

EFFECT OF WEED CONTROL METHODS ON PHYSICAL, BIOLOGICAL AND MICRO-PEDOLOGICAL PROPERTIES OF AN OBUDU ULTISOL

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ABSTRACT

The impact of raindrop and cropping activities are capable of disrupting natural soil aggregation and porosity. A weed vegetative cover could serve as a protective cover of soil and microbial population. Thus, this research was designed to investigate the changes of soil physical, biological and micro-pedological properties under natural conditions, as influenced by different methods of weed control in an Obudu Ultisol. The study adopted a randomized complete block design (RCB). Four methods of weed control – hoe-weeded, bare soil, cut and cut plus application of pre-emergence herbicides were studied on a continuously cropped Hapludults in Obudu Local Government Area in split plots of 4 x 10m of four replicates. The data collected were analyzed using ANOVA and co-efficient of regression analysis. In the rainy season, the insulating effect of cut and cut plus herbicide resulted in higher soil moisture content of 0.540mm compared to bare soil and hoe-weeded of 0.450mm soil moisture content. Micro-pedological observations revealed a sealing effect up to 15mm below the surface in the bare soil and hoe-weeded covers. The cut plus herbicides covers showed a decrease in bacteria, fungal and actinomycetes populations. A cut plus herbicides treatment was the best alternative to hoeing in reducing the degradation of soil physical properties and soil moisture content losses and thus recommended.

Keywords: Weed control methods, sealing, micro-pedology, biological factors, Ultisol, and soil moisture content.

INTRODUCTION

Soil degradation has been defined as process that lead to decline in the fertility or future productive capacity of soil as a result of human activity (United Nations Environment Programme (UNEP), 1993). Soil degradation in the tropics is a wide spread phenomenon which is rarely reversible. The degradation of soil may be caused by physical, chemical or biological factors. Sealing development in intensively cultivated soils as a result of some soil management practices as ploughing, harrowing, weeding and pre-emergence herbicides are those processes that are reversible. These practices can induce erosion, losses of soil, moisture and soil organic matter.

The erosivity of rainfall in the humid tropics is higher than that of the temperate. Soil erosion in Obudu is becoming more serious as farmers are forced to intensify their land cultivation Due to population pressure. There are alarming figures on soil degradation, both chemical and physical

in the poorer humid tropical countries. (Oldenman, *et al*, 1990).

The increased use of pesticides in agricultural soils causes the contamination or degradation of the soil with toxic chemicals. When these chemicals are applied there are possibilities that these chemicals may exert a certain degree of pressure on non-targeted organisms, including soil micro-organisms (Hutsch, 2001). Soil microbial biomass plays an important role in soil ecosystem where they are crucially involved in nutrient cycling and decomposition of organic matter.

Introduction of pre and post-emergent herbicides have been on the increase over the years in many countries. Nigerian farmers are increasingly using herbicides to control weeds in agricultural systems. The fate of these large quantities of applied chemicals in the soils is becoming more and more important as they could be leached into ground water or immobile and persist on the top soil. (Ayensina, *et al*, 2003). These could accumulate to toxic levels in the soil

and become harmful to micro-organisms, plants, wild life and man (Amakir in Sebiomo, *et al.*, 2011).

Little is known about the effects of various weed control methods on soil structure, soil moisture dynamics and other physical properties of the soils of Obudu. Farmers are increasingly adopting zero tillage techniques usually among small scale farming systems of the study area as in most tropics. The small-scale farmers adopt traditional farming systems which rely on manual cultivation. They produce such subsistence crops as rice, maize, cassava and yams on the clayey Ultisol. (Ukelina, 2006). Under continuous cultivation the clayey Hapludult are prone to sealing formation which is however reversible through seasonal fallowing.

Literature abounds on the influence of soil cover on soil losses and soil moisture loss (Lal, *et al.*, 1980, Parter, *et al.* 1992, and Tollner, *et al.*, 1984). There is however, the need for a proper understanding of the role of crop history, methods of weed control and vegetation cover on the protection of soil (Lal, *et al.*, 1980). Keeping stable mulch on soil surface is appropriate but it is always not a feasible practice in the tropical environment.

