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Influence of Mulching Materials on the Growth and Yield Components of Green Pepper at Busia County in Kenya

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Authors' contributions

This work was carried out in collaboration between all authors. Author ONE designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors JPGO and NKK reviewed the study design and all drafts of the manuscript. Author NKK managed the analyses of the study and performed the statistical analysis. Author ONE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Green pepper (*Capsicum annuum*) also named the bell pepper or sweet pepper is one of the most important and remunerative vegetable crops in the world. Due to the increased pressure on land, climate change and increased demand for the crop, there is need for better agronomical practices that will ensure enough food production.
Place and Duration of Study: In Kenya, little attention has been given to the use of organic and inorganic mulch materials to increase productivity of horticultural crops and therefore this study was conducted in Alupe, Busia-Kenya, during the long and short rains season of 2015 to assess the efficacy of black plastic, transparent plastic and straw mulch on growth and yield of green pepper.
Methodology: The treatments were black polythene mulch, transparent polythene mulch, straw mulch and bare soil as the control.

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Results: The straw mulch elicited significantly vigorous growth of seedlings compared to the other treatments but had the lowest number of leaves unlike transparent mulch which had the most with 58. The widest stem circumference was observed on mulched plots as well as the plant height where the control recorded the lowest height. The black polythene mulch gave significantly (*P=.05)* heavier fruits of 924.5 g/plant during the long rain and 681.1 g/plant in the short rain season. Unmulched plots of either variety had the lowest mass recorded for fruit in both seasons. The transparent mulch showed significantly *(P=.05)* more seeds per fruit (196), longest fruit length (8.5 cm) and greatest fruit diameter (9.2 cm). Based on the experimental results the black polythene mulches had greatest effects on the growth, and yield of sweet pepper and showed superior performance among the plastic mulches in the study area and therefore is recommended.

Keywords: Capsicum annuum; remunerative vegetable; mulches; greatest effect.

1. INTRODUCTION

Green pepper (*Capsicum annuum* L.) is one of the most important vegetables that are consumed worldwide, after tomatoes and onions [1]. It belongs to the family Solanaceae, and was believed to have been introduced by Columbus from the new world [2]. Africa's production of green pepper was 7.70 million tons per year both dry and green fruit from 0.89 million hectares. It is one of the most important vegetables grown in Kenya, and other parts of sub-humid and semi-arid tropics [3]. Green pepper is increasingly becoming an important fresh vegetable in Kenya. Pepper contributes substantially to the diet of people, it is a good source of vitamins A, C (more than that obtained from tomato), E, B1, B2 and D [4]. The crop also contains high amounts of potassium, phosphorus and calcium. Peppers are used in making vegetable curry, salad etc. and as well has various medicinal values, use in the treatment of paralysis, fever etc. [5]. It is an economically and traditionally important crop in the country. It is grown as an annual crop and produced for its fruits. It is one of the most important vegetable crops for fresh consumption, for processing and as a spice (for making stew). It is also a very important crop for spice extraction since it has a lot of oleoresin for dying of food items [5].

Mulching is an effective method of manipulating crop growing environment to increase yield and improve product quality by controlling weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content [6,7,8]. Green pepper has been reported to respond to conservation measures [9] as evapotranspiration losses from the soil are reduced, plants maximize the use of available moisture, which help them minimize fruit dropping [10]. Tukur [11] also reported that mulching green pepper plots with pine needles promoted harvesting duration and increases pepper life span.

A lot of research has been done to increase pepper productivity [1,2], but little attention was given to the effects of synthetic and grassed mulching materials in improving pepper yield, especially in Kenya. This work, therefore, is aimed at evaluating the most effective material to be used in mulching of green peppers to help boost its production within the study area and other similar environments.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted during the two cropping seasons (long and short rains which occurred between March and August, and September and December respectively) of 2015 at the Kenya Agricultural and Livestock Research Organization (KALRO), Alupe Crops Station in Busia County in western Kenya region. It lies within latitude 0.30° N, longitude 34.07° E with an elevation of 1157 m above sea level. The study was specifically carried out in the experimental field where the topography of the land is slightly undulating. The type of soil in this area was observed to be sandy-loam with moderate porosity, hence moderate water retention ability. Soil samples were taken from the field to the Kenya Plant Health Inspectorate Laboratory where the pH of the soil was determined to be 6.08, using a pH metre at 1:1 soil water ratio. The average annual relative humidity for the period from March, 2015 to March 2016 ranged between 73.6% and 78.9%. Average annual rainfall (mm) at the study area ranged from 49.6 to 215.8 mm with average

annual maximum and minimum air temperatures ranging from 29.1 to 35.9 and 16.9 to 18.3℃ respectively.

