EFFECTS OF FERTILIZER ON SOIL MOISTURE DYNAMICS AS CONDITIONED BY RAINFALL IN A CULTIVATED MAIZE PLOT

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ABSTRACT; The effect of fertilizer application on soil moisture dynamics of cultivated plot was studied under dry and wet condition on Makurdi fluvisol on a cultivated maize plot (100m^2) for period of eight weeks. Moisture content was investigated weekly on ten ridges of bare soil, Non fertilizer treated and a fertilizer treated each (2kg of N.P.K 20:10:10). Moisture content in the treated plot was found to be higher each week compared to that in the untreated plot by 3.11%. Rainfall increases from the first week of the experiment to the last week although recessed at the 3rd and 5th week. The fertilizer treated plot showed significant moisture retention of 3.97 (-3.97>2.36<3.97) at 5% levels and 7 degree of freedom on statistical test of paired comparison of t test. It was recommended that further work should be carried out on herbicides usage to determine if there will be an increase in moisture of the soil with absence of weed growth and alternate planting of maize with other crops should be advised as this may aid in the increase in moisture.

Key words; Soil, Rainfall, Fertilizers, Moisture, Dynamics, Maize Plot

1 INTRODUCTION

Worldwide fertilizer statistics provides a perspective on the role of fertilizers in maintaining a global balance between nutrient input and outflows. It is more specific within a region that tells more definitely whether fertilizer is contributing to soil quality enhancement or to environmental degradation. For example, in Europe where moisture is abundant and intensified cropping is common, fertilizer nutrient application rates are nearly triple the world average. Most fertilizers are inorganic salts containing readily available plant nutrient elements. Some are manufactured, but others, such as phosphorus and potassium are found in natural deposits. The nutrients added by normal application of fertilizers, whether organic or inorganic are incorporated into the complex soil nutrient cycles and relatively little of it winds up in the plant being fertilized during the year of application "[1]" .

Even when fertilizer application greatly increases, both plant growth and nutrient uptake from the fertilizer stimulated cycling of the nutrients and the nutrients ion taken up by the plant come largely from various pools in the soil and not directly from the fertilizer. This knowledge has been obtained by careful analysis from nutrient studies that used fertilizer with isotopically tagged nutrients and results from such a study show that as fertilizer rates increased, the efficiency of fertilizer nutrient used decreases heavily behind in the soil in increasing proportion of added nutrient and moisture "[2]".

In an attempt to study the effect of fertilizer application on soil moisture dynamics of a cultivated maize plot, the need to consider the effect of moisture content on the soil and the soil productivity as it relates to growing period of maize and crop intensity is relevant. The type of soil and its moisture content at different depths and period as well as the type of fertilizer is paramount. Moisture content determination is a routine test for determining the amount of water present in a quantity of soil in terms of its dry weight. Determination of moisture content is the most widely used soil test and it is required as a subsidiary test in many other soil tests.

Fertilizer application to some crops affects their economic value by affecting their quality as well as their yields so that effects on both quality and quantity should be provided for. For example, fertilization may affect both the size and yield of the vegetables crops and since the economic value of some sizes is greater than others, rates have to be estimated to optimize effects on the quality and quantity (yield) of crop product. Such crop (beetroot) that should be sold for canning, fertilizer improves the economic value of the product because the canning industry prefers a particular size, the value of the size.

If soil nutrient deficiencies are severe, programs of fertilizer application can be envisaged for the development of soil fertility and agriculture in which high rates of fertilizer application are used for first crops and progressively lower rates for following crops as soil nutrient levels are increased by the accumulation of residues from the successive application. This can be expected to lead eventually to a soil nutrient level that only needs to be maintained with maintenance rates of fertilizer application to replace the nutrients removed with cropping and to sustain the agriculture and soil fertility of an optimal level “[3]”.

All nutrient ions in a fertilizer applied to a field are taken up by the growing crop and the amount not utilized is very important on the effect of their long term intensive use. Many things happen to these residues in the soil, either they remain in the soil or they may be removed in the water leaching through the soil or running off the surface of the soil or they may be lost to the atmosphere by volatilization “[4]”.