This study was designed to investigate the effect of selected weed control methods on physical, biological and micro-pedological properties of Obudu Ultisol with the view to producing a more sustainable agricultural practice in the study area.

MATERIALS AND METHODS

The study was carried out in an ultisol (Hapludult, which originated from older granite consisting of granites, schist, gneiss and quartzite scattered in the high lands, the troughs and river valleys located at longitude 09°E and latitudes 06°N (Ukelina, 2006). The climate is tropical with alternate rainy and dry seasons in a year. The area under study has been fallow for the past two years after being previously cultivated to cassava. The predominant grass cover in the area are *Andropogon spp*, *Imperata cyhidrical*, *Axonopics compressas*, siam weed (*chromolanena odorata*) as well as shrubs *Olax viridis*, *Ficus spp*, *Afromosia laxiflora*. The experimental design employed for the study was randomized complete block design (RCB). Four methods of weeds control were adopted in four plots of size 4 x 10m in four replicates for each

method. The type of vegetative cover was allocated at plot level, depth was at split-plot level, and time at split-split plot level. The type of vegetative cover was allocated at plot level, depth was at split plot level, and time at split-split level.

Plot A: Hoe weeded treatment

Weed control here was by hand weeding using a hand-held hoe. The plots were weeded when weeds were 20 to 25cm high and uniformly spread on the soil surface to reduce the impact of raindrop.

Plot B: Bare soil treatment

Here the soil was kept completely free of vegetative cover by a combined application of glyphosate at recommended rates of 4kg ha^{-1} by dissolving 350ml in a 15litres' sprayer and atrazine powder at recommended rate of 3kg ha^{-1}

Plot C: Cut

The vegetative growth was at heights of 3 to 5cm by slashing with sharp cutlass. The cut vegetation was evenly spread on the soil surface to provide a certain level of protection to soil against the impact of rain drops.

Plot D: The cut-plus herbicides

The vegetation was cut as in plot C and then treated with glyphosate at 4kg ha^{-1} . This was done to allow the accumulation of vegetation on the soil surface as mulch following herbicides application.

Twenty soil samples were randomly collected on the plots at 15cm and 30cm depth for both physical and chemical analysis. This was done according Grossman and Ranches (2002) for the determination physical properties, and Gee and Or (2002) for the chemical properties. Bulk density was determined by core method according to Grossman and Ranches (2002) at 15 and 30cm.

Soil moisture content was determined by sampling about 60g of wet soil from the plot of 15cm and 30cm depth by use of auger sampler. The soil moisture content was computed as mean of two replicates for each plot according to Brady and Weil (2010). The samples for micro-pedological studies were collected at 15cm depth on the four plots. These samples were collected according method described by Fitzpatrick (1993). The samples were then air dried at 35°C for five days. The remaining moisture in the samples was removed by treatment with acetone and they were then cured with a mixture of polylite resin and ultra-violet dye. The samples were then cut into about 2cm slice for micro-

pedological examinations. The treated slices were photographed in black and white in a dark room with an ultra-violet lamp (Altermuller and Vliet-Lanoe, 1990).

Biological Factors

Microbiological enumeration was done with nutrient agar for heterotrophic bacteria by the pour plate method after incubation at 30°C for 24 to 48-hour isolation and enumeration of fungi was done with potato dextrose agar after incubation at 25 °C for 48 hours. Bacteria and actinomycetes were isolated and characterized based on cultural characteristics, staining reactions and biochemical reactions. This identification was then made with reference to Bergey's manual of systematic bacteriology. Total actinomycetes counts and fungal characterization were done by treating their

isolates with starch Casein Agar according to Barnett and Hunter (1992).

Data Analysis

The analysis of the data collected was done using ANOVA in the split-split plot scheme and regression analysis was done based on the harmonic transformation of Fourier transformations of soil moisture content = $f(\text{time})/\text{cover, depth}$ (Churchill, 1963).

