

EFFECTS OF HERBICIDES ON PHYSICAL AND INFILTRATION PROPERTIES OF SOILS OF RESEARCH FARM OF MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY YOLA, ADAMAWA STATE, NIGERIA

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ABSTRACT

This study was conducted with the aim of evaluating the effects of herbicides on soil physical and infiltration properties in Research farm of Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria. Two sites were identified, one of the sites uses herbicides to control weed while the other site serve as a control with no herbicides. Four profile pits were dug at each of the selected study locations. Field Infiltration test was conducted at the different site, soil samples collected from identified genetic horizons were analyzed in the laboratory for soil physical properties using standard laboratory procedures. The result of particle size analysis showed that mean percentage sand, silt and clay for herbicide usage (HU) were 35.66%, 37.22% and 27.13% and for non-herbicide usage (NHU) 53.76%, 32.13% and 14.11%, respectively. Soil texture was found to be predominantly Loam to Clay loam in texture and silt loam and loamy sand for HU and NHU, respectively. The coefficient of variation for Sand, Silt and Clay across the two sites (HU and NHU) recorded very high, moderate and low variability. Bulk density, Particle density, Porosity and Water holding capacity recorded coefficient of variation (CV) values of 3.66%, 3.72%, 0.23% and 3.98%, respectively and were general found to be low variability. This is an indication that use of herbicide did not in any way influence variability in the above soil physical properties across the different sites. The results further indicated that the initial infiltration rate and the cumulative infiltration were high in sites under NHU. In line with the above findings it is recommended that further studies should be carried out with the same kind of soil having the same characteristics to determine the extent or effects of spent oil on soil physical properties of the study area. Finally, proper and periodic monitoring of the physical and chemical properties of study area is very necessary, so that appropriate and preventive measures could be embarked upon as at when due, for optimum agricultural productivity.

Key Words: Bulk density, Herbicide usage, Infiltration, Porosity, Profile pits

1 INTRODUCTION

Herbicides also commonly known as weed killers, are substances used to control unwanted plants [1] Selective herbicides control specific weed species, while leaving the desired crop relatively unharmed, while non-selective herbicides (sometimes called total weed killers in commercial products) can be used to clear waste ground, industrial and construction sites, railways and railway embankments as they kill all plant material with which they come into contact. Apart from selective/non-selective, other important distinctions include *persistence* (also known as *residual action*: how long the product stays in place and remains active), *means of uptake* (whether it is absorbed by above-ground foliage only, through the roots, or by other means), and *mechanism of action* (how it works). Historically, products such as common salt and other metal salts were used as herbicides, however these have gradually fallen out of favour and in some countries a number of these are banned due to their persistence in soil, and toxicity and groundwater contamination concerns. Herbicides have also been used in warfare and conflict. The global drive for sustainable agricultural systems involves

optimizing agricultural resources to satisfy human needs and at the same time maintaining the quality of the environment and sustaining natural resources. In achieving this optimization conditions, herbicide use is of great importance. Herbicides are substances used to kill or suppress the growth of unwanted plants and vegetation. During the past decade, a large number of herbicides have been introduced as pre- or post-emergence weed killers in many countries of the world. As farmers continue to realize the usefulness of herbicide, large quantities would be applied to the soil. But the fate of these compounds in the soil is becoming increasingly important since they can be leached down, in which case ground water is contaminated or if immobile, they would persist on the top soil. This herbicide can then accumulate to toxic levels in the soil and become harmful to microorganisms, plants, wildlife and even human beings. The rate of herbicide decomposition in soil depend on the property of the preparation applied, herbicide dose, physical and chemical soil properties, humidity, temperature, plant cover, soil cultivation technique and the type of soil microorganisms present. The success of on-farm soil water conservation depends on many soil factors such as soil bulk density (BD), porosity, soil surface sealing and crusting, surface roughness, hardpans, hydraulic conductivity, and infiltration rates as they determine the hydrological properties of soil [2]. Soil compaction reduce infiltration, increase penetration resistance and limited root growth. Soil surface roughness (configuration) influences wind and water erosion by decreasing soil detachment and transport caused by erosion [3]. Soil surface roughness can however change considerably with rain, wind and soil cultivation events. There is a high use of herbicide in suppressing weeds and unwanted plants in cropped fields. Despite the importance of herbicide in Agriculture, continuous use of such chemicals has detrimental effects on soil physical properties and may reduce crop productivity. Therefore, this paper tends to use obtained data in order to assess the effects of continuous use of herbicide on the soil physical properties and proffer management strategies that may be adopted.

