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Differing effects of grass and polythene mulches on sweet potato productivity in derived savannah agroecology

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Summary: Sweet potato as a food crop that is grown for both its tuberous roots and vegetative parts, the latter of which also serves as animal feed. Its production in the savanna regions can be limited by high evaporative demand, especially where soils with low water retentivity are involved. This work studied the effects of various locally available polythene as mulch materials for sweet potato growth in derived savanna agroecology. An experiment was thus conducted at Nsukka, a derived savannah in southeastern Nigeria, with orange fleshed variety of sweet potato. Treatments were polythene mulches of contrasting colours (black, white, red and blue polyethylene), including also organic mulch (dry grasses) as reference and a no-mulch control. The experiment was executed in two successive cropping seasons, and the data averaged and analysed. Agronomic and weed incidence data collection was done fortnightly from 2nd to 10th week of planting. The results showed that the polythene mulches (especially the black one) were better in the control of weeds. Furthermore, the sweet potato yields were affected significantly ($p < 0.05$) by mulching on the total number of tubers for each plant with grass-mulched plots showing the highest value (36) and transparent polyethylene-mulched plots the lowest (19). Also, total weight of tubers per plant at harvest differed ($p < 0.05$), with grass-mulched plots showing the highest value (2.39 kg), followed by the control (no mulching) plots (1.62 kg), then the coloured polyethylene mulched plots with the red polyethylene-mulched plots as the lowest (0.64 kg). This study recommends the use of organic mulch or no mulching in sweet potato production in this agroecological zone as they produced the best yields.

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Key words: mulching, polyethylene, sweet potato, yield, weed suppression

Introduction

Sweet potato is the fifth major food crop especially in the developing countries after rice, maize, wheat and cassava (International Potato Center CIP, 2019). According to FAO's (2018) report, sweet potato's production and utilization has been on increase in the past few decades. FAO (2022) recorded that China is the highest producer of sweet potato with more than 75.80 millions of tonnes per annum harvest. The second largest producer in Africa is Nigeria with 3.74 million metric tons annually (Mmasa, 2023). As food, it contains a lot of important nutrients for both humans and animals, while also serving as an economic crop for many farmers (Nnadi et al., 2020). Researchers such as Adubasim et al. (2017) and Nuraini et al. (2023) noted some nutrient elements found in sweet potatoes to include proteins, fats, vitamins and carbohydrates. Sweet potato can be baked, roasted, boiled, or mashed, and they can be used in a variety of dishes, including soups, stews, and casseroles. In some parts of the world, sweet potatoes are even used to make desserts such as pie (Zaldariaga et al., 2022).

There have been agronomic studies on sustainable increased production of sweet potato in southern Nigeria through adopting appropriate plant spacing (Adubasim et al., 2017) and soil tillage and nutrient management practices (Nnadi et al., 2020; Obalum et al., 2020a; Ogumba et al., 2020; Ogumba et al., 2024). The prospects of mulching in its production has received little or no research attention. Mulching is an important agricultural technology referring to the covering of the soil with materials (which can be natural or synthetic) in crop production due to a range of believed beneficial effects mostly on the fertility of the soil together with other factors that could enhance crop productivity. It has been reported to conserve soil moisture and provide some benefits to growing crops (Obalum et al., 2012, 2017; Khan et al., 2015), as well as to the environment. For instance, grass mulch constitutes temporary detention of rain or irrigation water, thereby promoting its infiltration into the soil to minimize runoff losses and soil erosion, while ensuring favourable soil-water relations (Ezenne et al., 2019; Obalum et al., 2020b). Its ability to lower soil temperature can contribute to stabilizing the soil for increased resistance against erosion and retention of plant nutrients and water for crop growth (Osakwe et al., 2023; Okorie et al., 2024). However, mulch effects depend largely on the type of material used.

Mulching research has focused largely on cereal, leguminous and vegetable crops (Obalum et al., 2011a, b, 2017; Obi et al., 2024; Okorie et al., 2024), not on root and tuber crops. In the bulk of the tropical region, surface mulching is viewed as primarily for soil moisture conservation. Because sweet potato, specifically, is often viewed as a hardy, drought-tolerant crop (Nnadi et al., 2020), it is rarely considered a candidate crop for surface mulching. However, apart from soil moisture conservation, surface-applied mulch can have many other ecological and economic benefits (Obalum et al., 2011c). Mulching can also inhibit weed growth and emergence in farms due to reported effects on reduction of weed density accumulation (Sathiyamurthy et al., 2017; Mzabri et al., 2021; Obi et al., 2024). Weeds are enduring with vigorous growth habit, competing with the desired plant for nutrients, soil moisture and light. They can shelter and hence serve as hosts for diseases and pests such as weevils that attack sweet potato roots (Koussoube et al., 2018). Weeds therefore, can lead to reduced growth and yield of the sweet potato crops. They can also interfere with the harvest of sweet potatoes by entangling with the vines and with the stubborn ones growing through the flesh of the tubers, thereby making harvesting challenging and reducing tuber quality by imparting undesirable flavors and textures.

