The Effect of Mulching on Soil Moisture Retention and Yield of Lettuce (*Lactuca Sativa* L.)

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Abstract— *An experiment was conducted to evaluate the effectiveness of different mulching materials on soil moisture retention and yield of lettuce at the greenhouse located at Luyengo campus of the University of Eswatini during the months of January and February, 2019. The treatments consisted of grass mulch (GM), Plastic mulch (PM), leaf debris mulch (LM), and no mulch (NM) which was used as a control. Each of the treatments had four replications. The organic mulch was applied at a thickness of 10 cm, and the plots for experiments were randomly selected. Each plant received 600 cm^3 of water every 3 days using a homemade drip irrigation system (equivalent to 6 mm per irrigation circle). Data on soil moisture content was collected using the gravimetric method every 3 days (before irrigation).The growth parameters of the lettuce plants that were collected weekly were plant height, leaf number and leaf area. Both wet weight and dry weight yield were determined for each plot at the end of the experiment (six weeks after planting). Data collected was coded and entered into SPSS computer software. Data analysis was conducted using the analysis of variance (ANOVA) and the least significance difference (LSD) test to determine if means were significantly different. The results showed that GM treatment had high mean moisture retention at 9.3%. It was followed by PM and LM at 8.9%. The lowest moisture retention was realized from the control (No mulching) at 7.9%.The differences in mean moisture retention was significant between NM and NM ($p<0.05$). The same pattern was observed for the growth parameters, where GN had highest values and the control had the lowest values. The wet mass yield was highest for GM, at 164.7 g. The yield from LM was 149.3 g. It was followed by PM at 141.3 g. The lowest yield was obtained from the control at 108 g. The difference in mean yields for GM and NM were significant ($p<0.05$). They were not significantly different for all the other treatments ($p>0.050$. It was concluded from the experiment that grass mulching resulted in improved moisture retention and high yields.*

Keywords— Keywords-Drippers, irrigation, moisture, mulching, yield.

I. INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the most commonly used as salad vegetable. It belongs to the daisy family, Asteraceae. Lettuce probably originated from Asia, where it was grown for centuries and its early forms were used in Egypt around 4500BC [1]. Lettuce is a cool season crop grown for its tender head and leaves, but sometimes for its stem and seeds. It is rich in vitamins A and C and minerals like calcium. Lettuce is the dominant cultivated salad vegetable, which is commercialized worldwide. It is the most popular salad vegetable with the highest consumption rate and economic importance throughout the world). Farmers need to be educated for its production technology including judicious water management [2]. Water use efficiency is crucial and should be promoted in agricultural production [3]. A way of doing this is through mulching, which involves covering of the soil surface with crop residue (s) or other material such as paper or polyethylene film. Straw mulch helps to retain soil moisture, reduce temperature, conserves soil, control weeds and increase soil fertility. Mulches increase the soil moisture in the root zone and significantly decrease soil temperature. This provides a stable environment for seedling establishment and growth than soil that is not mulched. In addition, mulches increase the infiltration and storage of water in the soil and improve structure and macro-porosity of the soil along with reducing runoff and evaporation losses [4]. Water is essential for the sustenance of all forms of life. In the Kingdom of Eswatini, water utilization is expected to stimulate the economic development of the country through agricultural production. In the past few years, water availability has been scarce resulting to uneven water distribution across the country with high costs and worse, some water source went dry due to drought. This predicament has created a drive to conserve water in the country. Improving water efficiency is an ongoing goal in agricultural production, especially in area where water sources are limited and regulated. Farmers are adopting new strategies of conserving the little water they have for their production, especially vegetable production. That's when the need of other possible ways of water conservation through the use of mulch was considered, but there is still uncertainty of which mulch material is more effective, hence this study. Mulching benefits the soil in many ways which subsequently enhance the growth of the plants in that particular soil. Mulching offers tremendous potential for increased crop production through its marked effects on the soil environment which increase crop growth and yield [5]. Mulches are beneficial in soil and water conservation, modification of soil temperature and the temperature just

above the ground, preserving and improving soil physical and chemical properties, suppressing weed growth and enhancing biological activities in the soil. Mulching improves the soil moisture regime by reducing losses caused by surface run-off and evaporation. It insulates and protects soil from drying and hard-baking effects caused by evaporation of water from soil exposed to hot sun and winds. Mulched soils absorb water faster than soils of the same type without mulch. Under mulch, the soil moisture is conserved because of reduced evaporation, improved infiltration rate, and the suppression of unnecessary plant growth [6].