2 MATERIALS AND METHODS

2.1 The Study Area

The experiment was conducted at the Research farm of Modibbo Adama University of Technology, Yola (Figure 1). Yola is located at latitude 9°12' N and longitude 12°28' E in the savannah area of North East Nigeria, at the altitude of 158.8m above sea level. This area is characterised by the mean annual rainfall range of 700 to 1600mm and the temperature characteristics is typical of the West Africa savannah climate. Temperature in this climate region is high throughout the year because of high radiation which is relatively evenly distributed throughout the year. Maximum temperature can reach 40°C especially in April, while minimum temperature can be as low as 18°C between December and January. The area has a relative humidity of 20-80%. Agricultural practices in the area are mainly arable crops such as maize, millet, sorghum, rice, groundnut and beans etc.

2.2 Field Work and Soil Sampling and Techniques

The experiment was carried out on two sites, one with herbicide, the other as control. Four profile pits were dug at each of the selected sites in University farm of, Modibbo Adama University of Technology, Yola in Girei Local Government Area. Soil samples were collected from various pedon for Laboratory Analysis. Infiltration studies were also carried out on each of the selected sites. The collected soil samples were then stored in a properly labelled polyethene bags and taken to the laboratory for analysis. In the laboratory each sample was separately air dried, grinded using a porcelain pestle and mortar and passed through a 2mm sieve. The sieved samples were then used for all laboratory analysis.

2.3 Laboratory Analysis

The processed soil samples were analysed for some physico-chemical properties following standard procedures as described by [4]. Particle size distribution was determined by the Hydrometer method [5]. The soil bulk density, porosity, and water holding capacity were also determined.

2.4 Data Analysis

In this study, data obtained from each pedons and sites were presented in their means and illustrated in tables. Furthermore, mean differences in properties between soils developed across the two sites were analyzed using Coefficient of variation [6].

