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Effects of Grass and Plastic Mulch on Growth and Yield of Strawberries *(Fragaria x ananassa)* in Kiambu County, Kenya

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1 ABSTRACT

Strawberry (*Fragaria x ananassa*) is one of the fruit crops cultivated in many parts of the world. It is rich in vitamin C and other nutrients like carbohydrates and protein. In addition to being consumed fresh, strawberries can be dried and their flavour is popular in industries that manufacture foods, beverages, perfumes and cosmetics. Failure to conserve water in strawberry production by the soil poses great challenges to strawberry growers in Kenya including low yields and poor growth. The aim of the study was to evaluate the ability of mulch to conserve moisture and increase growth and yield of strawberries. The study was conducted at Kenyatta University research farm for three months with the treatments being black plastic mulch, clear plastic mulch, grass mulch, and no mulch, arranged in a completely randomized block design and each treatment replicated thrice. Data collected included the number of fruits, flowers, leaves, runners, buds per runner and fruit weight. Data was subjected to analysis of variance at 5% level of significance using SAS version 9.1.The results showed that mulches had better plant performance in the studied parameters. However, grass mulch proved to be more suitable for improving plant performance than the other mulches thus mulches should be used for better strawberry yield.

2 INTRODUCTION

Strawberry *(Fragaria x ananassa)* is an herbaceous, perennial plant with a compressed stem called the crown. The leaves, flowers and stolons originate from the crown (Mouhu *et al.,* 2013). The fruit, which belongs to the family of *Rosaceae,* is a small fruit crop of great nutritional and medicinal value (Mouhu *et al.,* 2013) that is consumed worldwide (FAO, 2001). The versatility of strawberries in fresh and processed forms has played an important role in their adoption in diets. Berries are important sources of vitamin C, which averages at 21mg per kg of fresh fruits. The plant thrives on loam, well-drained soils with a pH of 5.5–6.5. Temperature requirements are in the range of 10 to 30°C and average rainfall of 900 to 1200 mm (Kasperbauer, 2000). The varieties of strawberries grown in Kenya include Chandler, Douglas, Tioga, Selva, Tristar, Domanil, Rabunda, Pajaro and Tribute (Wang, 2002). The most widely grown variety in Kenya is Chandler, originating from the USA (FAO, 2001). Kenya exports its strawberries mainly to the UK, Holland, Germany, France and the Middle East (mainly Saudi Arabia). There are relatively few Kenyan based studies on the production of strawberries, although reports show production has been declining from 2014 t0 2016(FAOSTAT, 2018), partly due to water

scarcity and weeds, among other challenges. Plastic mulches (polyfilms) are often used in the raised-bed culture of strawberries to warm the soil, conserve moisture, control weeds, and keep fruits clean (Kasperbauer, 2000). The most commonly used polyfilm is black, which promotes the best root growth, water use efficiency, and nutrient uptake, compared to clear (transparent) and organic mulches. Karsten, (2015) observed that transparent polyfilm raises soil temperature significantly, whereas organic mulch reduces it. Mulch offers numerous advantages to strawberries. It minimizes water use by reducing evaporation, grass mulch improves soil quality and nutrient content as it decomposes. Soil temperature can be adjusted with the use of mulches. Mulches reduce soil evaporation and increase yield through increasing water use efficiency (Adekalu *et al,* 2006). Mulches cover the soil surface, providing a microclimate favourable for plants. They also influence plant growth and yield when added to the soil surface by reducing evaporation, increasing water infiltration, controlling soil erosion, and improving soil structure (ARUN, 2016). The method of increasing water use efficiency by synthetic mulch and organic mulch is different. The main factor preventing the evaporation by organic mulches is soil temperature, while the main factor preventing the evaporation by plastic mulch is the impervious, although they increase soil temperatures and affect plant physiology, which results in poor performance (ARUN, 2016). Mulching promotes better growth, increases nutrient availability in the soil, conserves moisture and reduces moisture conservation, and promotes development of the plant as well as modifying soil temperature (Kher *et al.,* 2010; Keramat *et al.,* 2011). Grass mulches not only improve soil structure but also help in the slow release nutrients and suppress extreme fluctuation of soil temperature (Shirgure *et al.,* 2003)