2.2 Land Preparation and Transplanting of Seeds

The land was cleared prior to sowing of seeds. Ploughing and harrowing were performed on the land before nursery beds were made. The green pepper seedlings were transplanted after 30 days on the bed on 23rd March, 2015 for the long rain season and 26th September, 2015 for the short rain season to the main experimental field. Uniform seedlings of height 15 cm with 3 to 5 leaves were transplanted. The green pepper variety used was California Wonder with planting distance of 40 cm x 40 cm on plots that measured 4.0 m × 2.0 m. The transplanted seedlings were watered right after transplanting. They were also watered frequently (20 L per plot) on subsequent days, at least twice a day (early morning and evening), depending on the soil moisture content. Hand picking of weeds, stirring of the soil to enhance aeration were carried out regularly. Neemazal (neem seed oil) with an active ingredient azadirachtin, an organic insecticide and fungicide with an active ingredient Mancozeb at the rate of 1g per litre of water were used to control pests and fungal diseases respectively.

2.3 Experimental Design and Application of Treatments

The experimental design was a Randomized Complete Block Design (RCBD) consisting of four treatments replicated three times. The treatments were straw mulch (Finger Millet-*Eleusine coracana*), black polythene mulch (0.25 µm thick), transparent polythene mulch (0.25 µm), and bare soil (control). The black plastic polythene and transparent plastic polythene mulches were laid just before transplanting with the straw mulch, sourced from dry finger millet straw spread to a 2 cm thickness on the plots just a day before transplanting. Transplanting holes were made at pre-marked points on the plastic mulches.

2.4 Data Collection

The crop was visually observed at 2 and 3 weeks after transplanting (WAT) on its vigor and recorded on a scale of 1-3, where 1 was poor and 3 vigorous. Plant height (cm), number of primary branches per plant, main stem base diameter (cm) and number of leaves per plant were recorded from five plants in each plot after two week intervals. The length (cm), diameter (cm) and number of seeds of five randomly selected mature green fruit were measured from each plot at harvesting. The total fruit mass (g) and number of seeds per fruit were recorded at final harvest.

2.5 Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) and means of plant growth parameters and fruit mass were compared using SAS computer software (Version 9). When significant differences were obtained *(P=.05)*, means were separated with Fisher's LSD test.

3. RESULTS AND DISCUSSION

3.1 Seedling Vigor

Significant differences at *P=.05* were observed between the mulching materials on the seedling vigor for both seasons where green peppers in the straw mulch had the greatest growth vigor compared to the other treatments (Fig. 1). During the long rain the green pepper plants in the black polythene had similar seedling growth vigor as the plants in the straw mulch. In both seasons the unmulched treatment had poor growth compared to the mulched treatments. This was due to the mulches' high rate of moisture preservation and allowed reduced transpiration rates by the plants in the mulched plots. Soil mulching also improved the micro-climate at the vicinity of the plants which facilitated plant growth. This has been reported in other studies where it was found that young green pepper seedlings cannot withstand either water deficit or excess soil moisture while older plants will be sensitive to moisture balances at crucial stages of flowering and fruiting [12].

The conservation of soil moisture may help in preventing the loss of water through evaporation from the soil facilitating maximum utilization of moisture by the plants. Mulching with plastic is a method by which soil moisture can be conserved [13].

3.2 Number of Branches and Leaves per Plant

Mulch treatments influenced significantly (*P=.05*) the number of branches for both seasons from week two after transplanting to week eight after transplanting with a linear increase in all

treatments. The straw mulch showed the least number of branches per plant and stagnated at week six while the other materials and the control continued to increase especially in the long rain season. The transparent mulch had the highest number of branches per plant for both seasons. All the mulches had the positive effect on generating and retaining a higher number of branches per plant. Favorable weather condition and moisture of the soil are important parameters affecting the number of branches per plant. It was reported that mulched tomato plants had more branches than that of unmulched plants, which confirms the present results [14].