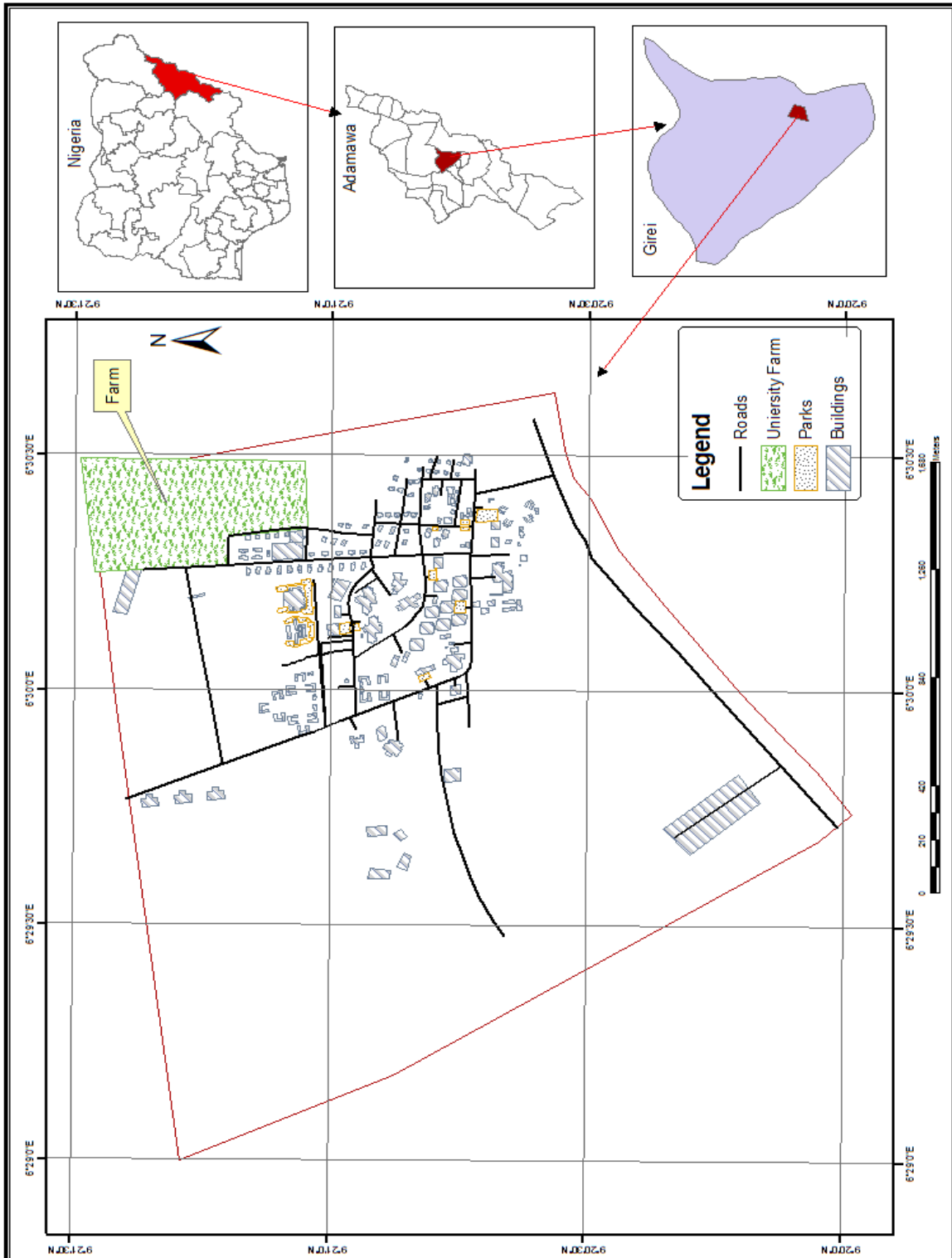


Figure 1. Map of Adamawa State showing study Area

3 RESULTS AND DISCUSSION

3.1 Soil Physical Properties

3.1.1 Particle Size Analysis

The result of particle size analysis (Table 1) showed that the soils from pedon 1 to 4 with herbicide usage (HU) has percentage sand ranging from 23.20-42.58% and a mean of 35.66%,

percentage silt ranging from 26.92-46.72 percent and a mean of 37.22% and percentage clay ranging from 17.25-37.75% and a mean of 27.13% and predominantly Loam to Clay loam in texture. The sites for non-herbicide usage (NHU) for pedon 1 to 4 (Table 1) showed that percentage sand ranging from 33.63-81.28% and a mean of 53.76%, percentage silt ranging from 12.97-51.12% and a mean of 32.13%, percentage clay ranging from 5.75-19.69% and a mean of 14.11% although small amount of silt loam and loamy sand is found in pedon 3 and 4. The coefficient of variation for particle size distribution (Sand, Silt, Clay) (Table 1) across the two sites (HU and NHU) recorded very high, moderate and low variability [7] for Clay, Sand and Silt, respectively. These results can be attributed to be more of the nature of the parent material than herbicide use. [8], attributed this variation to the nature of parent material on the different sites.

Table1. Soil Physical Properties of Study Area

Site	Pedon	Sand (%)	Silt (%)	Clay (%)	Textural class	BD (Mg/cm ³)	PD (Mg/cm ³)	Porosity (%)	WHC (%)
HU	1	36.03	46.72	17.25	Loam	1.58	2.59	39.12	10.07
	2	42.58	36.17	21.25	Loam	1.59	2.49	35.88	10.08
	3	23.20	39.05	37.75	Clay loam	1.57	2.69	41.25	14.29
	4	40.83	26.92	32.25	Clay loam	1.61	2.69	39.45	9.56
	<i>Mean</i>	<i>35.66</i>	<i>37.22</i>	<i>27.13</i>		<i>1.59</i>	<i>2.62</i>	<i>38.93</i>	<i>11</i>
NHU	1	52.51	31.74	15.75	Loam	1.65	2.77	40.41	9.52
	2	47.61	32.70	19.69	Loam	1.67	2.77	39.51	11.94
	3	33.63	51.12	15.25	Silt loam	1.69	2.81	39.89	9.85
	4	81.28	12.97	5.75	Loamy sand	1.70	2.68	36.42	15.19
	<i>Mean</i>	<i>53.76</i>	<i>32.13</i>	<i>14.11</i>		<i>1.68</i>	<i>2.76</i>	<i>39.06</i>	<i>11.63</i>
	<i>SD</i>	<i>12.80</i>	<i>3.60</i>	<i>9.21</i>		<i>0.06</i>	<i>0.10</i>	<i>0.09</i>	<i>0.45</i>
<i>CV (%)</i>	<i>28.63</i>	<i>10.38</i>	<i>44.67</i>		<i>3.66</i>	<i>3.72</i>	<i>0.23</i>	<i>3.98</i>	

HU= Herbicide Usage, NHU= Non Herbicide Usage PD= Particle density, BD= Bulk density, WHC=Water holding capacity, SD= Standard Deviation, CV= Coefficient of Variation

