Effect of Seasonal Rainfall Variability on Soil Hydraulic Properties and Adaptation Strategies Employed by Small-Scale Farmers for Sustainable Management and Productivity

[1]Abdulqadir Abubakar Sadiq, [2]Salamatu Ali Shuwa, [3]Ibrahim Abubakar Tukur and [4]Idris Sani Abubakar
[1, 2 & 3]Department of Agricultural Technology, Adamawa State Polytechnic, Yola Nigeria
[4]Department of Soil Science, Federal University, Kashere Gombe State Nigeria.
Author's Corresponding Email: sadiqhsadiq6@gmail.com

D.O.I: 10.56201/ijgem.v10.no2.2024.pg1.14

Abstract
The present research work aimed to determine the effect of seasonal rainfall variability on soil hydraulic properties and adaptation strategies employed by the small scale farmers for sustainable management and productivity in Mubi North LGA, of Adamawa State. Three (3) farmlands were e selected in the area namely Mayo-Bani, Digil and Muchala where Ten (10) soil auger points were collected using random sampling method at the depth of 0-30 cm and 30-60 cm during the Beginning, Middle and End of rainy seasons making the total of Sixty (60) soil samples in each location totaling to One Hundred and Eighty (180) soil samples respectively. Standard laboratory procedures were adopted in analyzing the soil data. Similarly, fifty (50 participatory farmers were randomly selected in each location totaling to One hundred and fifty (150) sample population where well-defined and structured questionnaires were administered to them on the adaptation strategic techniques employed towards soil and water conservation in the area. Analysis of Variance (ANOVA) was used to find out the variation of soil hydraulic properties as influence by rainfall variability while for the questionnaires descriptive statistics was used respectively. The results revealed that the sandy loam textured soils dominated the area with very low to high TP (10.9-56.22 %), low high Bd (1.23-1.9 g/cm^3). The moisture variation at beginning, middle and end of the season where as follows WCH (20.17-39.15 %, 24.16-52.16 % and 28.19-93.16 %), FC (8.09-31.16%, 6.8-26.19 % and 17.12-55.12 %), PWP (3.23-6.72 %, 5.27-10.47 % and 6.84-22.04 %) and PAW (4.86-10.08 %, 7.9-15.71 % and 10.28-33.08 %). In addition, there are significant differences among all the three phases of the season (Beginning, Middle and End) with P-value of 0.01as influenced by seasonal variation. Contour bed construction (34 %), tillage practices (24 %) and mulching (12 %) were among the most soil moisture conservation practices adopted by the farmers in the area. Therefore the use of low water potential crops and early maturing varieties should be adopted by the farmers in the area towards adapting the low moisture statuses of the soils for sustainable production.

Keywords: *Hydraulic Properties, Rainfall Variability, Soil, Sustainable*

INTRODUCTION

Soil is highly sensitive to climate change considering it processes of formation (pedogenisis) and development. There is strong relationship between the climate and the soil. Climate generally influences soil formation, development and quality. Climate change has potential impacts on soil health including supply of organic matter from biomass, soil temperature regime, soil hydrology, and salinity (Mondal, 2021). Climate change affects the environment, including soil (Brevik 2012). Thus, climate change is the most fundamental environmental factor affecting the soil quality and its productivity of an ecosystem. It has the potential to threaten global food security through its effects on soil properties and processes (Brevik 2013), since global demands for food and fiber for an increasing population are met by the soil (Mondal, 2021). Climate change might exacerbate land degradation through alteration of spatial and temporal patterns in temperature, rainfall, solar radiation, and winds (World Meteorological Organization, 2005).

Climate change may change the types, frequencies and intensities of various crops and livestock pests, also the availability and timing of irrigation water supplies and the severity of soil erosion (Nzeh *et al.*, 2016). Evidence has shown that climate change has already affecting crop yields in many countries (IPCC, 2007; BNRCC, 2008), which might be attributed to changes that might have cause in the inherent quality of the soil This is particularly true in low-income countries, where climate is the primary determinant of agricultural productivity and adaptive capacities are low (Spore, 2008). Global warming causes unpredictable and extreme weather events impact and in-creasingly affect crop growth, availability of soil water, forest fires, soil erosion, droughts, floods, sea level rises with prevalent infection of diseases and pest infestations (Adejuwon, 2004; Zoellick and Robert 2009; Bello, *et al.*, 2012). These environ mental problems result to low and unpredictable crop yields, which invariably make farmers more vulnerable, especially in Africa (Ziervogel *et al.*, 2006; UNFCCC, 2007).