An adequate and balanced supply of moisture is essential for plant growth. Moisture is constantly being taken up by plants together with nutrients and is lost by transpiration. It is estimated that 1kg of dry weight increase in plants requires about 500kg of transpired water. Thus a grain crop yielding 10t/ha will transpire 2000 – 5000 tones of water which are equivalent to 200 – 500mm of rainfall “[5]”. Therefore, a steady supply of water is necessary for growing plants to remain alive. Under certain extreme conditions plants may loose more water than they take up even though they may be adequately supplied in the soil. This condition is known as physiological drought which occurs commonly during the day in very hot climates but the plants recover during the cool of the night. The moisture on soils can be considered in terms of input, retention and losses.

The moisture entering the soil is derived from three main sources, rainfall, melting snow, and irrigation. In humid climates, the input by rainfall or from melting snow is usually adequate, but in arid and semi arid areas an adequate system of agriculture can be sustained only by irrigation which may take many forms.

Moisture retained in the soil will depend upon the amount removed and the speed of removal. Water will collate rapidly through the soil if it is very porous (through being very sandy or because of a well developed structure), thus the retention is likely to be very low. The well textured and organic soils have smaller pore spaces and the particles themselves can absorb moisture, therefore moisture retention is higher and moisture movement is slower. Thus, texture, organic matter content and structure affect the movement and retention of moisture in soils. Generally clays and organic soils have the highest available moisture. Clays retain more water than silts but a higher proportion is strongly held and therefore unavailable to plants. Where water is a limiting factor, moisture conservation can be achieved by mulching, contour ploughing, dry farming and snow traps.

The moisture retained in the soil is lost mainly by evapotranspiration. Therefore, the rate of loss will depend upon temperature and plant cover, as temperature and plant cover increase, moisture loses will also increase. However, only part of the capillary water retained in the soil is available to be taken up by plants which will wilt and die after the available moisture has been exhausted. It is probably correct to say that on the world scale, water is the main limiting factor to plant growth for even in humid areas. Supplementary irrigation in most years can accomplish a substantial increase in crop production. In many semi arid areas where irrigation is not possible, various methods of moisture conservation have to be practiced. Thus, for sustained agriculture, water management is an essential requirement. Generally, the farmer has no control over the rainfall but management can reduce deficiency or excess. In arid and semi arid areas dry farming is being practiced. It is a method of farming without irrigation practices; the land is being treated so as to conserve moisture. This technique consist of cultivating a given area in alternate years, allowing moisture to be stored in the fallow year. Moisture losses are reduced by producing mulch and removing weeds.

Water is of vital importance in the ecological functioning of soils. The presence of water in soils is essential for the survival and growth of plants and other soil organisms. The soil moisture regimes often reflect as a major determinant of the productivity of terrestrial ecosystems including agricultural systems “[6]”. Movement of water and substance dissolved in it, through the soil profile is of great consequences to the quality and quantity of local and regional water resources. Water moving through the regolith is also a major driving force in soil formation.

When soil moisture content is optimum for plant growth, the water in the large and intermediate – sized pores can move in the soil and can be used by plants. As some of the moisture is removed by the growing plants, however, that which remains in the tiny pores and in thin films around soil particles, the soil solid strongly attract this soil water and consequently competes with plant roots for it. Thus, not all soil water is available to plants. Depending on the soil, one – fourth or two – thirds of the moisture remains in the soil after the plants have wilted or died for lack of water.

The main objective of this work is to determine the effect of inorganic fertilizer on the soil moisture dynamics/characteristics and to determine whether the soil moisture content differs with the planting of maize and also the sustainability of the soil moisture using fertilizer.