The build-up of a large and active soil microbial biomass is critically important for sustaining the productivity of soils in organic farming systems [7]. Soil microbes, the living part of soil organic matter, function as a transient nutrient sink and are responsible for releasing nutrients from organic matter for use by plants. Mulching enhances microbial activities in the soil, which is essential in nutrient recycling [8].

The effect of mulch on crop yield is an integrated effect of many factors and it is difficult to attribute the yield increments to any one variable on its own [9]. Crops perform well when there is adequate soil moisture, nutrients and or optimum temperature. The presence of mulch enhances all the conditions mentioned above but mulch alone cannot provide adequate nutrients that the crop requires for development. The objective of this study was to determine the effect of mulching on soil moisture retention and the yield of lettuce.

II. MATERIALS AND METHODS

2.1. Description of study area and research design

The experiment was conducted at the greenhouse located at Luyengo campus of the University of Eswatini. Luyengo is located in the Middleveld of Eswatini at 26.683^o S and 31.20^o E with altitude of 733 m above sea level. It has an average annual rainfall that ranges from 850 to 1000 mm. The soils are classified under the Malkerns soil series (Oxisols), which are dark loam to sandy loams [10]. The experiment was Complete Randomized Block Design with four treatments that were replicated four times. The treatments were: grass mulch (GM), plastic mulch (PM), leaf debris mulch (LDM), and no mulch (NM) as a control.

2.2. Land preparation and planting, and irrigation

Land was cultivated uniformly using a hand fork to break clods and the soil was loosened. A fine tilth was prepared on the plots using a hand rake before planting seedlings. Seedlings were obtained from Vickery Nursery, a local commercial nursery. One seedling was planted by hand in each hole, with seven lettuce seedlings being planted per replication. They were planted at 30 cm apart within rows and 40cm between each treatment. The different organic mulching materials were applied at a thickness of 10 cm seven days after planting the seedlings. Weeding was done using a hand hoe whenever necessary. The crops were monitored on a daily basis to observe and treat any symptoms of pest and disease attack, there were none observed.

The plants were irrigated using a homemade drip irrigation system. It was a low cost drip irrigation system which is a gravity fed system. This irrigation method involves the delivery of water through a pipe distribution network consisting of a main pipe that delivers water to lateral pipes under low pressure and emission through small outlets (emitters or drippers) into the soil surrounding the plant. The components of this drip irrigation kit include the water storage tank of 210 liters capacity, a gate valve that controls the movement of water entering the system, a backflow preventer, a filter, a tubing adapter that connects the drip tubing with the filter, and the main pipe that delivers water to the laterals of the system. Each plant received 600 cm^3 in every irrigation cycle which lasted for 1.2 hours. This was equivalent to 6 mm of water per irrigation cycle.

2.3. Data collection and analysis

The parameters that were measured every week during the study were leaf number, leaf width, and leaf length of the plant. The parameters were collected from all the plants in each replication. The Leaf Area Index (LAI) was calculated using equation 1.

$$LAI = Y \times N \times AL \times AP^{-1} \quad (1)$$

Where;

Y- is the population of the plants per plot

N- is the average number of leaves per plant

AL- is the average area per leaf (cm^2)

AP- is the area of the plot (cm^2)

The leaf area was calculated using equation 2.

$$LA = L \times W \times 0.7 \quad (2)$$

Where;

LA- is the leaf area (cm^2)

L- is the leaf length (cm)

W- is the leaf width (cm)