In Nigeria is experiencing adverse climate conditions with negative impacts on the welfare of millions of people Adejuwon, (2004). Available evidences showed that Nigeria is already being plagued with diverse ecological problems which have been directly linked to the on-going climate change (Adefolalu, 2007; Ikhile, 2007). Further, all these effects will be highly region specific, depending on the magnitude of the climate change, soil properties and climatic conditions (Pareek, 2017). Similarly, Nigeria is currently experiencing increasing incidence of disease, declining agricultural productivity, increasing number of heat waves, unreliable weather patterns, declining rainfall in already desertprone area (Nzeh *et al*., 2016). It causes drastic changes in rainfall patterns with rising temperatures which introduces unfavourable growing conditions; it modifies growing seasons which could subsequently reduce productivity (Nzeh *et al.*, 2016). Thus, for many poor countries like Nigeria that are highly vulnerable to effects of climate change, understanding farmers' responses to climatic variation is crucial, as this will help in designing appropriate coping strategies (Apata, 2020) Generally, Studies on the impact of climate change (particularly rainfall and temperature) and climate related adaptation measures on soil quality are very scanty. Thus, this research saddled to determine the effect of climate change on soil quality and the adaptation strategies employed by the small-scale farmers for sustainable management and productivity.

STATEMENT OF THE PROBLEM

Kumar and Das (2014) stated that there is overwhelming evidence which points the consequences of climate change in land degradation. Understanding of the consequence and their effects are urgently required to know how climate and soils interact and to understand changes in soil due to change in climate. It is a known fact that climate is one of the factors affecting soil formation which also influences its nutrients availability and variability within the soil horizon. Seasonal variation of climatic variables most importantly temperature and rainfall are considered to have direct effects on soil quality than the other variables. Mubi North LGA, is characterized with seasonal acute changes of precipitation which lead to decline in quality and productivity of soils in the area. These climatic changes are expected to modify soil physical parameters (texture, structure, bulk density, porosity), chemical properties (soil pH, salinity, cation exchange capacity, nutrient cycle) soil fertility, nutrient and water availability. Adapted strategies are employed to mitigate such problem by some of the small scale farmers in the area. It is therefore, highly imperative to study and understand the effects of rainfall variability on soil hydraulic properties and to assess coping strategies adopted for sustainable farming in the area. Thus, it is based on this threat that this research work aimed to determine the effect of rainfall variability on soil hydraulic properties and adaptation strategies employed by the small scale farmers for sustainable management and productivity

RESEARCH METHODOLOGY

The Study Area

Mubi lies between latitudes 9°30' and 11^0 north of the equator and longitudes 13° and 13°45' east of the Greenwich Meridian at an altitude of 696 m above sea level. It is situated in the northern savannah ecological zone of Nigeria. It has a land area of 4,728.77 km^2 and a population of 759,045 in 2003 (Adebayo, 2004). The climate of the study area is characterized by alternating dry (November to March) and wet (April to October) seasons. The mean annual rainfall ranges from 700 mm to 1,050 mm. The seasonal maximum temperature of 37.0°C occurs in April and minimum of 12.7°C in January. Maximum relative humidity is 90% and minimum is 50% (Adebayo, 2004). The vegetation is a typically Sudan savannah type, which implies grassland interposed by shrubs and few trees mostly acacia (*Acacia albida*), locust-beans (*Parkia biglobosa*) and Eucalyptus trees (*Eucalyptus spp*) among others (Adebayo, 2004).

The soils of the study area fall under the category of lithosols following the guidelines of FAO/UNESCO soil classification, characterised by rock-basements within shallow depths from the soil surface and orchard-type vegetation due to its limitation in inherent fertility with undifferentiated basement complex parent material represented by magmatite-gneisses, schists, quartzites, pegmatite, diorite and amphibolites (Nwaka, *et al.*, 1999 and Adebayo, 2004).

Method of data collection

Three (3) areas with intensive agricultural activities were selected namely Mayo-Bani, Digil and Muchala in the study area. In each of the location Ten (10) soil auger points were made using auger method at the soil depth of 0-30 cm and 30-60 cm making the total of Twenty (20) soil samples in each location which were collected in three (3) replicated times based on the seasonal variations (table 1) making a total of Sixty (60) soil samples using systematic random sampling method respectively. The total soil samples were collected for the research were One Hundred and Eighty (180) which were packed in a polythene bags were well labeled and were taken to the laboratory for analysis. Period for the samples collection in relation to rainfall variability are depicted on Table 1 below. The collected soil samples were air dried, grinded and sieve in 2 mm sieve for the analysis of related soil physical and hydraulic properties using standard laboratory procedures.

