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Dynamics of Macro Fauna under Conservation and Conventional Agriculture in Maize /Legume Cropping System at Sidama Zone in Southern Ethiopia

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Abstract

Conservation agriculture (CA) is based on three principles of minimum soil disturbance, surface crop residue retention, crop rotations and is one of the available options in southern Ethiopia. CA has been intensively promoted for more than a decade to combat declining soil fertility and to stabilize crop yields. Soil macro fauna have almost the same important role as soil microorganisms in affecting soil characteristics. However, data regarding the population and the biodiversity of soil macro fauna in Ethiopia are still rare. The objectives of this study were to determine dynamics of macrofauna in conservation agriculture of maize legume cropping system. Research results from Boricha and Locabaya, southern Ethiopia, indicate that load and type of macrofauna dominated CA and increment of macrofauna in number from year to year determined . High percentage of macrofauna in Hawassa (59.9%) in 2014 from plots of maize intercropped with common bean. From the same treatment in Boricha ,as to that of Hawassa, during 2014 and 2015, (108.8%) and (419.6%) were recorded, respectively. In lockabaya, high percentages 24.3% and 210.5%, were recorded due to maize intercropped with cowpea in 2014 and 2015 respectively. In Conventional agriculture , total decline of macrofauna observed. it was concluded that CA favors the growth and load of macrofauna which resulted in reduced soil fertility and have a large impact on food security.

Keywords: Ants; Centipedes; Earthworms; intensification; intercropping; legume; maize; termites.

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1. Introduction

Biodiversity is related to ecosystem variation as well as that of all sorts of animals, plants and microorganisms throughout the biosphere. Every differences in energy input and/or physical conditions of soil greatly affect the populations and the biodiversity of soil organisms. The activities of soil flora and fauna are intricately interwoven, and therefore very difficult to study separately [1]Soil macro fauna, together with soil microorganisms, play an important role in the process of decomposition, namely in chewing and tearing plant tissues, and moving the soil organic matter on the soil surface from one place to another, often into the soil. Together with soil micro flora, soil animals utilize the energy content of plant residues [2] The total amount of soil biomass (macro, meso and micro-organisms) in soil organic matter fraction is very small, in nature soil biomass varies between 1 to 5% of the total soil organic matter. Biomass activities have long been recognized as a key factor influencing many soil processes such as soil genesis and ecosystem productivity. They also play major role in the biochemical and physical aspects of soil fertility, soil structure, and water relationships [3,4] soil macrofauna live in the soil, its organic matter and the solution that fills its porosity [5] gives a more reliable and relevant measure of ecological risk, because they integrate all the physical and chemical conditions of the soil [6] According to [7] organisms that belong to soil macro fauna in general have a body size greater than 2 mm. Macro fauna found in soils include earthworms, termites, ants, snails, mites, centipedes, millipedes, insects and small mammals. Conservation agriculture (CA) is based on the three principles of minimum soil disturbance, surface crop residue retention and crop rotations. In Ethiopia conservation agriculture practiced in different areas few years back. In most of southern Ethiopia few farmers practice conservation agriculture in parts of moisture stress areas. Problem of our people not practicing conservation agriculture is because of they don't know importance of it in soil fertility case. Not only that are not aware how conservation agriculture favorable in global warming case. In conservation agriculture soil became fertile due to inner nutrient enrichment by activities of macrofauna and microorganisms. There were different macrofauna established due to CA time to time practicing with continuous way. In southern Ethiopia there was little practice of CA which is one of the available options and there is no information on load of macrofauna in that few practices. Therefore the objective of the current study was to evaluate dynamics of macrofauna in conservation and conventional agriculture in maize/ legume cropping system of Sidama zone in Hawassa, Locabaya and Boricha district.