RESULTS AND DISCUSSION

The soil moisture content for each depth is shown in figure A and B. The ANOVA is presented in table 1. The coefficients of regression analysis (r_2) were above 0.85 in all cases. The soil physical properties at 15 and 30cm depth are shown in table 2 and the chemical properties are shown in table 3.

Table 1: Analysis of Variance of Soil Moisture Content Data

Source	Soil moisture content	
	D. F	M. S
Plot	3	1,780.79 ^{ns}
Cover	3	2,078.32 ^{ns}
Error 1	9	1,160.47
Depth	1	213,166.00 ^{**}
Cover x Depth	3	2,102,30 ^{ns}
Error 2	20	1,016.02 ^{**}
Time/hoe weeded/depth 15cm	11	
Regression	10	11,652.13 ^{**}
Residual	1	542.63 ^{ns}
Time/hoe weeded/depth 30cm	11	
Regression	9	7,840.19 ^{**}
Residual	2	250.81 ^{ns}
Time/bare soil/depth 15cm	11	
Regression	10	8,655.70 ^{**}
Residual	1	669.22 ^{ns}
Time/bare soil/depth 30cm	11	
Regression	10	5,466.62 ^{**}
Residual	1	13,12 ^{ns}
Time/cut/depth 15cm	11	
Regression	10	14,460.10 ^{**}
Residual	1	2,005.80 ^{ns}
Time/cut/depth 30cm	11	
Regression	10	8,004.28 ^{**}
Residual	1	26.52 ^{ns}
Time/cut + herbicides/depth 15cm	11	
Regression	10	15,006.26 ^{**}
Residual	1	71.26 ^{ns}
Time/cut + herbicides/depth 30cm	11	
Regression	11	9,701.18 ^{**}
Residual	1	706.02 ^{ns}
Error	215	
C.V.		3.33

**significant at 1%, ns not significant

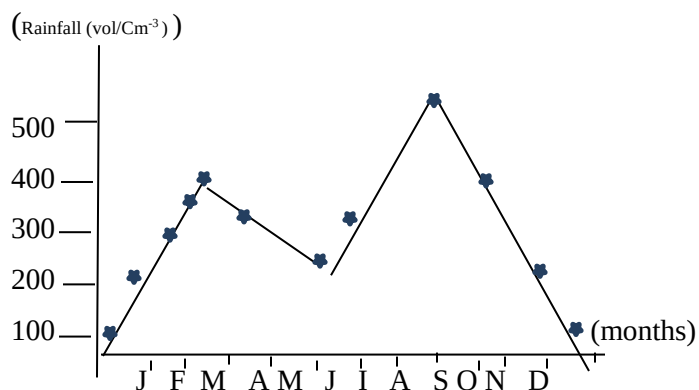


Figure 1: Rainfall distribution pattern in Obudu.