Table 1. Farm locations and period for the soil samples collection in relation to seasonal rainfall variability

Replicate sampling	**Time for sampling**	**Description of season**	**Mayobani**	**Digil**	**Muchala**
First sampling	May-June	Beginning of wet season	20	20	20
Second sampling	August-September	Middle of wet season	20	20	20
Third sampling	October-November	End of wet season	20	20	20
		Total sample at each location	**60**	**60**	**60**
			Grand total Samples = 180		

Laboratory Analysis of the soil Samples

Determination of Soil physical Properties of the selected farmlands

The following were some of the important selected soil physical properties determined for the purpose of this study;

Particle size distribution

Particle size distribution was determined using Bouyocous Hydrometer Method (Jaswal, 2003). The textural class of the soil was then determined using Marshal's textural triangle.

Bulk density

The soil bulk density was determined by Dumitru *et al.,* (2009).

Total porosity (TP)

Total porosity was calculated according to the following formula (Dumitru *et al.*, 2009):TP = 100 (1- Bd/Pd) where Bd is bulk density (g/cm^3) and Pd is particle density (g/cm^3).

Available porosity (AP)

An indicator used to evaluate the proportion of pores occupied by air is AP (%,), considering soil water content at field water capacity (County Soil Survey Office of Braila, 2018). It was calculated using the formula: AP = TP-FWC/BD, where TP is total porosity (%), FWC is field water capacity (%), BD is bulk density (g/cm^3).

Determination of Soil Hydraulic Properties

The following were some of the important selected soil hydraulic properties determined for the purpose of this study;

Soil hydro-physical parameters related to vegetation water needs and its accessibility for plants were estimated using the formulas below (Dumitru *et al.*, 2009; Dumitru *et al.*, 2011). The following equations were used:

Water holding capacity (WHC) and field capacity (FC)

The Water Holding Capacity (WHC) and Field Capacity (FC) were determined from the soil core samples as describe by Zhang *et al.*, (1999) and Haiqiang, *et al.*,(2019)

Permanent wilting point (PWP)

Permanent wilting point (PWP %) was estimated using the formular
PWP= ½.5 X FC. Since depth of water in root zone at FC is 2.5 times that of PWP (Uttar Pradesh Public Service Commission, UPPSC-AE, 2004).

Plant available water (PAW)

Plant available water (PAW %) was determined using the formular
PAW = FC-PWP (Dumitru *et al.*, 2011). Where FC = Field Capacity and PWP = Permanent Wilting Point.

STATISTICAL ANALYSIS

The soil data were subjected to descriptive analysis and Analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Soil Physical properties of the study area

Soil properties that might have direct effects on soil hydraulic properties are presented on Table 2 and discussed as follows;

Soil texture

The physical properties of the area were shown on Table 2. The textural class of the soil was found to be sandy loam at Mayo-Bani having values of sand 64.12%, clay 21.3 % and Silt 14.61 % at the upper horizon(0-15 cm)while at the sub-surface (20-30 cm) the sand, clay and silt proportions were 62.39 %, 20.52 % and 16.33 % respectively. Similar trend was observed at Muchala where the sand, silt and clay percent at the surface layer was 67.60 %, 16.2 % and 16.2 % while at the sub-surface layer there was increased in the proportions of the soil textures with the corresponding values of 70.00 %, 17.8 % and 18.2 % respectively. It could be observed that the percent of sand and clay decreases with increasing depth. In contrast, loam soil was found to have dominated Digil area with mean values of sand 46.61 %, silt 17.53 % and clay 26.66 % at the surface (0-15 cm). Meanwhile, at the subsurface 54.75 % sand, 22.41 % silt and 22.44 % clay were recorded accordingly.