3 MATERIALS AND METHODS

The current study was conducted at Kenyatta University research farm from November 2015 to March 2016. The site is located at 1.1802° S, 36.9282° E and 1,710m above sea level and receives an average rainfall of 1,000 to 1,200mm per year with the long rains falling from March to July and short rains from October to December. Temperature at the site ranges from 27 to 30°C and the soils are fibrous clay. Land was ploughed and harrowed to a fine tilth, followed by manual preparation of beds. The plots, measuring 1-m wide by 1-m long each, were marked, and an equivalent of 1 kilogram of phosphorous (P_2O_5) was uniformly broadcasted on the surface and incorporated into the soil using a hoe to a depth of 20 cm. Bed edges were raised to 10 to 15 cm above the ground. The experiment was laid out in a randomized complete block design. Mulches (no mulch, dry grass, clear polyfilm, and black polyfilm) were assigned to the plots and each treatment was replicated three times. A distance of 1 m separated adjacent replications. The spacing between planted splits in a single row was 30 cm, giving 9 splits per replicate. Planting splits were 15 to 15.6 cm in height and were obtained from mature plants maintained in a greenhouse at the same location. Holes were opened in the mulches to facilitate insertion of splits into the soil. The splits were planted in November 2015. Cut dry grass was applied above the bed surface and new grass was added every one month to ensure the soil underneath was not exposed. During dry periods, all plots were irrigated equally. Weeding was done every month in and around the entire experimental site. Data recorded included plant number of leaves, runners, splits, buds, flower stalks as well as berries. Plants treated with grass mulch had the highest number of flower stalks per plant (14) and control, the least number (4) of fruits; from a low of 3 (control) to a high of 8 (grass mulch). Regarding leaves, the highest average resulted from grass mulch (47) and control resulted to a low of 5 runners, and buds per runner. Plants

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mulched with grass had the highest number of runners (7) and buds (11) while the unmulched plants had the least number of runners (1) and buds (1). Fruit weighed from (66.9 g/plant) for plants treated with grass mulch. Minimum weight of fruits was observed in no mulch treatment (30.5 g/plant). All data were calculated per plant except for buds, which were calculated per runner. All the other data was taken from seven plants picked. Randomly and the results averaged. Data was subjected to analysis of variance (ANOVA) and means were separated using Fisher's Protected LSD test at the $P \leq 0.05$ significance level using SAS (Statistical Analysis System) version 9.1.


Clear polythene mulch


Black polythene mulch


Grass mulch

4 RESULTS AND DISCUSSION

4.1 The Effect of Mulching on Leaf Numbers: A good mulching material with adequate supply of nutrients is essential for plants to attain maximum production. It was observed from this experiment that mulching effectively regulates soil temperature and preserves soil water (Iqbal *et al.,* 2006). The effect of mulch on the number of leaves was significant ($P \leq 0.05$) and consistent throughout the season. The number of leaves increased steadily over the season from a low of 5 to a high of 54 (Figure 1). The number of leaves produced by plants under clear and black polyfilms was similar and higher than those produced by plants under no mulch but lower than those produced under dry grass mulch. The increased leaf growth under both polyfilms could be attributed to the promotion of root growth, and nutrient uptake by these polyfilms (Sharma, 2008). The difference between the effects of dry grass and other types of mulches was attributed to the fact that grass mulch reduces runoff following decomposition; therefore, soil structure is likely to benefit from the use of organic mulches (Feldman *et al.,* 2000).

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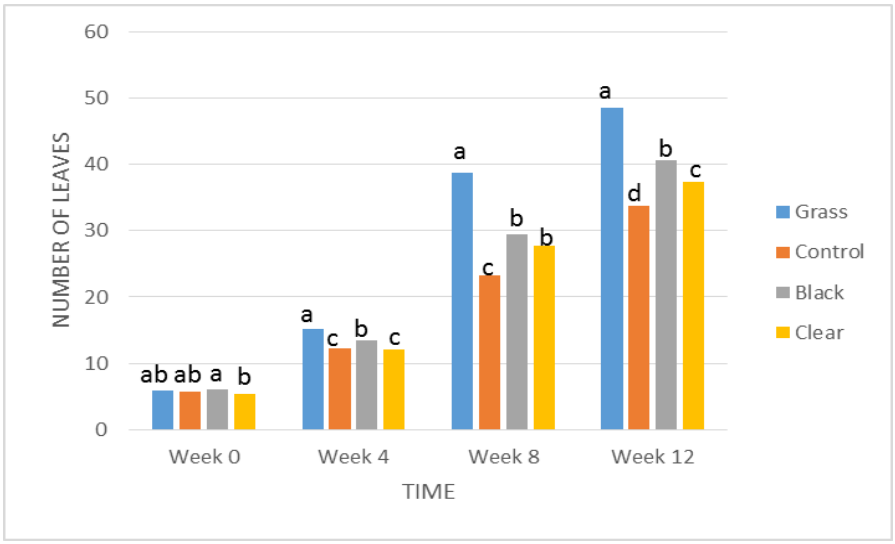