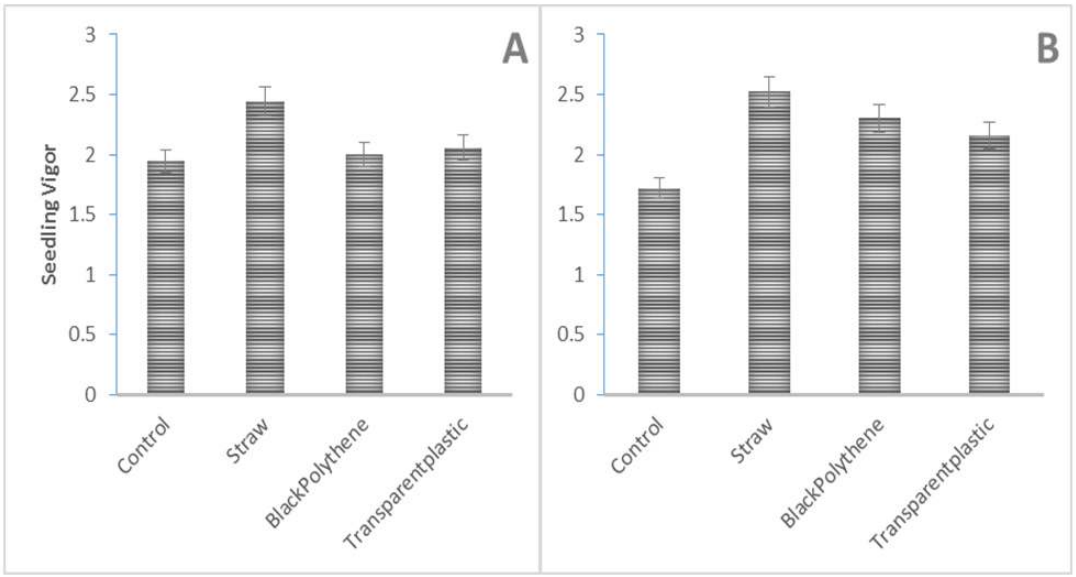

Fig. 1. Influence of mulching materials on seedling vigor of green pepper during the short rain season of September – December 2015 (A) and long rain season of March – August 2015 (B) in Busia, Kenya

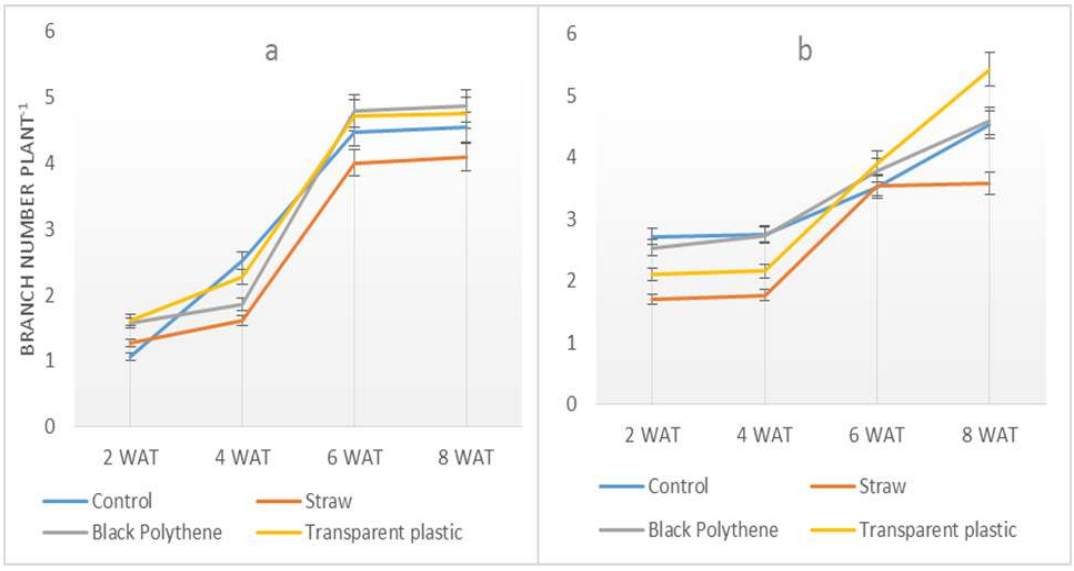

Fig. 2. Effect of mulching materials on the number of branches per plant during the short rain season of September – December 2015 (a) and long rain season of March – August 2015 (b) in Busia, Kenya

The maximum number of leaves per plant was found on the plants mulched with transparent and black plastic polythene mulches at all growth stages but with significant differences between treatments only observed at week 8 and 10 after transplanting (Fig. 3). The transparent mulch had the highest number of leaves per plant at ten weeks after transplanting (10 WAT) with a mean of 56 leaves per plant. The microclimatic condition which was improved by the mulches might have provided a suitable habitat for producing higher number of leaves by the plants. Similar findings were observed in another study where the effectiveness of plastic mulches for the production of leaves in maize was better than the control as was reported by Izakovic [15].