Bulk Density

The bulk density of the soil ranges from 1.65 g/cm^3 -1.92 g/cm^3 at Mayo Bani, 1.55 g/cm^3 -1.90 g/cm^3 at Digil which could be as considered as medium to high while at Muchala was found to range from low to high (1.23 g/cm^3 - 1.80 g/cm^3) respectively. It could be explained that the high bulk density of the soil at the upper layer (Mujilu and Duvu) could be connected to the agronomic activities such as intensive tillage practices using tractors which tends to increase the compaction of the soil thereby reducing the porosity and infiltration which consequently leads to erosion formation and development. Thus, this assertions concords with the findings of Azooz and Arshad, (1996) who explained that tilled soils under continuous cultivation tend to become less porous and more dense with time in the plow layer. In addition, the particle density was generally moderate in all the study areas having a range values of 2.1 g/cm^3 -3.00 g/cm^3 , 2.12 g/cm^3 - 3.10 g/cm^3 and 2.12 g/cm^3 - 2.81 g/cm^3 at Mayo-Bani, Digil and Muchala areas correspondingly.

Total Porosity

The total porosity of the soil was very low to low at Mayo-Bani ranges from 10.9 % -39.52 %, while at Digil was very low to medium pore spaces (15.56 %-48.28 %) of loamy textured soil and very low to very high (23.25 %-56.22 %) was observed at Muchala respectively. Similarly, extremely low to medium available porosity was recorded at Mayo bani, while at Digil extremely low to medium and very low to very high was found at Muchala with corresponding values ranges of 1.31 %- 16.32 %, 3.09 %-19.65 % and 7.35 % -36.71 %. These variations of total porosity could be attributed to the bulk density of the soil. It is known fact that total porosity is considered to be the product of bulk density. For any given soil, the higher the bulk densities, the more compacted the soil is and the lower the pore space (Anne *et al.,* 2015) as also observed in this study. Generally, the total porosity of the soil suggest the presence of adequate aeration coupled with high water retention which ease root penetration of plants, continuous nutrient supply , improve infiltration rate and reduce high run-off thereby subjecting the area to low erosion and degradation processes. This is because most tropical soils have low inherent fertility (Sanchez, 1976) and several soil related constraints to sustained intensive cropping such as nutrient imbalances, compaction and soil erosion.

Table 2. Shows the Soil Physical Properties of the study area

Sample	Sand (%)	Clay (%)	Silt (%)	Bulk Density (g/cm ^{3})	Particle density (g/cm^3)	Total Porosity (%)	Available Porosity (%)
Mayo-Bani							
0 – 15 cm	64.12	21.3	14.61	1.77	2.68	33.11	12.15
15 – 30 cm	62.39	20.52	16.33	1.86	2.64	28.04	8.75
Min – Max	58.65 – 67.30	15.5 – 26.89	9.07 – 19.5	1.65 – 1.92	2.1 – 3.00	10.9 – 39.52	1.31 – 16.32
S.E+	0.29	0.40	0.36	0.01	0.04	1.02	0.52
C.V %	4.610	19.243	23.293	4.670	14.092	33.328	50.194
Digil							
0 – 15 cm	46.61	26.66	17.53	1.76	2.39	25.83	8.23
15 – 30 cm	54.75	22.44	22.41	1.73	2.67	41.03	15.55
Min – Max	5.35 – 65.50	13.2 – 35.15	2.5 – 31.60	1.55 – 1.90	2.12 – 3.10	15.56 – 48.28	3.09 – 19.65
S.E+	1.75	0.69	0.88	0.01	0.03	1.02	0.51
C.V %	34.581	28.081	44.261	6.303	10.415	29.995	43.237

Muchala							
0 – 15 cm	67.60	16.2	16.2	1.49	2.72	42.13	20.45
15 – 30 cm	70.00	18.2	17.8	1.49	2.41	37.81	17.98
Min – Max	52 – 89	12 – 24	6 – 25	1.23 – 1.8	2.12 – 2.81	23.25 – 56.22	7.35 – 36.71
S.E+	0.93	0.36	0.63	0.02	0.03	1.04	1.01
C.V %	13.476	20.837	36.892	13.891	10.338	25.934	52.420

Seasonal Effect of Rainfall on Hydraulic Properties of the Studied Soils

Water Holding Capacity (WHC)

Results on the seasonal effects of rainfall on hydraulic properties were presented on table 3. The results shows that at the beginning of rainy season (May-June) the water holding capacity (WHC) was low to moderate (20.17-39.15 %), while at the middle season (July-August) the WCH varied from low to high (24.16-52.16 %) and at the end of the rainy season (September-October) was low to extremely high respectively. It could be noted that in all the three phases of the rainy season the WHC content increases with depth which could be attributed to increases in the amount of precipitation coupled with the transportation of fine soil particles from topsoils to deep soils through soil macropores, particularly in arable lands. (Su *et al.*, 2010; Hishe *et al.*, 2017). Generally, there was significant difference (P= 0.01) among all the three phases season with the WHC content of the soil. This clearly described the impact of increased rainfall on soil moisture content as the season moved from May to October. Thus, soil water content governs the transport characteristics of water and solutes in soils (Fereshte *et al.*, 2016).