Figure 1: Number of leaves on strawberry plants under grass, plastic, and no mulch treatment.

Growth of Runners: The effect of mulch on the number of runners was significant ($P \leq 0.05$) only at week 8 and 12, when plants under grass mulch had more runners than plants under both plastic and no mulch treatment (Figure 2). Grass mulch could have promoted runner development due to the decomposed organic matter optimizing water use efficiency, and enhancing root and shoot growth. Changes in root zone temperature can affect the uptake and translocation of essential nutrients, therefore influencing root and shoot growth of crops (Chu *et al.*, 2016). The observed enhancement on runners with types of mulches might also be attributed to the benefits of organic and synthetic mulches which lead to increased organic matter to the soil, reduced water loss, and reduced soil erosion (Chu *et al.*, 2016) leading to the promotion of vegetative growth, which positively reflects on runners. Soil temperature can be adjusted with the use of mulches. Mulches reduce soil evaporation and increase yield through increasing water use efficiency (Adekalu *et al.,* 2006). Mulches on the soil surface reduce evaporation, increase water infiltration, control soil erosion as well as improving soil structure; thus affecting plant growth and yield affect (Bakshi et al., 2015). The method of increasing water use efficiency by synthetic mulch and organic mulch is different. The main factor preventing the evaporation by organic mulches is soil temperature, while the main factor preventing the evaporation by plastic mulch is the impervious property in them (Muñoz *et al.,* 2017). The impervious property contributes to heating up of the soil, which may affect growth positively.

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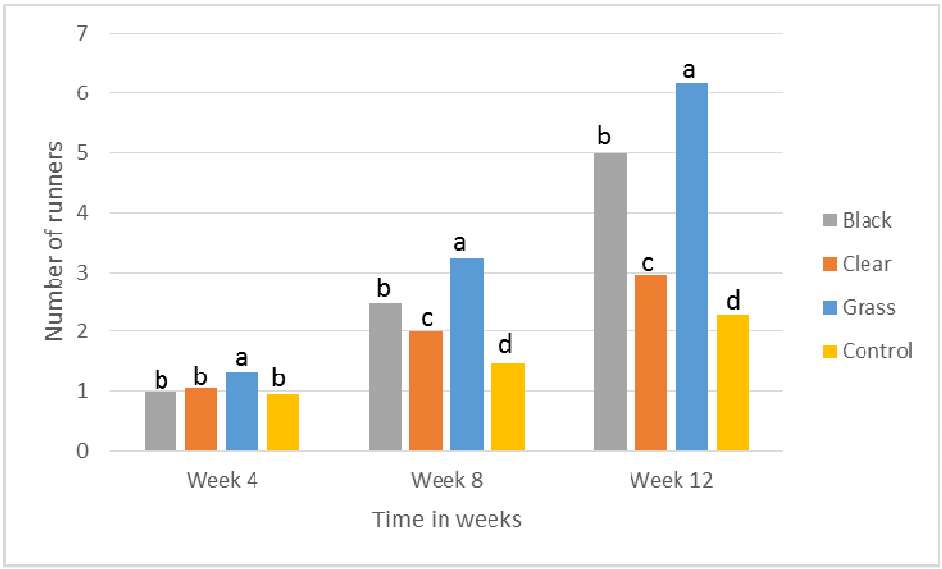

Figure 2: Number of runners on strawberry plants under plastic and grass mulch application.