2 MATERIALS AND METHOD

2.1 Site Selection

A flat well drained /moderately textured sandy loam was preferred, shackles and water logged field were avoided. Land ($100m^2$) was cleared properly ahead of the rains and ridges (10m long) were made at a spacing of 75cm between ridges following the agronomic factor for maize production on minimum tillage depth of 30cm. A total of 21 ridges were made and grouped into three, 7 ridges (no plant), another 7 plated without fertilizer application and the last group planted and fertilized. Planting was carried out in May on the land as it is best to plant after 2 – 3 consecutive rains to ensure good seed germination and plant establishment. Planting was carried out on average of three seed per hole on planting depth of 5cm. 2kg of fertilizer (N: P: K 20:10:10) was applied 3 weeks after planting in August,

2.2 Sample Collection and Analysis

Three soil samples used for this study were collected from a cultivated maize plot at every weak after crop emergence. These will guide to an extent the variation that exists between the bare plot (A), untreated plot (B) and fertilizer treated plot (C). Plot B and C had maize crops undergoing activities like evapotranspiration.

Plate1; Untreated plot

Plate2; Treated plot

The mass of the containers and wet soil was recorded in moisture content determination tables. The samples were dried at a constant temperature in the oven (105^OC) for a period of 24hours until all moisture was removed and placed in a desicator to cool without absorbing moisture from the surroundings. The weights of dried sample were taken using an electronic weighing balance and results were recorded.

The moisture content of a soil mass can be defined as a ratio (usually expressed as a percentage) of the mass of moisture present in the soil to the mass of dry soil present.

$$M = \frac{M_w}{M_d} X 100\% ---------- (1)$$

Where: M_w = Mass of moisture present in the soil

M_d = Mass of dry soil present

The same procedure was used to determine the average weekly moisture contents of the treated plots and the untreated plots for the remaining growth period of the maize crops up to week eight and the results presented in table 2

2.3 Rainfall data

The main source of moisture impute into the experimental plots is by precipitation. Data on amount of rainfall for the study period were obtained from the meteorological unit of Nigerian Air Force Base Makurdi.

This research is a field experiment carried out in pairs for sake of comparing two different techniques. We are more interested in the difference between treated plot and the untreated plot rather the variation assigned to a particular plot. A comparative experimental design and analysis of student t- test was used to compare the effect of fertilizer treatment on moisture since there are not more than two treatment "[7]". The null hypothesis and the alternative hypotheses are stated as;

A. H_0; M*ct* = M*cut*(for all n), and that each pair of means are equal, any difference may have arisen by chance (or there is no significant difference in moisture content between the treated and the untreated plot)

B. H_1; Mct ≠ M*cut* (for all n) and there is significant difference between the treated plot and untreated plot

3 RESULT AND DISCUSSION

Trends in moisture content with time for the three plots are as presented in fig 1. The trend is showing a gradual increase in moisture content with time for bare plot as

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rainfall event were increasing , this could be as the result of the soil particle absorbing the water molecules marking the unset of rain. The untreated plot shows trends of moisture with a gradual drop up to week 3 with a recess in week 5 indicating the activities of crop development (flowering and cob formation) that requires more moisture withdrawal from the soil. The treated plot however assumed almost uniform moisture for the growth period indicating check and balance between plant uptake evapotranspiration and precipitation.

Table1 shows that average moisture content for treated and untreated plot were 21.16% and 24.27% respectively. The major input of the water into the soil was through precipitation and the output of water from the soil was through evaporation. An appreciable difference in average moisture content of 3.11% exists between the treated and untreated plot (Table 1). Higher moisture content in treated plot as compared with that of the untreated plot could be attributed to the performance of the fertilizer in moisture retention as against the evapotranspiration and subsequent removal of water by crops since equal amounts of rainfall conditioned the two plots.

Table 1: Moisture Content (%) of Research Plots

Time (week).	Rainfall (mm)	Moisture Content (%)		
		A	B	C
1	28.2	20.21	20.21	26.98
2	27.3	19.58	19.28	24.78
3	21.2	19.18	20.31	23.67
4	25.6	20.65	22.74	24.17
5	56.1	18.58	19.34	23.04
6	45.2	22.49	23.04	24.34
7	83.6	18.92	20.79	23.01
8	86.7	21.86	23.54	24.14
Mean			21.16	24.27

The total weekly rainfall distribution of the period under review is as given in table 2 The relationship between rainfall and moisture content for treated and untreated plots was physically appreciated by the chart presented in figure 2. Physical appreciation of the trend indicated high rainfall except for the week 4 with corresponding rise in moisture as a result of the soil particle retaining water within their lattices. It was observed that soil water storage depended largely upon the texture of the soil as good soil structure helps absorb water and leads the moisture to be evenly distributed through the soil.