Table 2. Coefficient of Variability [3]

CV (%)	Rating Scale
<10	Low
10-20	Moderate
20-30	High
>30	Very High

3.1.2 Bulk density

Bulk densities of soils for pedon 1 to 4 for HU range from 1.57-1.61g/cm³ and a mean of 1.59g/cm³ (Table 1), while for NHU bulk density values ranged from 1.65 to 1.70g/cm³, with a mean of 1.68 g/cm³. In sandy soils, dry density can be as high as 1.6g/cm³; in clayey soils and aggregated loams, it can be as low as 1.1g/cm³ [8]. Lower soil bulk density is desirable for plant growth, low bulk density soils have greater water infiltration rates which minimize runoff, improve water quality, and reduce storm water flow. In this particular study, the coefficient of variation in soil bulk density (BD) (Table 1) across the different land uses recorded a low variability (3.66%) [9], this result indicated that herbicide use did not highly influence BD variation.

3.1.3 Particle Density

The particle density of mineral soils has a very limited range, although the density of most soils varies from 2.60g/cm³ to 2.75g/cm³. Particle density of pedon 1 to 4 ranges from 2.49 to 2.69g/cm³, with mean value of 2.62g/cm³, for sites under herbicide usage (HU), while particle density values for NHU across pedon 1 to 4 ranges from 2.68 to 2.81g/cm³, with mean value of 2.76g/cm³ (Table 1). The coefficient of variation for particle density (PD) (Table 1) across the different land uses recorded a low variability (3.72%) [3], this is an indication that herbicide use did not in any way influence the content and distribution of soil particle density.

3.1.4 Porosity

As densities increases, pore space decreases and the amount of air and water held in the soil also decreases. The percentage porosity for HU ranged from 35.88 to 41.25% with a mean of 38.93%, while for NHU, porosity values ranged from 36.42 to 40.41%, with a mean of 39.06% (Table 1). Across the two sites (HU and NHU), the coefficient of variation was found to be low (0.23%) [3], for soil porosity (Table 1). This showed that use of herbicide did not create variability in soil porosity.

3.1.5 Water holding capacity

Water holding capacity of soil influences crop growth, rotting pattern and ability to supply water to crops during dry period. Soils that hold generous amounts of water are less subject to leaching losses of nutrients or soil applied pesticides. This is true because a soil with a limited water holding capacity (i.e., a sandy loam) reaches the saturation point sooner than a soil with a higher water holding capacity (i.e., a clay loam). The data on the water holding capacity of soils in HU indicates that the water holding capacity ranged from 9.56 to 14.29% with a mean value of 11.00%), while for NHU, water holding capacity obtained values ranged from 9.52 to 15.19%, with a mean value of 11.63% (Table 1). The coefficient of variation in water holding capacity (Table 1) across the different land uses recorded a low variability (3.98%) [3], this showed that use of herbicide did not influence variability in soil water holding capacity of the different sites.

3.2 Infiltration Studies

Infiltration rate has been shown to be a deciding factor in the supply of irrigation water, assessment of textural and structural conditions of soils and transmission water characteristics of the sub surface layers of soils [8, 9], [8] further reported that the rate of the process, relative to the rate of water entering the root zone and how much, if any will run off. Infiltration is a pivotal process in potential soil degradation, chemical, and down valley flooding [9]. The data from the double ring infiltration test (Tables 3 and 4) are compared by linear plots (Figs. 2-5) of each site of infiltration test (site 1 to 4) for herbicide Usage (HU) and (Tables 5 and 6 and Figs. 6-9) sites 1 to 4 for non-herbicide Usage (NHU). The initial infiltration rate is low for the entire sites for Herbicide Usage (HU) and Non Herbicide Usage (NHU) ranging from 0.04 to 0.45 cm/hr and 0.11 to 0.75cm/hr, respectively. The low infiltration rate and the variability across the different land uses with NHU sites recording a higher Infiltration rate (IR), may be due to the variation in the porosity of the area. When pore size distribution is skewed toward smaller pore, it results in decrease in infiltration while that skewed toward large pore enable water penetrate, hence the lower water intake in all the site and most especially at the site of non-herbicide Usage (NHU) in table (Tables 5 and 6) may be due to the high bulk densities of the sub soil and loose nature of the subsoil, which is friable and easily dispensable and likely to collapse after the heavy water pounding. The cumulative infiltration can be said to be low in the entire sites for Herbicide Usage (HU) and Non Herbicide Usage (NHU) ranging from 0.15 to 2.80 cm/hr and 0.25 to 4.54cm/hr, respectively. However, great variation exists across the different land uses, as sites under NHU recorded higher CI values when compared to sites under HU (Tables 3, 4 and 5, 6). The higher CI obtained in sites under NHU is due to abundance of ant holes in the area which makes the soil extremely porous [10]. Those ants create abundant of micro pores in holes. Generally steady state for both HU and NHU was attained after 28 to 30mins and 27 to 30mins respectively. Large areas of semi-arid areas are covered by sandy soil which are prone to crusting and compaction leading to more runoff and low water use efficiency [11]. It has been suggested that, tillage can improve the physical and hydro-physical properties of the soils and consequently increase rainwater harvesting and crop yields [12]., Deep tillage in form of subsoiling-ripping (SR) has also been recommended to improve soil hydraulic conditions [13]. It has also been reported that, tillage practices that increase soil surface roughness such as tied ridging and ripping can increase soil water storage and availability to crop because they are able to capture rainfall and increase the time for infiltration to take place resulting in better crop yields [14], [15],