2. Materials and methods

An experiment was carried out in Hawassa (1700m asl and sandy loam soils), Lokabaya (1650m asl and clay loam) and Boricha (1850m asl and sandy clay loam) districts between 2014 and 2015 to explore dynamics of macrofauna in conservation and conventional agriculture systems. Six treatments comprising sole maize and common beans, intercropped maize/common bean and cow pea, rotations of maize/bean under conservation and conventional tillage were laid in CRBD in three replications. Macrofauna was counted at the harvesting time from random samples of three 0.25m x 0.25m sized quadrants in each plot. Sample preparation and material use (for the presence and abundance of soil macro-fauna were according to sampling methodology of tropical soils biology and fertility institute (TSBF method) **[**8**]** The counts were averaged to obtain treatment means, and then converted in hectare basis. The obtained data were analyzed using SAS 9.1 computer software and treatment means were separated using LSD at 5% level of probability.

3. Result and Discussion

3.1. Population of Macro fauna in 2014 and 2015

Results of this study have demonstrated the benefits of conservation agriculture in enhancing soil fauna richness and abundance. Total number of macrofauna were high in number when maize intercropped with common bean in Hawassa(1820.5) and Boricha (1033.9). Whereas, in Locabaya it was 884 when maize intercropped with cow pea during 2014 (Figure 1). High number of 8573 and 5950 macrofauna observed in Boricha and Lokabaya during 2015, respectively when maize intercropped with common bean and cowpea under conservation tillage (Figure 2). Higher macrofauna taxonomic richness and abundance of mesofauna in CA treatments than in CT without residue application are related to an improved microclimate and access to food in the CA system[13] Changes in tillage, residue, and rotation practices induce major shifts in the number and composition of soil fauna and flora, including both pests and beneficial organisms [15,16]. From year to year high increment of macrofauna detrmined in conservation agriculture but decline of macrofauna determined in conventional agriculture from Year to Year in the study . this study in line with [17] which means Soil organisms respond to tillage-induced changes in the soil physical/chemical environment and they, in turn, have an impact on soil physical/chemical conditions, i.e. soil structure, nutrient cycling, and organic matter decomposition. Disturbances caused by tillage operations and residue removal (CT) are known to negatively affect sensitive fauna [13]. this result also in line with [1] Intensive tillage has reduced the soil organic matter content. Although this soil had the lowest organic matter content, it had the highest soil reaction, which would affect the population of the soil macro fauna.

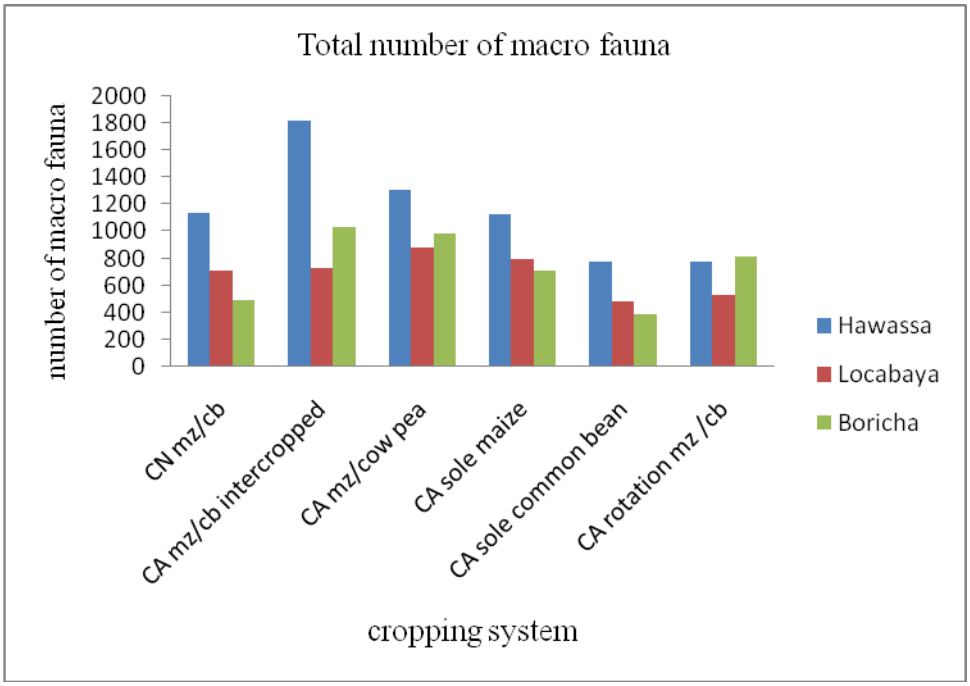

Figure 1: Total number of Macro fauna between treatments in different locations on 2014