Number of Buds: The number of buds increased as plants grew older. Significantly ($P \leq 0.05$) more buds developed under grass mulch and black polythene than under both clear and no mulch treatments throughout the season (Figure 3). This response was probably attributed to the effect of mulch in raising the temperature and promoting growth. Mulching probably triggered increased soil moisture contents (Munoz *et al.,* 2017). Diverse mulching materials affected the plant parameters differently and grass mulch had the best performance. Solaiman *et al.* (2008) worked on Asters and observed greater shoot growth with straw. The main factor preventing the evaporation by organic mulches is soil temperature, while the main factor preventing the evaporation by plastic mulch is the impervious property, which has effects on plant physiology through heating up of soil, hence poor plant performance (Bakshi *et al.,* 2015).

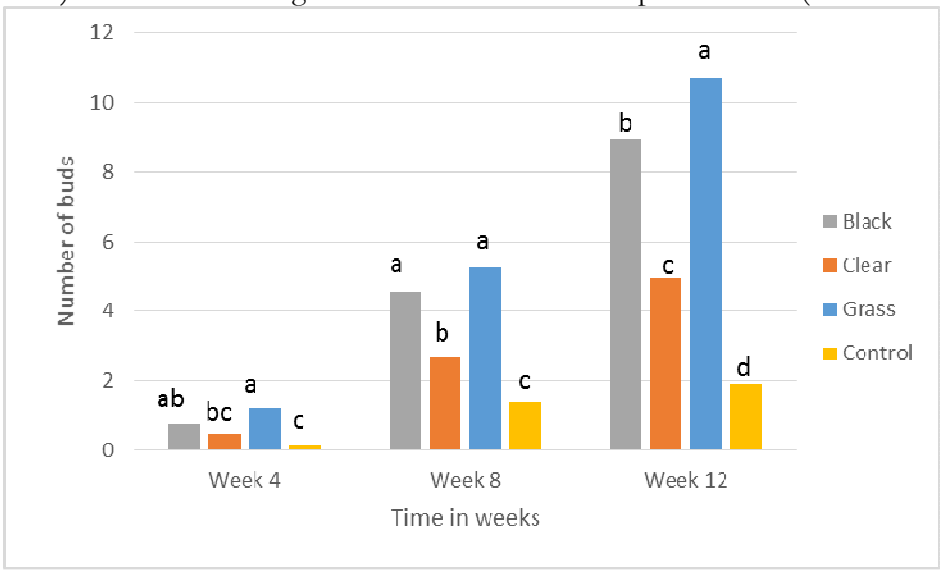

Figure 3: Response of strawberry buds to grass and plastic mulch application

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Flower Development: Plants started flowering at 8 weeks and flower growth increased as the season progressed (Figure 4). At 12 weeks, the number of flowers increased and the effect of mulch became significantly different between the treatments ($P < 0.05$). Grass mulch resulted in the highest average number of flower stalks per plant (10); followed by black polyfilm (6), then clear polyfilm (5). This trend was maintained until the 12 weeks growth stage, when plants under no mulch produced the lowest number of flower stalks (4), compared to the highest (14) for plants under grass mulch (Figure 4). The increase in flower initiation and growth on mulched plants was attributed to the nutritional gain warming effects of both organic and inorganic mulches (Kasperbauer, 2000). Relatively better moisture and thermal regimes enhance root growth, which ultimately leads to increase in the potential for efficient nutrient uptake (Kumar and Dey, 2011). Nitrogen and phosphorous are the main elements required for growth and development of crops. Precipitation takes an enormous quantity of phosphorous into the soil's immobile pools and plants are unable to use it (Hao *et al.,* 2002; Badawi, 2010). Application of mulch reduces the loss of phosphorous by limiting precipitation so it may lead to plant growth. Grass mulches not only improve soil structure but also help in the slow release of nutrients and suppress extreme fluctuation of soil temperature (Shirgure *et al.,* 2003).