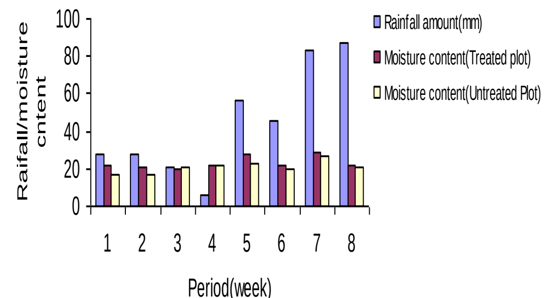

Fig 2; Raifall and Moisture content bar chart

High variation existed in the rainfall amount between week 5 and 8 as the moisture content do not show corresponding rise, this is as an indication that at saturation of soil not all rainfall translate into soil moisture as part of it were lost as runoff and some even intercepted by crop vegetations and lost by evapotranspiration. The Makurdi Fluvisol is also known to be well drained and had the tendency to loss excess water by deeperculation.

The t test of paired comparisons for field experiment on eight weeks which are independent observations from moisture content for treated and untreated plots with means Mct and Mcut respectively is presented in table 2. For 5% level of significant and seven degree of freedom, we obtain $t_{0.025,\ 7}$ = 2.36, but the computed t- value of 3.9789 is greater than 2.36, we conclude that there is a significant difference between the moisture content of the fertilizer treated plot and that of the untreated plot at 5% Level of significance and 7 degree of freedom thus rejecting the null hypotheses.

Table 2: Student t- test for treated and untreated Mean Moisture Content (%)

Days	Treated plot	Untreated plot	Difference	$d_i - \bar{d}$	$(d_i - \bar{d})^2$
	Mct	Mcut	di = Mct – Mcut		
1	26.96	20.21	6.75	3.77	14.2149
2	24.78	19.28	5.50	2.54	6.4516
3	23.26	20.31	2.95	-0.18	0.144

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4	24.17	22.74	1.73	-1.28	1.6384
5	22.04	19.34	2.70	-0.28	0.0784
6	24.34	23.04	1.30	-1.68	2.8224
7	23.01	20.79	2.22	-0.76	0.5776
8	24.14	23.54	0.66	-2.32	5.3824
			$\sum$ 23.8		$\sum$ 31.3097

$$\bar{d} = \frac{\sum di}{n} = \frac{23.8}{8} = 2.975 \qquad s_d^2 = \frac{\sum (d_i - \bar{d})^2}{n-1} = \frac{31.3097}{7} = 4.4728 \qquad s_d = \sqrt{4.4728} = 2.1149$$

$$t = \frac{\bar{d}}{s_d / \sqrt{n}} = \frac{2.975}{2.1149 / \sqrt{8}} = 3.9789$$

Table1 shows that average moisture content for treated and untreated plot were 16.04 and 20.10% respectively. The major input of the water into the soil was through precipitation and the output of water from the soil was through evaporation. An appreciable difference in average moisture content of 3.11% exists between the treated and untreated plot (Table 1). Higher moisture content in treated plot as compared with that of the untreated plot could be attributed to the performance of the fertilizer in moisture retention as against the evapotranspiration and subsequent removal of water by crops since equal amounts of rainfall conditioned the two plots.

4 Conclusion

It is quite obvious from this study that application of inorganic fertilizer to some extent improves the soil condition hence increasing the water holding capacity (moisture). Applying the required amount of fertilizer at the right time will go a long way in improving the performance of the soils. Farmers are advised to adopt the agronomy of their crops and understand the nature of the soil before applying the fertilizer.

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