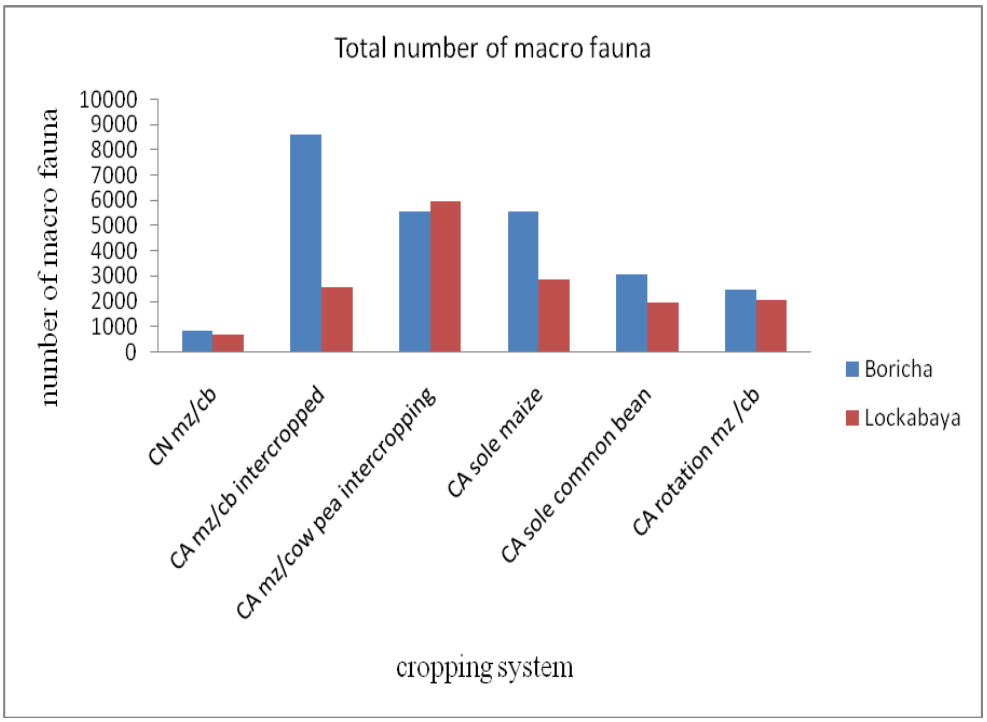

Figure 2: Total number of Macro fauna between treatments in different locations on 2015

3.2. Mean number of Macro fauna in different location on year 2014

The number of termites, earth worm and ants were not variable in 2014 in Hawassa district. However, there was significant ($p<0.05$) variation in numbers of millipeds and centipeds among treatments. Results showed that significantly highest number of millipeds were recorded due to CA/MZ/intercrope compared to CA sole MZ. However, the counts of millipeds were invariable in other treatments the significantly (<0.05) lower counts of millipeds in sole maize and sole common bean plots were attributed to nutrient decline when compared to intercropped one. From this study there was no earthworm count found in Hawassa district as indicated in (Table 1). Significantly ($p<0.05$) higher count of centipeds were recorded due to CA/Mz /cb intercrops compared to other treatment levels. There was no significant difference between treatments in locabaya district to macro fauna counts. However, high count value obtained in treatment under conservation agriculture maize intercropped with cowpea in case of termite, ants and others. Where as high count obtained in treatment of maize intercropped with common bean under conservation agriculture in the case of earth worm and centipedes. Lowest count obtained in termite by the treatment of maize with common bean rotation under conservation agriculture. Lowest count of termite by the treatment mz/cb rotation was due to the chemical intensity associated with managing the crop. Although lowest count in the case of earth worm, ants, centipedes and others macrofauna. obtained in treatment of sole common bean under conservation agriculture, There was no count in whole treatments in the case of millipede macrofauna in locabaya district (Table 1). There were no significant mean values found between treatments in Boricha districts. Though high and lowest count of macrofauna obtained in different treatment. For instance, high count found in treatment of sole maize in macrofauna under conservation agriculture of termite, ants, millipede and centipedes. On the other hand, high count in macrofauna of others attained by maize intercropped with common bean under conservation agriculture. Lowest count of