Table 3. Infiltration studies for Herbicide Usage (HU)
Site 1 Site 2

Time (min)	IR (cmh ⁻¹)	CI (cm)	Time (min)	IR (cmh ⁻¹)	CI (cm)
2	0.45	0.45	2	0.15	0.15
2	0.25	0.70	2	0.20	0.35
2	0.35	1.05	2	0.25	0.65
2	0.35	1.40	2	0.15	0.75
2	0.30	1.70	2	0.30	1.05
5	0.18	1.88	5	0.10	1.15
5	0.28	2.16	5	0.10	1.25
10	0.12	2.28	10	0.11	1.36
10	0.08	2.36	10	0.13	1.49
20	0.05	2.41	20	0.09	1.58
30	0.22	2.63	30	0.20	1.78
30	0.04	2.67	30	0.13	1.91
60	0.13	2.80	60	0.11	2.02

At 0.04cm/hr, steady basic infiltration rate was attained after 30 minute which last for 60 minutes in HU site 1.

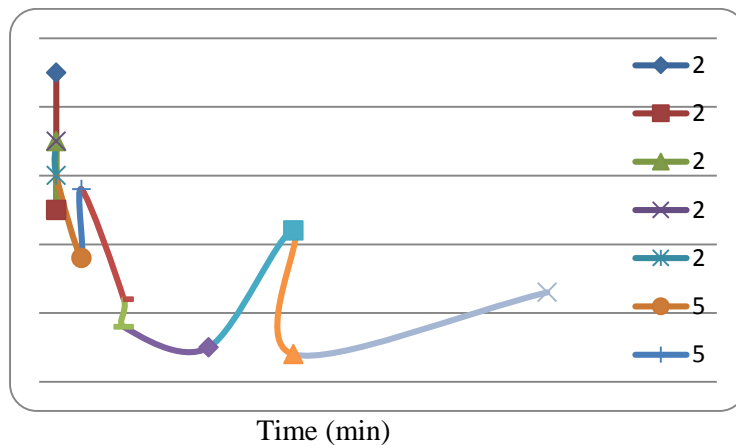


Figure 2. Herbicide Usage Site 1 infiltration rate graph

At 0.13cm/hr, steady basic infiltration rate was attained after 30 minute which lasted for 60 minutes in HU site 2.

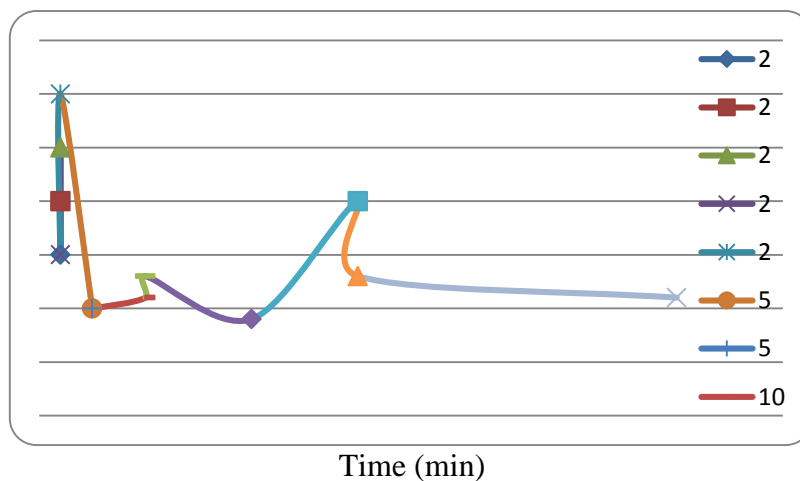


Figure 3. Herbicide Usage site 2 infiltration rate graph

Table 4. Infiltration studies for Herbicide Usage (HU)