The Water at Field Capacity (FC)

Field capacity is the amount of water held in the soil after excess gravitational water has drained away and after the rate of downward movement has materially decreased. The water at field capacity (FC) during the beginning and middle of the rainy season was low at surface and sub-surface layers with mean values of 11.93 % and 14.30 %, and 15.70 % and 18.94 % respectively. These results revealed poor moisture characteristics of the soils that will insufficiently support effective crop growth and development in the area. By implication, the effective growth and development of crops will be achieved through supplementation of water (irrigation). This could be attributed to the antecedent moisture conditions of the sandy loam textured soils of the study area. Moraru *et al.*, (2020) have highlighted that soils with coarse textures (sandy loam) have a reduced field water capacity while soils with fine textures (clay loam, clay) may store a larger amount of water. However, sandy loam soils are considered wet, but unable to provide plants with the water they need. However, it could be noted the water content at FC increases with increasing depth in all the farm locations. In contrast, at the end of the rainy season (September-October) the FC content was high at surface layer (29.13 %) and sub-surface (33.75 %) layer. The FC content was sufficient to support the crop growth and development at the end of the season. The water at field capacity (FC) shows significance difference among all the phases of the season with P-value of 0.02. This might be affiliated to increase in antecedent moisture conditions and wetting depth of the soil. This further explains that crop performance in the area might not be affected through insufficient moisture content of the soil in the area.

Permanent Wilting Point (PWP)

Permanent wilting point is defined as the water content at which the leaves of a growing plant reach a stage of wilting from which they do not recover. Different plants have different values of soil water suction at wilting point. Furthermore, at the beginning of the rainy season the permanent wilting point (PWP) of the soil was vary from very low to low (3.23-6.72 %), meanwhile at middle season shows low to medium content (5.27-10.47 %) and low to very high was observed at the end of the season. This result revealed that the content of PWP at the beginning and middle seasons shows susceptibility of wilting and drying of crops due to low moisture content of the soil. Therefore, the PWP of the soil of these periods could be improving through irrigation to supplement the moisture content. There was significance difference of PWP among all the phases of the season with P- value of 0.01.

Plant Available Water (PAW)

Plant Available Water (PAW) is the amount of water that can theoretically be extracted by plants it Plant growth is largely governed by the available water capacity of the soil, which is the difference between the soil moisture held at field capacity and wilting point is the amount of water contents at the field capacity and permanent wilting point respectively (Grewal, *et al.*, 1990). The plant available water (PAW) content of the soil was generally low at the beginning of the rainy season with mean value of 6.98 % at 0-15 cm and 7.90 % at 15-30 cm. The plant growth at this stage will be very slow due to insufficient available water which could be linked to low precipitation coupled with low initial water content of the soil. Moreover, the compaction rate of the studied soils caused by overgrazing and intensive tillage might be attributed to decrease in soil porosity which may affect the distribution and content of soil moisture. Sands *et al.*, (1979) hypothesized that compaction-caused reductions in total porosity may result in little change in moisture retention, and therefore plant growth proceeds relatively unaffected until root growth is inhibited. In contrast, during the middle rainy season (July-August) the PAW was moderate at the surface and sub-surface layers (9.83 % and 11.36 %) which could be connected to the increase in precipitation amount with the increased initial water content of the soil. Moreover, very high (17.48 % at Surface and 19.845 % sub-surface) PAW was recorded at the end of the rainy season (September –October) due to high amount of rainfall experienced in the period coupled with saturated soil spores with water. Plant growth and development will be effective with no supplementary requirement in the area. There was significance difference of PAW among all the phases of the season with P- value of 0.01.