macrofauna of ants, millipeds, centipeds and others obtained in the sole common bean under conservation agriculture by. Except termite and earth worm which is lowest count obtained when maize with common bean intercropped under conventional agriculture (Table 1).

Table 1: Mean of Macro fauna count in 2014 in Boricha, Loka Abaya and Hawassa areas under CN and CA

	Hawassa						
Nº	Treatment	termite	earthworm	ant	millipeds	centipeds	other
1	CN mz/cb	264.5ab	0	471.1ab	98.1ab	124ab	180.6a
2	CA mz/cb intercropped	447.2a	0	846.3a	125.9a	168.9a	232.25a
3	CA mz/cow pea	269.9ab	0	604.8ab	107ab	98.85bc	225.95a
4	CA sole maize	264.5ab	0	571.9ab	50bc	57.0c	180.6a
5	CA sole common bean	202.65b	0	445.7ab	0c	41.85bc	83.7a
6	CA rotation mz /cb	147.35b	0	353.0b	69.25abc	91.85bc	114a
	Mean	265.6	0	548.8	75.03	97.1	169.5
	CV	28.6	0	30.5	37.8	26.6	36.2
	LSD 5%	195.1	0	430.25	72.8	66.5	157.72
	Significance	ns	ns	ns	*	*	ns
	Lokabaya						
1	CN mz/cb	250.65a	108.95a	149.9a	0	66.15a	135.4ab
2	CA mz/cb intercropped	203.8a	129a	186.4a	0	74.1a	133.65ab
3	CA mz/cow pea	278.5	72.4a	296.2a	0	63.75a	173.4a
4	CA sole maize	266.7a	55.9a	262.2a	0	43.3	171.25a
5	CA sole common bean	204a	50a	147.9a	0	0a	85.35b
6	CA rotation mz /cb	107.25a	90.2a	193.3a	0	0a	135.5ab
	Mean	218	84.4	205	0	41.2	139.1
	CV	44.6	39.2	60.7	0	108.8	16.2
	LSD 5%	250.6	85.1	321.77	0	115.3	57.8
	Significance	ns	ns	ns		ns	ns
	Boricha						
1	CN mz/cb	69.25b	0a	186.6a	0a	50a	190ab
2	CA mz/cb intercropped	317.2a	0a	364.7a	50a	100a	202a
3	CA mz/cow pea	258.8ab	0a	335.9a	27.4a	38.75a	328ab
4	CA sole maize	173.0ab	27.4a	215.2a	38.75a	38.75a	221ab
5	CA sole common bean	125.3ab	27.4a	169.4a	0a	0a	65ab
6	CA rotation mz /cb	220.25ab	0	289.9a	0a	77.4a	223b
	Mean	193.9	9.1	260	19.3	50.8	203
	CV	46.5	219	43	163.4	80.5	31.6
	LSD 5%	232.1	51.4	288.1	81.3	105.1	166
	Significance	ns	ns	ns	ns	ns	ns