3.3 Plant Height and Stem Girth

The smallest plants were observed in the control plots at all the growth stages while the mulched plots showed significantly taller plants (Fig. 4). There was a linear increase in all the treatments with the control lagging until 10 weeks after transplanting (10 WAT) where the black polythene consistently showed the tallest plants. The increased plant height in mulched plants was possibly due to better availability of soil moisture and optimum soil temperature provided by the mulches. Changes in the plant height of green pepper have been observed by using different mulches and plastic mulch increased the plant height more than other mulches [16].

Mulched plants had significantly higher base diameter than those in controls at all growth stages for both seasons, followed by the control which had the least (Fig. 4). The plant without mulch had the smallest base diameter at all growth stages. This result was in conformity with the report of Easson and Fearnehough [17] on forage maize. Similar result was also reported by Panchal et al. [18] who found that mulch had a significant effect on total chlorophyll content in green pepper under black plastic mulch and showed the greatest total chlorophyll content among the mulches thereby enhancing plant heights positively.

Less moisture depletion under the mulches was a result of prevention of contact between the soil and dry air, which reduced water loss into the atmosphere through evaporation. Also, mulches reduce impact of raindrops and splash, thereby preventing soil compaction, reducing surface run-off and increasing water infiltration [19]. All these combined to increase the soil moisture content and reduce moisture depletion. As moisture depletion is least under the plastic mulches so the rate of moisture recharging ability would be least because water infiltration will be prevented. None the less, capillary movement of water molecules through the soil pores from the water table will supply water to the root zone of the crop grown under plastic mulch [7].

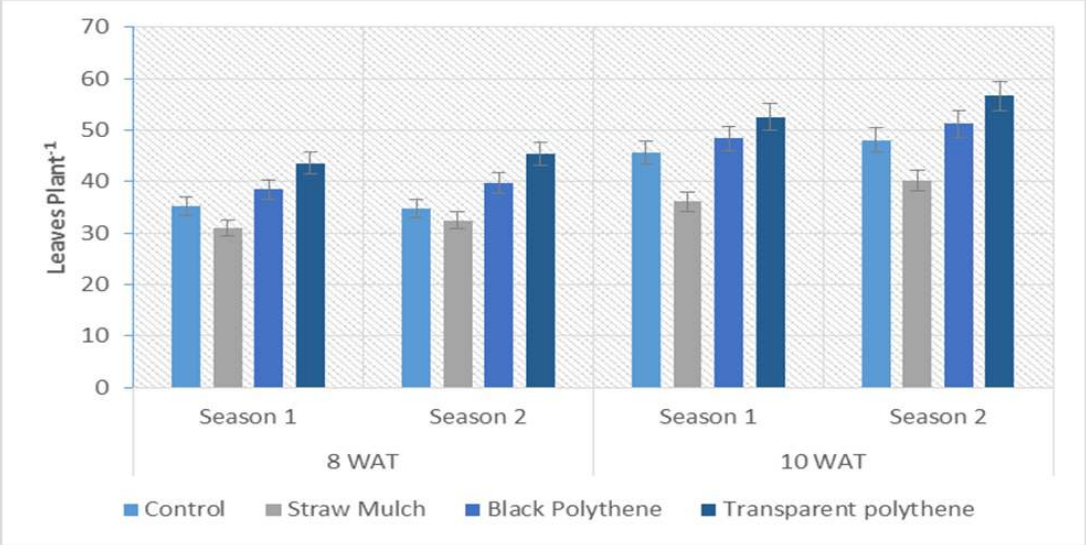

Fig. 3. The number of leaves per plant among mulching treatments in Busia, Kenya during the short rainy season (September – December 2015) and long rainy season (March – August 2015)