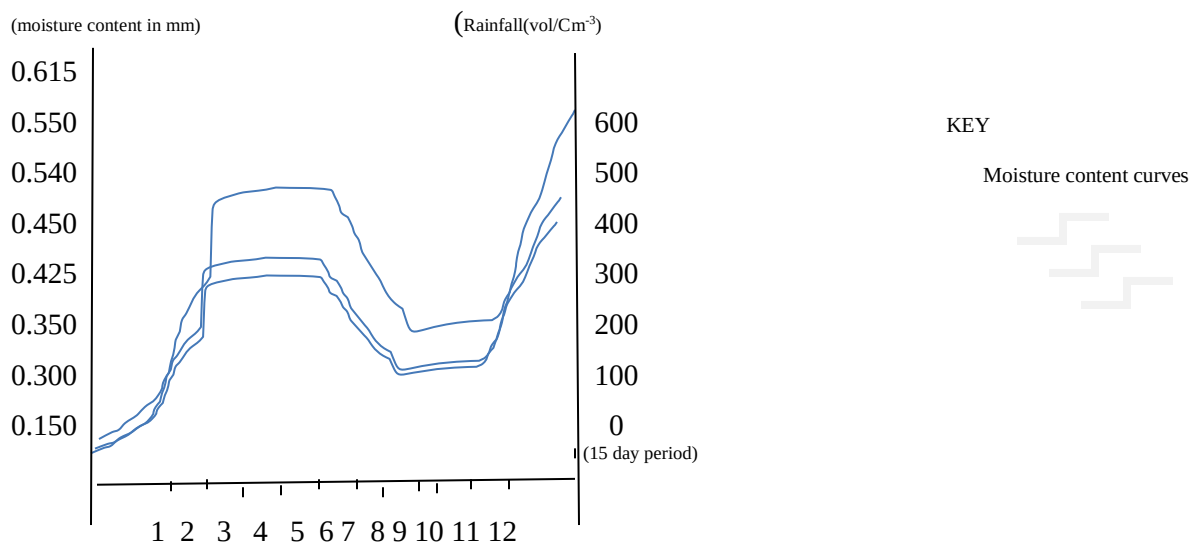


Figure 2: Soil moisture content of soils at 15cm

Table 2 : Physical Properties of Soil at 15cm and 30cm Depth

Characteristics	Depth	
	15cm	30cm
Bulk density gcm-3	1.4	1.5
Field Capacity m-3	1.5	1.3
Soil separate size analysis		
Coarse sand	30	35
Fine sand	60	20
Silt	9.8	9.8
Clay	29.2	20.2
Porosity	0.600	0.620

Table3: Chemical Properties of Soil tt 15cm and 30cm Depth

Depth (cm)	Organic mgcm ⁻³	pH (H ₂ O)	P	Ca	N	Al	H + Al	S	Mg
						Cmolkg ⁻¹			
15	1.6	4.0	0.01	0.03	70	6.4		3.2	2.70
30	0.05	4.0	2.0	0.01	0.02	6.0	6.3	2.8	3.01

The soil moisture behavior at 15cm depth is shown figure 2. The cut and cut + herbicides covers showed higher values of soil moisture content as against the hoe weeded and bare soil especially at the rainfall peaks of June, September and October. It was also observed that soil moisture contents of the hoe-weeded and bare plots soils were lower than that of cut and cut + herbicides at the peaks of the rainfall.

These differences in the values may be associated with the difference between the amount of solar radiation intercepted by both dead and living vegetative cover and the bare soil surface. A lower temperature that may be observed at the top soil may lead to reduced moisture losses (Hillel, 1971). In the cut and cut + herbicides plots, moisture removal by transpiration was high due to the presence of weeds (Jesen, *et al*, 1990) and may have actually occur at the depth of 15cm. Instead, the frequent cutting of the grasses provided a surface mulch that enhanced infiltration (Parker, *et al*, 1992) as well as internal drainage which allowed water to infiltrate deeper in the profile and it is retained for longer periods. Water in the deeper yards of the profile is less likely to be lost by evaporation. Also, the rate of evaporation by wind action is decreased due to the cut cover.

There is no clear differences during the rainfall peaks in June, September, and October in figure 1 among the different methods of weed control the soil moisture content in the bare soil plot was observed to be increasing at different rate compared to what obtained at other treatment plots and the difference increase with depth the reduced quantity of moisture infiltration and its downward redistribution may be due to seal formation which resulted in mechanical impedance and high amount of water loss by surface runoff.

The hoe-weeded and bare soil plots showed lower water loss over time compared to the cut and cut + herbicides plots. This may be as a result of the high uptake of soil moisture through transpiration in the later plots (Jensen, *et al*, 1992). At 30cm depth it was observed that the cut showed higher moisture content between June and September than the cut + herbicides at the same periods. The reverse was the case in September where the moisture content of the cut + herbicides was higher. This was found to be

immediately after the application of herbicides that resulted in lower rates of rates of transpiration.

It was observed in the field that a considerable amount of water was lost due to surface runoff in both the hoe-weeded and bare soil plots. This was however not measured. The surface runoff enhanced sealing formation which led to the reduction in infiltration rates and moisture redistribution in the soil.