Site 3			Site 4		
Time (min)	IR (cmh ⁻¹)	CI (cm)	Time (min)	IR (cmh ⁻¹)	CI (cm)
2	0.30	0.30	2	0.30	0.30
2	0.40	0.70	2	0.20	0.50
2	0.25	0.95	2	0.35	0.85
2	0.20	1.15	2	0.30	1.15
2	0.30	1.45	2	0.20	1.35
5	0.16	1.61	5	0.08	1.43
5	0.14	1.75	5	0.16	1.59
10	0.09	1.84	10	0.13	1.72
10	0.23	2.07	10	0.22	1.94
20	0.16	2.23	20	0.11	2.05
30	0.05	2.28	30	0.13	2.18
30	0.06	2.34	30	0.17	2.35
60	0.26	2.60	60	0.17	2.52

IR= Infiltration Rate; CI=Cumulative Infiltration

At 0.05cm/hr, a steady basic infiltration rate was attained after 30 minute which last for about 60 minute in HU site 3

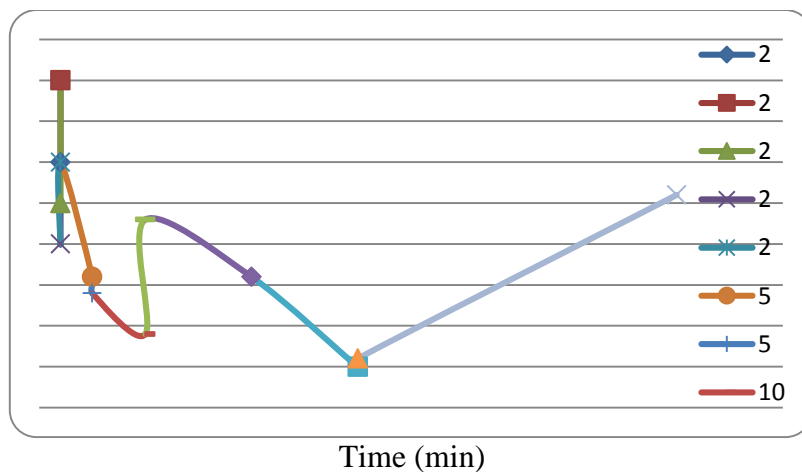


Figure 4. Herbicide Usage site 3 infiltration rate graph

At 0.16cm/hr, a steady basic infiltration rate was attained after 28 minutes which last for 60 minutes in HU site 4

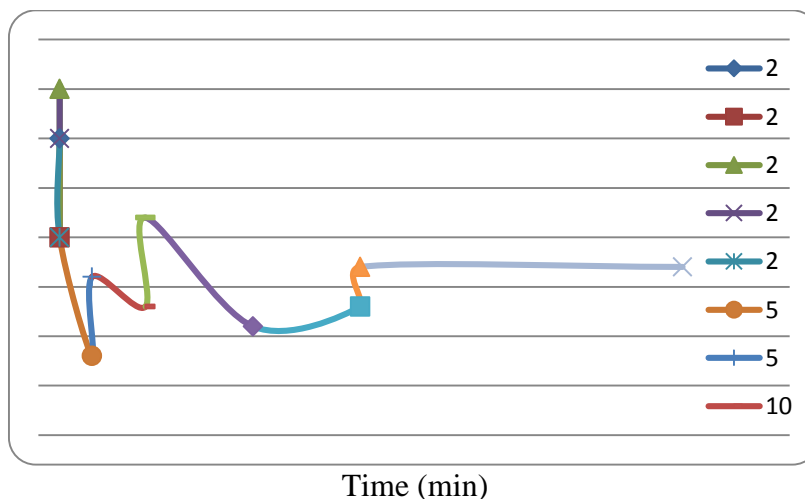


Figure 5. Herbicide Usage site 4 infiltration rate graph

Table 5. infiltration studies for Non Herbicide Usage (NHU)