Where: Others: - bettles, spiders, scorpions,white grub and crickets

3.3. Mean number of Macro fauna in different location on year 2015

There was significant difference observed between treatments in Boricha district in 2015. From table 2 there were an increment of macrofauna when compared to 2014 in all CA plots such as termites ,ants, centipeds and others macrofauna (the most dominating group). Except CN which was tremendous decline by count of all macrofauna types when compared to CA practices in 2015. There was no earth worm count at all on 2015 this was due to elino case which were few found at 2014 and disappear 2015. There were no significant differences obtained in locabaya district in 2015 between treatments. Millipeds macrofauna few or not found in locabaya

districts the same as previous results (2014) this was an indication of soil and climate of the area which was not favored the growth of millipeds. On the other hand, termite, ants, centipeds and others are the most dominating group in CA plots. This attributed to the fact that CA enhanced the soil macrofauna activities in the absence of soil disturbance due to repeated tillage. Moreover, macro fauna, can alleviate excessive build up of soil organic matter in the surface horizons. Whereas, in CN, there were total decline of macrofauna when compared to 2014 (Table 2).

Table 2: Mean of macrofauna count in 2015 in Boricha and Loka Abaya areas under CN and CA

Boricha							
Nº	Treatment	termites	earthworms	ants	millipeds	centipeds	others
1	CN mz/cb	55de	0	237.5c	36.25b	113a	145.8bc
2	CA mz/cb intercropped	2919.5a	0	2394.5ab	225a	231a	408.5ab
3	CA mz/cow pea intercropping	492.5c	0	2206.5b	31c	285a	300abc
4	CA sole maize	1e	0	2631a	1c	1.5b	275bc
5	CA sole common bean	1635b	0	586.5c	2c	97.5b	130c
6	CA rotation mz /cb	191.5d	0	666.5c	105b	305a	485a
	Mean	891.58	.	1493.3	72.75	191	315
	CV	6.75	.	10.76	18.79	25.7	23.5
	LSD 5%	154.77	.	413.2	35.14	126.05	190.72
	Significance	*	.	*	*	*	*
Locabaya							
1	CN mz/cb	16.6a	0	555.5bc	0a	0b	66.6 a
2	CA mz/cb intercropped	165a	0	1500bc	100a	366.5	416.5a
3	CA mz/cow pea intercropped	216.5a	0	5183.5a	0a	50b	500a
4	CA sole maize	0a	0	2350b	0a	150ab	350a
5	CA sole common bean	415a	0	1300c	0a	50b	150a
6	CA rotation mz /cb	150a	0	1400bc	0a	100ab	400a
	Mean	166.08	.	2233.3	16.6	119.4	336.08
	cv	111.08	.	17.7	346.4	92.96	76.22
	LSD 5%	474.28	.	1020.4	148.4	285.37	658.51
	Significance	ns	.	*	ns	ns	ns

Where: Others: - bettles, spiders, scorpions,white grub and crickets

3.4. Percentage of Macro fauna

The percentage of macro fauna between treatments when substracting the control shows that high percentage of macro fauna were recorded in Hawassa location by the treatments conventional agriculture maize with comment

bean intercropped . by the same treatment in Boricha location high percentage as well as increament of macro fauna in year 2015 were obtained. In Locabaya case high frequency of macro fauna were obtained by treatment conservation agriculture maize with cow pea intercroped in 2014 and 2015 (Table 3).

Table 3: Percentage of Macro fauna in different location

		2014			**2015**	
No	Treatment	Hawassa (%)	Boricha (%)	Lockabaya (%)	Boricha (%)	Locabaya (%)
1	CNmz/cb	0	0	0	0	0
2	CA mz/cb intercropped	59.9	108.5	2.24	419.6	33.0
3	CA mz/cow pea	14.7	99.4	24.3	234.6	210.5
4	CA sole maize	-1.25	44.01	12.4	235.8	48.7
5	CA sole common bean	-32	-21.9	-31.5	84.1	-0.1
6	CA rotation mz /cb	-31.8	63.5	-25.9	46.6	7.0