0.7- is the correction factor

The soil moisture content for each treatment was determined every three days using the gravimetric method which involves collecting a sample of wet soil, weighing it before and after oven drying it at 105^o C for at least 48 hours. The soil samples were collected using a 98 cm^3 cylindrical ring before irrigation (irrigation cycle was 3 days) from each treatment, weighed, oven dried at 105^o C for 48 hours, then weighed again to get the dry mass. The amount of water lost was calculated as a percentage of the mass of the dried soil as expressed in equation 3.

$$\%\, Soil\ water = \frac{Weight\ of\ wet\ soil\ (g) - Wieght\ of\ dry\ soil\ (g)}{Weight\ of\ dry\ soil} \times 100\% \quad (3)$$

One plant was harvested by cutting it from the base from plot at maturity (six weeks after planted). The harvested plants were weighted to determine wet mass. There after they were oven dried for 48 hours at 105^0 C, and weighted to determine dry mass.

Data were entered into SPSS computer software. The Analysis of Variance (ANOVA) and the least significant difference (LSD) were used to determine if means were significantly different.

III. RESULTS AND DISCUSSIONS

The results showed that there were some variations in soil moisture retention under the different mulch materials (Table 1). Grass mulch treatment had highest soil moisture retention (at 9.3%), followed by both plastic mulch and leaf debris mulch, at 8.9%. The control had the lowest soil moisture retention at 7.9%. The difference in soil moisture retention was significant for the grass mulch and control ($p<0.05$). Organic mulch reduces evaporation of soil moisture and thus improving soil moisture retention [11].

TABLE 1
RESULTS SHOWING MEAN VALUES FOR PARAMETERS

Treatment	Parameters*					
	Moisture retention (%)	Mean plant height	Mean leaf number	Leaf area index	Mean wet mass	Mean dry mass
Control	7.9^a	15.2^b	10	0.37^c	108^d	6.3^e
Grass mulch	9.3^a	21.7^b	13	0.77^c	164.7^d	8.7^e
Plastic mulch	8.9	16.0	10	0.45	141.3	7.4
Leaf debris mulch	8.9	18.2	11	0.47	149.3	8

* ***Parameters on same column with same symbol indicate that their means were significantly different.***

Grass mulched treatment recorded the highest mean plant height of 21.7 cm after the 6-week growing period. It was followed by Leaf debris mulch (LM) with a mean height of 18.2 cm and the Plastic mulch (PM) with a mean plant height of 16 cm. The Control treatment (NM) had the lowest mean plant height of 15.2 cm (Table 1). The mean plant height for Control and Grass mulch were significantly different ($p<0.05$). They were not significantly different for all the other treatments ($p>0.05$).

Leaf area index is a reference tool for crop growth as leaves are the most important structure for photosynthesis [12]. The mean LAI for GM was the highest at 0.77. It was followed by LM and PM) which recorded 0.47 and 0.45 respectively. The Control (NM) had the lowest LAI at 0.37. The LAI values were significantly differently for NM and GM ($p < 0.05$), and not significantly different for all the other treatments. GM treatment had the highest mean number of leaves, at 13. It was followed by LM with mean number of leaves at 11. The mean number of leaves for PM and NM were 10. The mean number of leaves were not significantly different for all the treatments ($p > 0.05$).

The results for yield were presented in terms of the mean wet mass and mean dry mass (Table 1). The mean yield per plant for GM was the highest (at 164.7 g wet mass and 8.7 g dry mass). The control (NM) had the lowest mean mass (at 108 g wet mass and 6.3 g dry mass). Like most other parameters, the difference in mean yield was significant for GM and NM ($p < 0.05$). They were not significant for all the other treatments ($p > 0.05$). Mulching improves nutrition absorption; weed control and temperature adjustment, leading to improved growth and yield [13].

IV. CONCLUSION

Mulching of the soil resulted in improved growth and yield of lettuce. The performance of lettuce under all the three treatments (GM, PM and LM) was higher than of the control (NM). The differences in mean values for all the parameters (except for mean leaf numbers) were significant for GM and NM. They were not significant for all the other treatments. Based on the findings of this study, it is concluded that mulching has a positive effect on soil moisture retention and yield of lettuce. Grass mulch should be adopted as a moisture conservation measure that would result in significant increase in the yield of lettuce.

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