Table 3. Shows the effects of seasonal rainfall on the hydraulic properties of the studied soil

Depth (Cm)	WHC (%)	FC (%)	PWP (%)	PAW (%)
Beginning of Season	(%)	(%)	(%)	(%)
0 – 15 cm	28.65	11.93	4.77	6.98
15 – 30 cm	31.08	14.30	5.24	7.90
Min – Max	20.17 - 39.15	8.09 - 31.16	3.23 - 6.72	4.86 - 10.08
S.E+	0.17	0.13	0.03	0.04
C.V %	17.530	30.172	16.139	17.148
Middle of Season				
0 – 15 cm	35.43	15.70	6.55	9.83
15 – 30 cm	40.54	18.94	7.57	11.36
Min – Max	24.16 - 52.16	6.8 - 26.19	5.27 - 10.47	7.9 - 15.71
S.E+	0.21	0.13	0.04	0.07
C.V %	16.738	21.984	18.417	18.405
End of Season				
0 – 15 cm	56.42	29.13	11.66	17.48
15 – 30 cm	61.03	33.75	12.96	19.45
Min – Max	28.19 - 93.16	17.12 - 55.12	6.844 - 22.04	10.28 - 33.08
S.E+	0.69	0.37	0.15	0.22
C.V %	35.383	35.300	35.467	35.438
P – value	0.01*	0.02*	0.01*	0.01*

WHC: Water Holding Capacity, **FC**: Field Capacity, **PWP**: Permanent Wilting Point, **PAW**: Plant Available Water

Soil Moisture Conservation Practices Adopted by the Farmers in the Study Area

Results on the adopted soil moisture conservation practices by the farmers in the study area were presented on Table 4. The results revealed that bed co contour bed construction is the most adopted (34 %) soil conservation practices by the farmers in the area. This practice consists of plowing the land and dividing it in to beds with contour bunds so that it can retain water. Contour bunds are small bunds usually of 20 - 45 cm high and built along a contour with the aim of catching and retaining the runoff water to infiltrate slowly into the soil. Similar report of Sadiq and Tekwa (2022) revealed that the method is among the most effective techniques employed by the peasant farmers in the study area which they used to improve the soil moisture status. In addition, a tillage practice was perceived as the second most (28 %) adopted soil moisture conservation techniques employed by the farmers in the area. The purpose of tillage is to create a soil environment favorable for plant growth through creating improves moisture condition of the soil. Mulching practices was perceived by 12 % of the responded to have adopted in the area. Mulching involves the use of organic or artificial materials to cover the soil, when crops have been planted. Mulching is known to have played vital role in the soil conservation and maintenance of soil fertility reduction such as reducing the rate of soil water evaporation, reduced impact of solar energy (temperature moderation) as reported Asadu *et. al.,* (2004) and Kolawoye and Tian, (2004). The use of organic manure and crop residues incorporation were perceived by 10 % of the farmers to have adopted them as means of conserving moisture content of the soil while only 6 % of the farmers adopted cover cropping method respectively. Thus, cover crops provides a protective cover against soil erosion and also helps in reducing the rate of soil moisture loss through reduced evaporation from soil surfaces (Asadu *et. al.,* 2004).

Table 4. Soil moisture conservation practices adopted by the farmers in the study area

S/n	Soil moisture conservation practices	Frequency (150)	Percentage (100 %)
1	Mulching	18	12
2	Cover Cropping	9	06
3	Contour Bed Construction	51	34
4	Crop Residues Incorporation	15	10
5	Tillage Practices	42	28
6	Use of Organic Manure	15	10

CONCLUSIONS

Understanding the effects of climatic variable (rainfall) on soil hydraulic properties is highly imperative towards providing valuable information which will be used in soil management and strategic techniques for sustainable food production. The present study investigates the effect of seasonal rainfall variability on the moisture status of the soils of Mubi area. the results revealed that the moisture properties (WHC, FC, PWP and PAW) of the studied soils at the beginning of the season (May-June) were insufficient to support crop growth and development in the area which could be due to the low antecedent moisture content of the soil, wetting depth, sandy loam textures of the soil. While at the middle of the season (July-August) there is moderate moisture content which might support the growth and development of the crop with the supplement through irrigation and conservation practices. At the end of the season the moisture properties (WHC, FC, PWP and PAW) are high due to maximum antecedent moisture content absorbed through rainfall events from the beginning and middle seasons. Therefore, to obtained sufficient moisture status in all the three phases (Beginning, Middle and End) of rainy seasons that will support and sustain crop production in the area there is need for the farmers in the area to improve the soil texture, porosity and Bd towards improving the water retention capacities through the addition of organic matter, minimum or no tillage practices. Similarly, the use of low water potential crops and early maturing varieties should be adopted by the farmers in the area.

ACKNOWLEDGEMENTS

The authors have sincerely acknowledged the support of **Tertiary Education Trust Fund** (**TETFUND)** for sponsoring this research work.

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