From the above result there were increments of macrofauna in conservation agriculture practices . The result of an improvement in species richness upon adoption of CA clearly demonstrates the importance of reduced tillage in protecting fauna activity and habitat. Similar study showed that Analysis of variance showed significant ($P<0.001$) treatments and sites effects on the results. Correlations between amount of crop residue cover applied in CA systems and abundance and also species richness were positive[19]. In all locations termites and antes were the most dominated macrofauna in study. Termites are renowned primary shredders of most dry organic materials; hence their populations tend to increase with increasing amounts of organic material applied as soil cover. this finding in agremment with [19] Termites were the most predominant macrofauna group across all the sites. There was a significantly higher macrofauna population in CA systems than conventional practice. This was true for all the groups; i.e. termites, ants, centipedes and beetle-larvae. In the CA systems, abundance increased with increasing amount of crop residues applied. This was due to the residue effects which had more nutrient availability for the soil and keep the environment safe for macrofauna perpetuation. This result in agreement with [9] which is large organisms appear to be especially sensitive to agro ecosystem management. Although crop rotations could theoretically beneficial for soil macrofauna populations through greater biomass returns to the soil. The higher counts of millipeds and centipeds in CA/Mz/cb intercrops were due to major benefit of weed, pest and disease management. legume cover crops and short duration fallows of fast-growing legume trees can fix substantial amounts of N_2 from the air [10] and improve soil fertility giving strong increases in the yield of subsequent serial crops [11] as well as providing substantial biomass for mulch [12] Also finding of the above result also showed decline of macrofauna in conventional agriculture practices when compared to 2014 to 2015. For the reason that in disturbed (tilled) soil macro fauna eaten by birds, hens and the like. In turn of this finding the same author said that tillage, through direct physical disruption as well as habitat distruction strongely reduces the populations of both litter transformers and ecosystem engineers [12] In addition earthworm macrofauna found in this study few in first year of study in different district and absent in second year (2015) study. This were due to climate change of the region in ELINO case since earth worm prefer dark

environment for growth. this finding disagree with [13] which means earth worm activity is also reported to be related to increased infiltration in zero tillage soils through enhanced soil surface roughness and increased soil macroporosity, especially when populations are significant. Also Earthworms which are a major component of the soil macrofauna are important in soil fertility dynamics as their burrowing activities aid in improvement of soil aeration and water infilitration . the fact that the population of earthworms are affected by tillage practices has been documented in ploughless tillage review by [18]. Moreover in current study in locabaya district millipeds were absent in two of consecutive years. This may be attributed to soil type of locabaya district did not favor the growth of millpeds. The same study {19] shows Millipedes (Diplopoda), earthworms (Haplotaxida), crickets (Orthoptera) and mites (Acarina) were also observed on a few occasions but their numbers were very low. Therefore according to [20] Therefore, species diversity and evenness appeared to depend on the quality of organic material retained on the soil surface. Total number of macrofauna increase from year to year in conservation agriculture in study this were in agreement with [12,20] .

4. Conclusion and Recommendation

From the current study it was concluded that macrofauna type and dominance diversified and increase year to year in conservation agriculture and the reverse holds true in conventional agriculture. This means Conservation agriculture practices have potential to increase agricultural productivity through better efficiency in utilization of inputs and other resources due to improved soil conditions. In Boricha and Hawassa conservation agriculture maize intercropped with common bean recommended for farmers. whereas in Locabaya conservation agriculture maize cowpea intercrope recommended for farmers . Therefore Maize residue retention yielded superior macrofauna diversity under conservation agriculture practices. Finally, conservation agriculture exhibited potential to attract higher levels of macrofauna and this is important as the initial stage in natural rehabilitation of degraded arable lands. Soil macrofauna are important regulators of decomposition, nutrient cycling, soil organic matter dynamics, and pathways for aeration and water movement as a consequence of their feeding and burrowing activities. Further study also needed to establish conservation agriculture in different Region of Ethiopia.

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