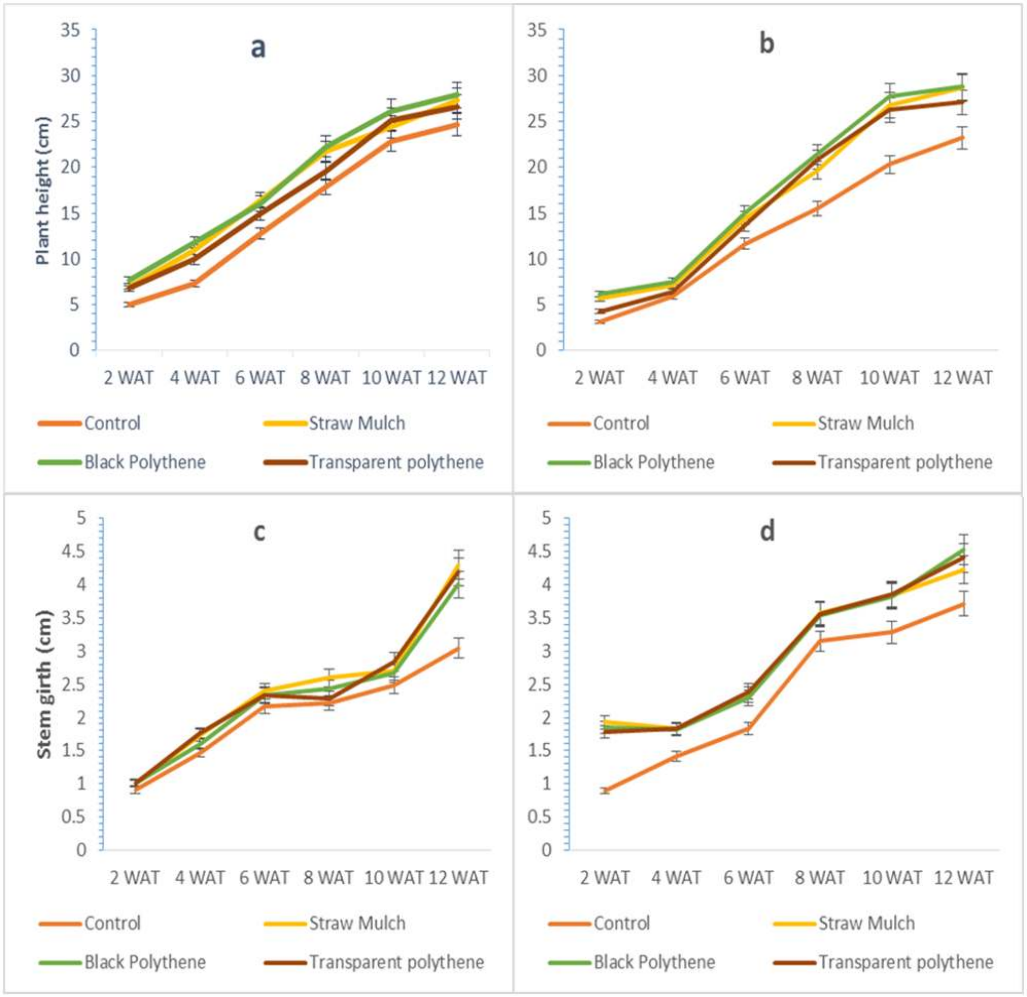

Fig. 4. The influence of mulching materials on the plant height of capsicum in the short rains of September – December 2015 (a) and long rains of March – August 2015 (b), and stem girth in the short rains season of September – December 2015 (c) and long rain season of March – August 2015 (d) in Busia County, Kenya

3.4 Fruit Length, Diameter and Number of Seeds

Fruit length and diameter was significantly different (P<.05) between all the treatments as compared to the control for both seasons (Fig. 5). The mulched plots had a greater fruit diameter and length with a maximum of 7.8 cm on the black polythene treatment for the length and 5.5 cm on the straw mulch for the fruit diameter.

The increase in fruit length may be due to the varying moisture regimes in the soil for the different mulching materials used. Probably the black polythene, transparent polythene and straw mulches conserved more moisture due to lower evaporative losses than the unmulched plots. Alabi [20] reported that the increase in the number of leaves would increase photosynthetic surfaces and the current photosynthates produced would enhance the physiological activities leading to production of more assimilates used to significantly increase fruit production, fruit sizes and fruit diameter. Larger and wider hot pepper pods are considered to be the best in quality and are more in demand for fresh as well as dry pod use in markets [21]. Therefore, subjectively, this quality attribute, along with pod length and pericarp thickness, could be preferred by consumers over thinner and shorter pods.

