{ns}	-0.64*
Soil temperature	-0.31^{ns}	0.21^{ns}

Note: note ns: not significant; *: significant.

4. Conclusion

Soil tillage system both full tillage or minimum tillage does not affect the population and biomass earthworms on the growing cassava season.While, herbicide application decreased earthworms population only at one month after herbicide application (0 MAP), but has no effect on earthworm populations and biomass at sampling time 3, 6 and 11 MAP. The earthworm population and biomass was higher in the topsoil (0–10 cm) compared with the deep soil layers (10–20 cm and 20–30cm). The soil moisture content and soil temperature had positive correlation with earthworm population.

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