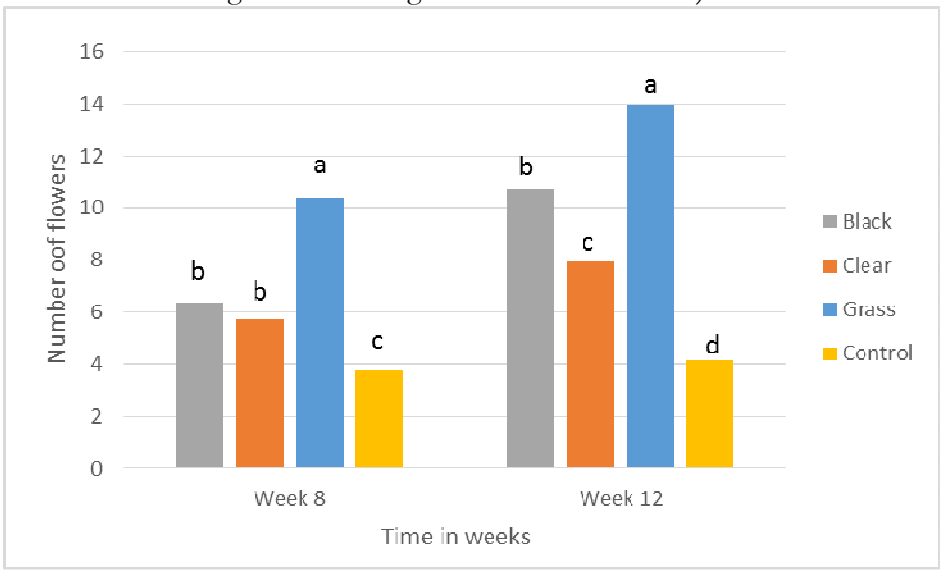

Figure 4: Number of flowers of strawberry plants under grass mulch, plastic mulch, and no mulch.

Effect of Different Mulches of Fruit Yield: Comparison among mulch treatments indicated that grass mulch produced the highest weight of fruits, which was obtained from averaging 10 fruits then multiplying them by the average number of fruits in each treatment. Results were 66.9 g/plant for plants treated with grass mulch, statistically higher than all other mulch treatments (Figure 5). The minimum weight of fruits was observed in no mulch treatment (30.5 g/plant). The black and clear polythene were not statistically different from each other (Figure 5). The combined effects of soil temperature, soil moisture, and weed suppression not only works to improve crop growth but they also facilitate hand picking and lead to higher yield and increased fruit size. The results are similar to those of Berglund *et al.* (2006), who reported that better establishment of strawberry plants gives higher yields grown under plastic mulch. The

improvement of yield might be related to the elevated soil temperature and the quality of radiation under the cover. Similar results were obtained by Wang *et al.* (2002). Sharma *et al.* (2008) reported that grass cover significantly improved plant physiology, growth and yield. They concluded that berry weight and yield were the highest in plants grown under grass and black plastic mulch. Similar results were found by Ibara *et al.* (2001) on growth of muskmelon.

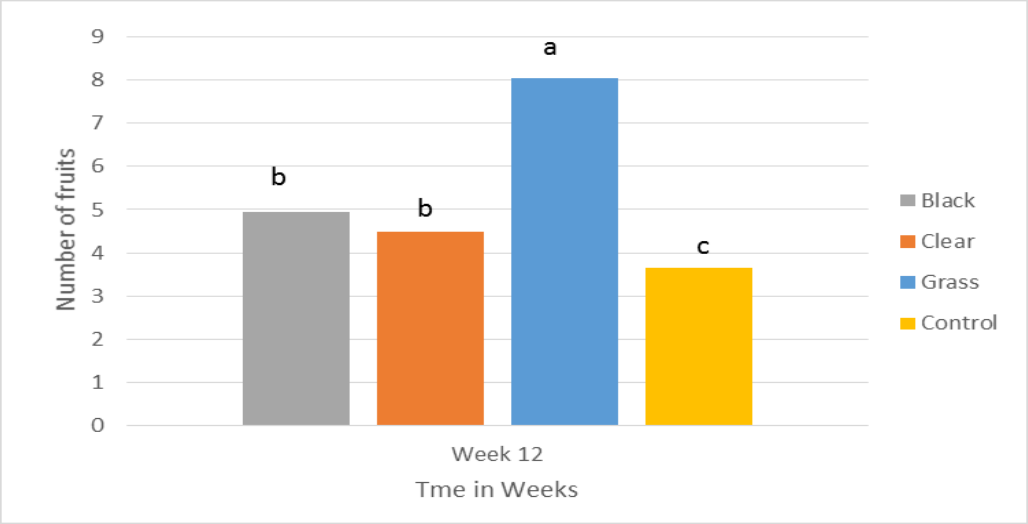

Figure 5: Response of strawberry fruit numbers to grass and plastic mulch application

5 CONCLUSION

The study showed that mulches help in water conservation in strawberry production, the mulches promotes increase in plant growth, which is reflected in the yields thus mulches should be used for better strawberry yields.

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