The transparent mulch resulted in the highest number of seeds per fruit while the control had the lowest during the long and the short rain seasons (Fig. 6). The differences were however not significant among the mulched treatments. Bosland and Votava [22] indicated that, in some cultivars of green pepper seed can contain up to 60% of the dry mass of the fruit which makes it an important economic part of the crop.

3.5 Fruit Mass

The effect of different plastic mulches on fruit mass per plant was significant at P<.05. The black plastic polythene mulch had the heaviest fruits (924.5 and 649.8 g/plant) which was however insignificantly different from the other mulched plots for both seasons as shown in Fig. 7. The transparent mulch did have the second heaviest fruits then followed by the straw mulch with 890.5 and 649.8 g/plant and 858.7 and 635.5 g/plant during the long and short rain seasons respectively. Ravinder et al. [19] reported that mulching significantly improved the number of fruits per plant thus the mass and reduced the percentage of fruit abortion compared to unmulched control, as found in the present experiment. They observed that the plants in the black plastic mulch produced the highest fruit mass per plant (533.4 g) and per hectare (21.3 t), followed by blue and transparent plastic mulches. Control plot showed the lowest fruit yield both in per plant (336.3 g) and per unit area (13.45 $t \cdot ha^{-1}$).

Fruit yield increased in mulched plot because of increased number of fruits per plant. These results coincide with those of Siborlabane [23], who pointed out that the yield and quality of the fruit for the fresh tomato market varies according to the type of mulch used on the plantation. The increase in the number of fruits per plant of mulched plot was probably associated with the conservation of moisture and improved microclimate both beneath and above the soil surface. The suitable condition enhanced the plant growth and development and produced increased fruit bearing nodes compared to the control. Considering relationship between the soil moisture content and fruit number, it was clear that fruit number was strongly related with soil moisture content. Olarewaju and Showemino [24] observed the increase in biological activities in the soil to influence nutrient availability and subsequently the fertility of such soils.

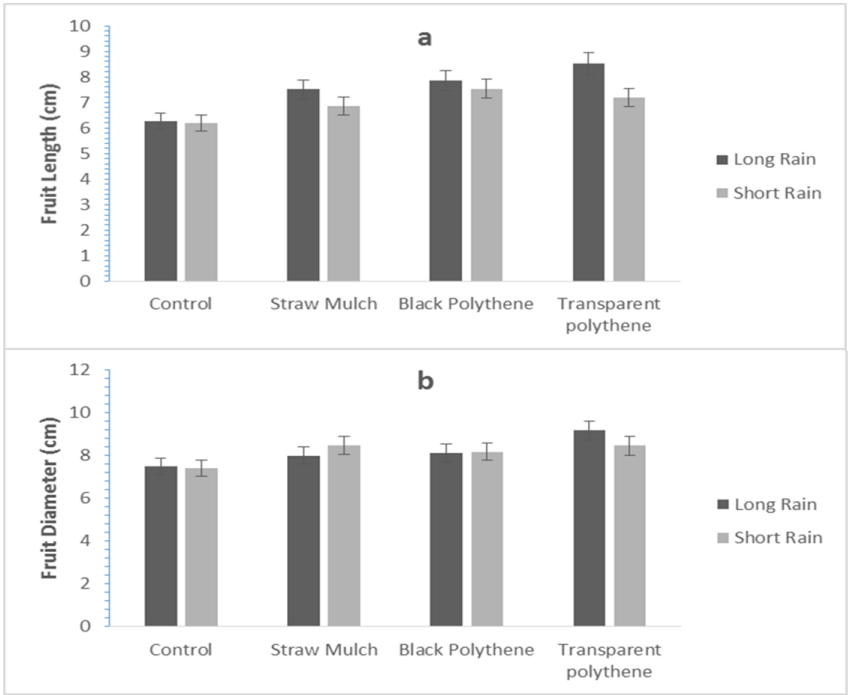

Fig. 5. The fruit diameter (a) and fruit length (b) as influenced by different mulching materials in the long rains of March – August 2015 and short rain season of September – December 2015 in Busia, Kenya

