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Effect of Tillage Practice on Soil Moisture Retention under Three Selected Cowpea Varieties

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Authors' contributions

This work was carried out in collaboration between all authors. Author RNK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GNC and JMK managed the analyses of the study. Author RNK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To evaluate the effect of tillage practice on soil moisture retention under three cowpea varieties.

Study Design: The treatments were laid out in a randomized complete block design with a factorial arrangement and replicated three times.

Place and Duration of Study: The experiment was conducted at St. Theresa farm and Nakamane irrigation scheme in Turkana county between November 2014 and January 2015.

Methodology: Treatments comprised three tillage practices: conventional tillage (control), conventional tillage + mulch, and zero tillage and three cowpea varieties: M66, K80, and Kenkunde. Soil samples were collected using an auger (25 mm internal diameter) from near randomly selected 5 plants at the depth of 15 cm in all treatments at an interval of 7 days. The gravimetric moisture was determined using the FAO equation.

Results: Tillage + mulch and zero tillage conserved 37.07% and 31.63% more moisture than conventional tillage at St Theresa demo farm, respectively. At Nakamane irrigation scheme, zero

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tillage retained more moisture content of 33.02% followed by conventional tillage + mulch at 32.24% as compared to conventional tillage. Significant interaction was realized between tillage practice and variety at Nakamane experimental site only. The main effects of variety had no effect on moisture retention.

Conclusion: Tillage practice has significant effect of moisture retention in Turkana county. Any cowpea variety established has no effect on moisture retention. A broader use of tillage practices and varieties is advisable for further studies.

Keywords: Cowpea; moisture retention; tillage.

1. INTRODUCTION

Tillage is widely known to affect crop available moisture [1]. Despite high soil water retention due to zero tillage, crop performance has not consistently shown to be better than conventionally grown crops due to the influence of soil type, tillage depth and soil conditions such as moisture content at the time of tillage and prevailing climatic conditions [2]. Tillage impact on crop yield is related to its effects on root growth [3], soil water content and nutrient use efficiencies [4]. Whereas no till is ideal in moisture deficient soils, conventional tillage is more suitable where rainfall is adequate [5]. Tillage has an effect on sustainable use of soil resources [6]. Although conventional tillage modifies soil properties such as moisture content. It is also associated with negative effects such as erosion and soil infertility [7] as compared to no-tillage methods [8]. As a result, there is more emphasis on conservation and no-tillage practices [9]. Mulch application has been observed to enhance soil moisture storage by accumulation of organic matter and improvement of soil structure [10]. As observed [11], conventional tillage + mulch reduces evaporative soil moisture loss to between 5-10% providing 20-25 mm transpiration in sole cowpea as opposed to conventional tillage which contributes to soil degradation, soil water loss and poor environmental management [12,13]. The use of no till was reported to have advantageous effects on soil moisture retention [12,14]. Based on these reasons, it was necessary to investigate on tillage practice effect on soil moisture content in Turkana County where crop available water is at a premium due to erratic rainfall. In addition, varieties are reported to contribute to soil moisture retention [15] which necessitated the need to evaluate their possible influence on moisture conservation in Turkana County.

2. MATERIALS AND METHODS

2.1 Experimental Site Description

The field experiments were carried out at St. Theresa demo farm and Nakamane irrigation scheme along Turkwel river in Turkana County, North west of Kenya. The field stations are within an elevation range of 597 m to 800 m above sea level with an annual rainfall of 150 mm to 500 mm and a temperature range of 24°C to 38°C. The predominant soils in St Theresa demo farm and Nakamane irrigation scheme sites are undifferentiated tertiary volcanic soils, derived from colluvial and alluvial deposits. The soils are shallow to moderately deep, well drained and dark reddish brown/dark greyish brown in colour. The soils are classified as riverine alluvium and are pale brown to dark brown. They are deep, non-saline and locally calcareous. The soils at St. Theresa are stratified fine sand to loam with a high infiltration rate while those at Nakamane irrigation scheme are stratified fine sand to clay [16].

2.2 Experimental Design

The experiments were arranged in a randomized complete block design with a factorial arrangement and replicated three times. Treatments comprised tillage practice: conventional tillage (control), conventional tillage + mulch, and zero tillage and three selected cowpea varieties: M66, K80 and Kenkunde. Individual plots measured 4 m x 3 m within each block and were separated by 0.5 m paths. There was 1 m buffer zone between blocks. Individual block measured 43 x 3 m to give a total area of 129 m² and were separated from the adjacent block by 1 m buffer zone. The entire experimental plot was 43 x 17 m to give a total area of 731 m². Under conventional tillage, land was prepared to a fine tilth through physical tilling before sowing at 50 mm depth [17].