Site 1			Site 2		
Time (min)	IR (cmh ⁻¹)	CI (cm)	Time (min)	IR (cmh ⁻¹)	CI (cm)
2	0.25	0.25	2	0.35	0.35
2	0.45	0.70	2	0.55	0.90
2	0.35	1.05	2	0.30	1.20
2	0.40	1.45	2	0.40	1.60
2	0.25	1.70	2	0.40	2.00
5	0.14	1.84	5	0.28	2.28
5	0.24	2.08	5	0.26	2.54
10	0.23	2.31	10	0.29	2.83
10	0.19	2.50	10	0.26	3.09
20	0.11	2.61	20	0.30	3.39
30	0.23	2.84	30	0.50	3.89
30	0.29	3.13	30	0.35	4.24
60	0.17	3.30	60	0.30	4.54

IR=Infiltration Rate; CI=Cumulative Infiltration

At 0.29cm/hr, a steady basic infiltration rate was attained after 27 minutes which lasted for 60 minutes in NHU site 1

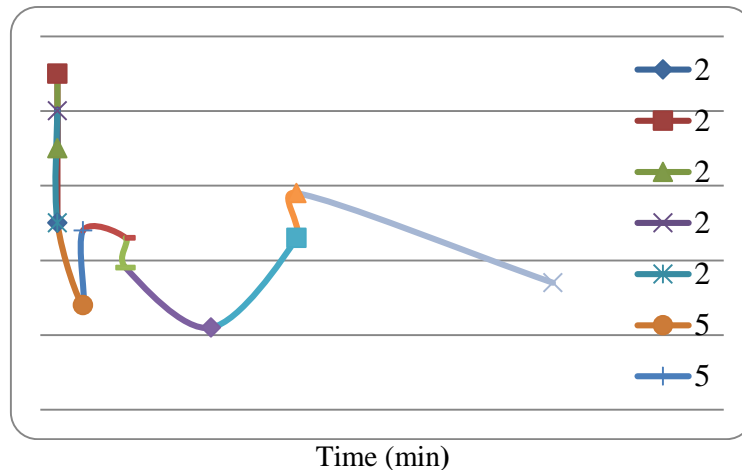


Figure 6. Non Herbicide Usage (NHU) site 1 infiltration rate graph

At 0.35cm/hr, a steady basic infiltration rate was attained after 30 minutes which last for 30 minutes in NHU site 2.

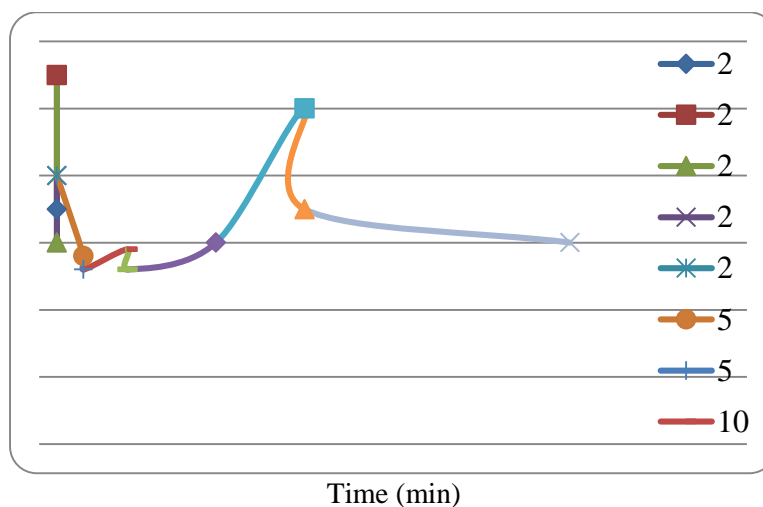


Figure 7. Non Herbicide Usage NHU site 2 infiltration rate graph

Table 6. Infiltration studies for Non Herbicide Usage (NHU)

Site 3			Site 4		
Time (min)	IR (cmh ⁻¹)	CI (cm)	Time (min)	IR (cmh ⁻¹)	CI (cm)
2	0.75	0.75	2	0.25	0.25
2	0.65	1.40	2	0.15	0.40
2	0.45	1.85	2	0.20	0.60
2	0.12	1.97	2	0.30	0.90
2	0.12	2.09	2	0.35	1.25
5	0.25	2.34	5	0.30	1.55
5	0.28	2.62	5	0.22	1.77
10	0.30	2.92	10	0.19	1.96
10	0.30	3.22	10	0.15	2.11
20	0.14	3.36	20	0.19	2.30
30	0.10	3.46	30	0.32	2.62
30	0.13	3.59	30	0.11	2.73
60	0.20	3.79	60	0.28	3.01

IR= Infiltration Rate; CI= Cumulative Infiltration

At 0.13cm/hr, a steady basic infiltration rate was attained after 30 minutes which last for 60 minutes in NHU site 3