The above observations showed that in a tropical environment characterized by a highly erosive rainfall practice of weed management can greatly have altered the soil surface porosity (Faria, 1996) and the rate of infiltration (Hutugalle, 1994). Therefore, weed control should not only be viewed from a point of a competitive process of nutrient, moisture and light between weed and crop but also from the point of soil moisture consumption and development of soil structure. Thus, in Obudu where the amount of rainfall and reduction in evapotranspiration could be enhanced by frequent cut herbicides (mulch) or both (cut+ herbicides) resulting in more available moisture to the crops.

Seal Formation

Seal formation was observed in the bare soil and hoe-weeded plots however; it was less pronounced in the later. The formation or degradation and redeposition of seal were observed in both bare soil and hoe-weed plots. There were visible signs of sheet erosion resulting in formation of channels in the bare soil plot. Similar physical degradation characteristics although to a lesser degree were observed in the hoe-weeded plot. This may be due to the effect of continuous hoeing that break the surface seal enhancing infiltration rate. There were no signs of erosion or redeposition and channels observed in the cut and cut + herbicides plots.

Micro Pedological Observation

A clear relationship between the type of soil cover and structural reorganization was revealed by photographs of the polished block pictures. The cut and cut plus herbicide plots qualitatively contrast the hoe-weeded and bare soil plots. A high biological activity indicated by the presence of many channels and pores was

observed in the Ad-horizon of the cut and cut plus herbicide which may be due to the retained stable and trash cover on the surface soil. No trace of sealing was observed in the upper part but traces of small aggregates were seen at the upper part and surface. The hoe-weeded plot showed clean evidence of mechanical dispersion and breaking down of microaggregates. These observations agreed with FitzPatrick (1993) earlier assertion. The suspended, dispersed particles are carried by runoff and deposited where they become involve in micro-sedimentation process or crust formation. Crust formation is best explained by sedimentological concepts. Close observation of the hoe-weeded plot indicates that the sealing materials were composed mainly of quarter size range from very fine to fine sand.

Effects on Biological Properties

The different types of weed management have resulted in differences in types and distribution plant species within the study period. It was observed that the plant species differ with type of cover and time. In the hoe-weeded cover *Cyperus rotundus* and *Brachiaria plantaginea* predominate the other species.

Brachiaria population was noticed to have reduced in wet season. Similar types and number of weeds were observed during the first periods. After the first application of herbicides in the cut plus herbicide cover there was a great infestation of *Cyperus rotundus*. Also there was a general development of bryoppates and some algae species especially where the mulch was thinner. This indicated a very favourable micro-environment for the species and worms which help to maintain the soil structure in the surface soil. This is in line with the observation of Fario, et al, (1998) that the presence of plant species and worms in surface soil help to maintain the crumb structure in the surface soil thereby enhancing water infiltration. In the hoe-weeded and bare soil treatments sealing was observed which was absent in the cut and cut plus herbicides. Wet seasons and dry season weeds were absent in the bare soil due to the frequent removal of the weeds.

SUMMARY AND CONCLUSION

It was observed that weed control methods adopted on Hapludults of Obudu had significant influence on the water content of the soil. Higher soil water contents were observed in the cut plus herbicide soils than in the hoe-weeded and bare soils. The result from the study revealed that control practices can greatly alter soil surface porosity and the infiltration rate. The increased water availability in the soil to crops could be as a result of the regular cut, mulch or both cut plus herbicide. Therefore, weed management could both be analyzed only from the view of a competition for water with a given crop. The seal formation was observed in the hoe-weeded and bare soil covers and absent the cut and cut plus herbicide covers where good structured pattern and high biological activities was obtained. Observations of micro-pedology revealed active micro-erosion and micro deposition which may be as the result sealing development to a depth of 10mm that may be associated, with the distortion of aggregates and their re arrangement. Therefore, the control of weed by cutting and systematic application of herbicides was a more promising alternatives for reducing losses of soil water and physical degradation of soil.

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