In the second treatment (**tillage+mulch**), land was prepared to fine tilth through physical tilling before sowing at 50 mm depth and mulch was applied at the rate of 4tha⁻¹ [18,11]. In the third treatment (**zero tillage**), land was cleared off weeds before sowing at 50 mm depth. Water was applied in all treatments by basin irrigation method. The gravimetric moisture was determined at the interval of seven days from top soil surface (0–15 cm) in the entire growth period.

2.3 Data Collection

Moisture retention was determined by collection of soil samples from a depth of 15 cm in each experimental plot. For each plot, soil was collected near the root zone of randomly selected plants. The collected samples were then weighed into 20 g using an electronic scale. The 54 samples were transferred into a well labeled polythene bag of known weight. The samples were air dried for three days. Weights of dry samples were recorded using the electronic balance. Soil moisture retention was then calculated using the following equation [19].

$$\text{Moisture retention} = \frac{\text{Moisture treatment} - \text{Moisture control}}{\text{Moisture control}} \times 100$$

2.4 Data Analysis

Data collected was subjected to analysis of variance (ANOVA) using the Genstat (2012) software package version 15.1. Where the F values were significant, means were compared using the least significant difference (LSD) test with 5% of significance level.

3. RESULTS

3.1 Effects of Tillage Practice and Variety on Moisture Retention

Compared to the control, tillage + mulch and zero tillage conserved 37.07% and 31.63% more moisture, respectively, at St Theresa demo farm. However, at Nakamane irrigation scheme, zero tillage retained more moisture of 33.02% followed by conventional tillage + mulch at 32.24% as compared to conventional tillage.

Significant interaction was observed between tillage practice and variety at Nakamane experimental site only. The main effects of variety had no effect on moisture content.

4. DISCUSSION

The effect of tillage practice on moisture retention was significant in both experimental sites. Conventional tillage + mulch had higher mean moisture retention than zero tillage at St Theresa demo farm which in turn had higher moisture retention than conventional tillage. However, at Nakamane irrigation scheme, zero tillage retained more moisture followed by conventional tillage+mulch then conventional tillage. Similar results were observed by [20] who reported more water retention in zero tillage than conventional tillage. This finding was in contrast with the works of [21], who demonstrated that conventional tillage had more moisture than zero tillage. While mulched plots retained moisture by lowering soil temperature, zero tillage reduced soil moisture losses by decreasing soil capillaries that enhance evapotranspiration [22]. Zero tillage reduced moisture loss by developing a thick layer

Table 1. Effects of tillage practice and variety on moisture retention

| Variety (V) | Theresa | | | | Nakamane | | | |
|------------------------------|----------------------|------|------|------|----------------------|------|----------|------|
| | M 66 | K 80 | Ken | Mean | M 66 | K 80 | Kenkunde | Mean |
| Tillage (T) | | | | | | | | |
| Conventional tillage | 0.20 | 0.21 | 0.21 | 0.21 | 0.22 | 0.21 | 0.20 | 0.21 |
| Conventional tillage + mulch | 0.37 | 0.37 | 0.38 | 0.37 | 0.32 | 0.32 | 0.33 | 0.32 |
| Zero tillage | 0.32 | 0.31 | 0.32 | 0.32 | 0.32 | 0.33 | 0.34 | 0.33 |
| Mean | 0.30 | 0.30 | 0.30 | | 0.29 | 0.29 | 0.29 | |
| LSD _(P≤0.05) T | 0.0192** | | | | 0.0074** | | | |
| LSD _(P≤0.05) V | 0.0192 ^{ns} | | | | 0.0074 ^{ns} | | | |
| LSD _(P≤0.05) T*V | 0.0092 ^{ns} | | | | 0.0129* | | | |
| cv% | 6.4 | | | | 2.6 | | | |

* indicate significant, ** indicate highly significant and ^{ns} indicate non-significant

which restricted upward movement of water to evaporative surface by reducing diffusivity gradient. While conventional tillage improved water infiltration, it also tended to increase evaporation in control plots. In both experimental sites variety had no significant effect on moisture retention. This was attributed to little genetic variation in root biomass which substantially led to little differences in protection of the soil from increased evaporation, soil water absorption and water use efficiency. It could also be due to little above ground canopy formation differences. The results showed that tillage + mulch and zero tillage had comparative advantage over conventional tillage due to their influence on soil to hold moisture for longer period by lowering temperature [23] which reduced evapotranspiration thus making soil moisture available for plants growth.

5. CONCLUSION

Tillage practice has an effect on soil moisture. Conventional tillage + mulch and Zero tillage practices had higher moisture retention than conventional tillage. None of the varieties studied had influence on moisture retention. Further work is required on broader application of more tillage practices and cowpea varieties on moisture retention.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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