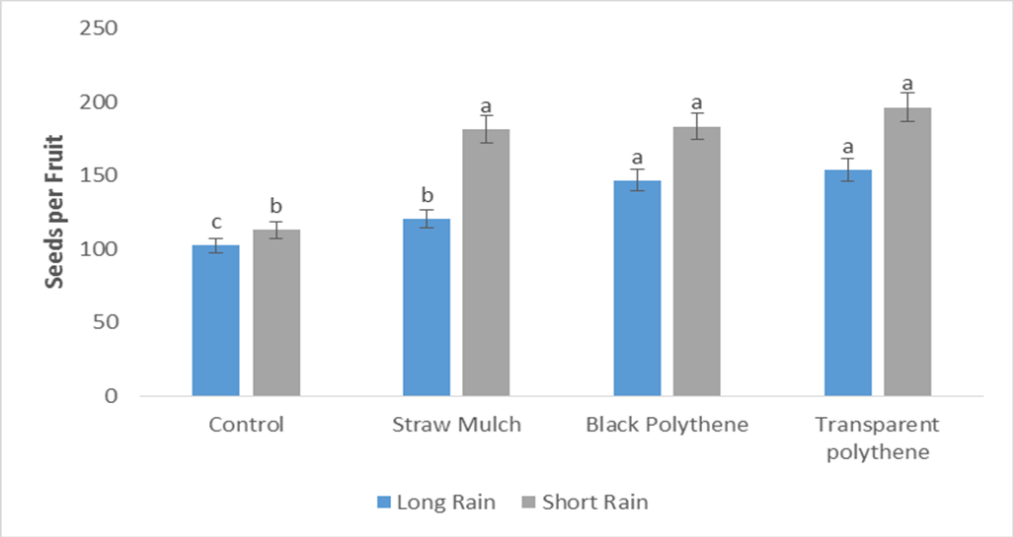

Fig. 6. The average number of seeds per fruit for the long rains of March – August 2015 and short rains of September – December 2015 in Busia County, Kenya

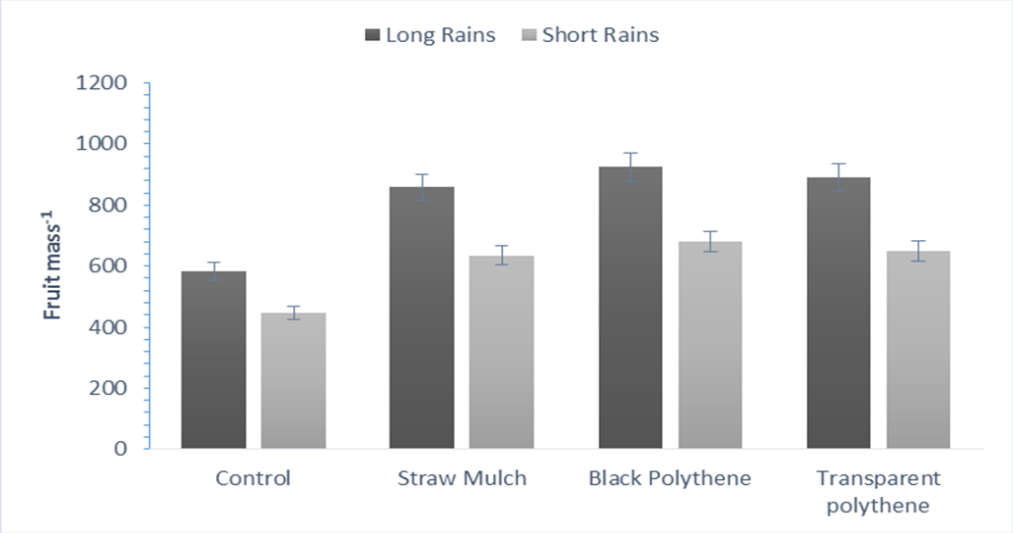

Fig. 7. The total fruit mass as influenced by mulching materials in two seasons of 2015 in Busia County, Kenya

4. CONCLUSION

For vegetable growers to remain competitive in today's export market place and continue to supply to the local market, they must continually strive for higher quality, superior yield and extended production cycles of green pepper. Based on the experimental results, it could be concluded that plastic mulches had significantly positive effects on the growth, and yield of green pepper, and black plastic showed superior performance among the plastic mulches in the study area. It is therefore recommended that black polythene mulch be used in growing green pepper in the study area for better conservation of soil moisture and nutrients for good crop growth and higher yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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