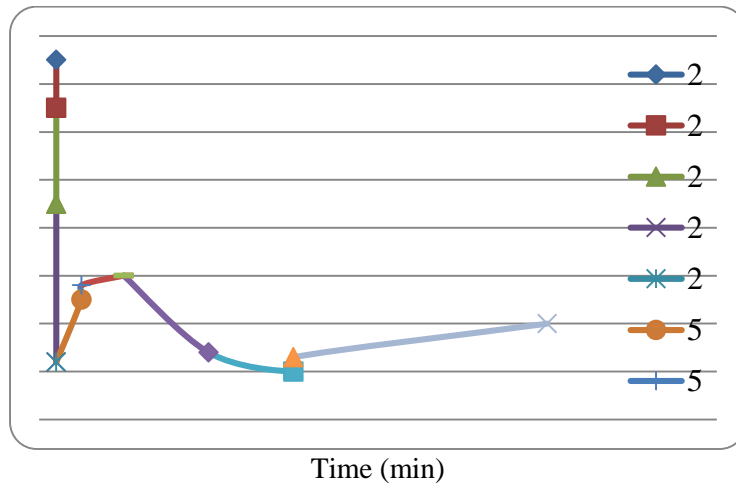


Figure 8. Non Herbicide Usage NHU site 3 infiltration rate graph

At 0.11cm/hr, a steady basic infiltration was attained after 30 minutes which last for 60 minutes in NHU site 4

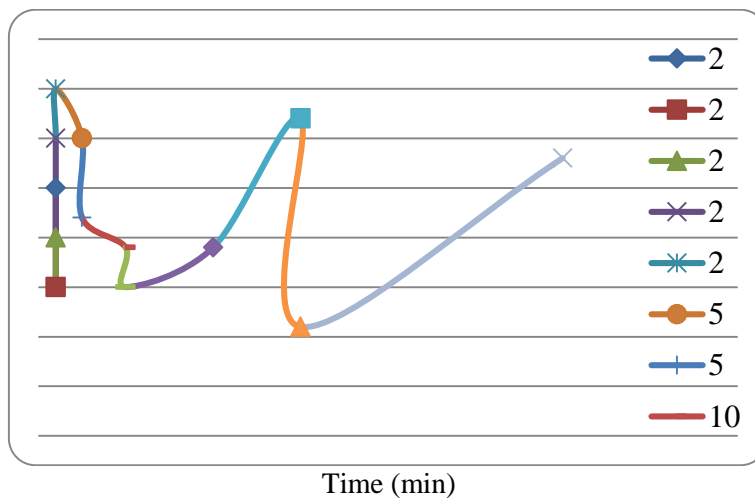


Figure 9. Non Herbicide Usage NHU site 4 infiltration rate graph

4 CONCLUSIONS

The result of particle size analysis showed that mean percentage sand, silt and clay for herbicide usage and non-herbicide usage were 35.66% and 53.76%, 37.22% and 32.13%, 27.13% and 14.11%, respectively. Soil texture was found to be predominantly Loam to Clay loam in texture and silt loam and loamy sand for HU and NHU, respectively. The coefficient of variation for Sand, Silt and Clay across the two sites HU and NHU recorded very high, moderate and low variability. Bulk density, Particle density, Porosity and Water holding capacity recorded CV values of 3.66%, 3.72%, 0.23% and 3.98%, respectively and were general found to be low variability. This is an indication that use of herbicide did not in any way influence variability in the above soil physical properties across the different sites. The results further indicated that the initial infiltration rate and the cumulative infiltration were high in sites under NHU. In line with the above findings it is recommended that although herbicides are important management tools in agriculture because they can be used instead of tillage for weed control, thereby conserving soil and moisture, the current trend in multiple crop rotations and conservation tillage practices allows growers to use a greater variety of herbicides to effectively manage weeds. However, these herbicides have diverse biological, chemical and physical characteristics that may lead to negative effects on soil properties. The indiscriminate use of herbicides has progressively turned out to be a matter of environmental disquiet modifying soil fertility status due to their adverse effects on soil microbial communities, physical and-chemical properties of soil. Their residual impact must be well thought-out for environmental safety despite the vital usefulness in managing weeds. Indiscriminate use of herbicide for the control of weeds should therefore be avoided. Finally, proper and periodic monitoring of the physical and chemical properties of the study area is very necessary, so that appropriate and preventive measures could be embarked upon as at when due, for optimum agricultural productivity.

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