Recently some studies have been carried out on mulching effects on sweet potato crops such as Zagipa et al. (2024), Paramyta et al. (2024), and Shrestha & Miles (2022) in Kazakhstan, Indonesia and USA, respectively. The outcomes of these studies in other regions of the world may not aptly apply to the vast savannah region of tropical Africa. To our knowledge, the present study is the first to evaluate polythene mulch against the conventional grass mulch on sweet potato production in tropical Africa. The study was initiated with the main purpose of evaluating how different locally available mulch materials (organic and synthetic) affect sweet potato production on dominantly coarse-textured soils of derived savannah agroecologies.

Materials and methods

Study site

This field experiment was conducted at the Demonstration Farm of the Department of Crop Science, University of Nigeria Nsukka for two seasons in 2022 and 2023 and averaged data used. The area is located at 06° 52’N and 07°24’E on the southeastern Nigeria region of derived savannah agroecology. The average elevation of the place is 447 m above sea level with two distinct seasons of rainy and the dry seasons (Obi et al., 2024). Rainy season is normally from month of April to October but has a short dry period in August (Uguru et al., 2011). The usual average annual rainfall of the region of the experiment is approximately 1550 mm although 85% of this rain is recorded mostly in the rainy season. Temperature of the area ranges from about 22°C minimum with 30 °C as the maximum with the average relative humility at above 60% (Uguru et al., 2011).

Experimentation

The planting materials (vine cuttings) of orange fleshed sweet potato variety and the treatments being organic mulch (black, white, red and blue polyethylene) and organic mulch (dry grasses) were all sourced locally. Land preparations were done manually using hoes and cutlasses. A field area of 8 m × 11 m was cleared using cutlass. Seedbed was made manually using hoe. The seedbeds were partitioned into three (3) blocks and each block was divided into 6 plots. Each plot had a measurement of 2 m by 3 m and was spaced 0.5 m apart from each other while blocks were kept at a distance of 1 m apart. Organic fertilizers were applied uniformly to each plot of the experiment. The polythene mulches were spread on the plots meant to receive them while the grass mulch was applied. This field experiment was replicated into three using a layout of the Randomized Complete Block Design (RCBD). The plots were established at a plant spacing of 90 cm x 90 cm.

Parameters measured

Data collection: the sampling unit comprised of four plants from the middle row of each plot.

Number of leaves on each individual plant: This was done by counting the leaves on the sampling plants per plot starting from two weeks to 10 weeks after planting (WAP).

Number of weeds in each plot: It was done by counting the number of weeds in a plot.

Plant girth: It was done by measuring the circumference of the stem base with a measuring tape.

Number of branches in each individual plant: In each plot the number of branches of the sample plants were counted and recorded.

Length of vine: It was done by measuring the vine length with a calibrated measuring tape.

Total number of harvestable tubers in each plant: Total harvestable tubers in each plant was done by recording the total number of tubers harvested from the sampling plants.

Total weight of harvested tubers per plant: The total weight harvested of tubers were recorded for each individual sampling plant.

An analysis of variance (ANOVA) for an RCBD field experiment layout was performed on the collected data with the aid of a statistical software called GenStat. Also Fisher’s Least Significant Difference was used as the post-hoc for treatments means separation at 5% probability level. Figures presentation of data were done using excel workbook.

Results

Mulching has been reported to not only increase the growth and yield of crops but also improved the soil water content, weed and disease control as well as temperature regulation of especially in the upper soil structure layers (Weeratna et al., 1992). In ***Figure 1*** it was detected that the different mulch types influenced the number of branches produced by the sweet potato, though the treatments did no differ significantly throughout the periods of observation. However, the blue polyethylene mulched plots had plants with the highest number of branches produced by a plant at 4, 8 and 10 WAP, transparent colored polyethylene and red polyethylene mulched plots had plants with the highest at 2 and 6 WAP respectively. The red polyethylene mulched had plants with the lowest values at 2 WAP, black polyethylene mulched had plants with lowest values at 4, 6 and 8WAP, and the control had plants with lowest values at 10 WAP. At last period of experimentation 10 WAP, blue polyethylene mulched plots had plants with the highest number of branches (25) as against the control which had the lowest number of branches (17).

Figure 2 shows how the different mulch types affected the number of leaves produced by the sweet potatoes. Again, there was no significant treatment effect ($p > 0.05$) during the experimentation. However, the blue polyethylene mulched treatments produced plants with the highest number of leaves averaged at 439 while the control had plants with the lowest values (272), followed by the black polyethylene mulched plots (338). The treatments also had no effect that was significant at $p > 0.05$ on the plant’s girth in the experiment (***Figure 3***).

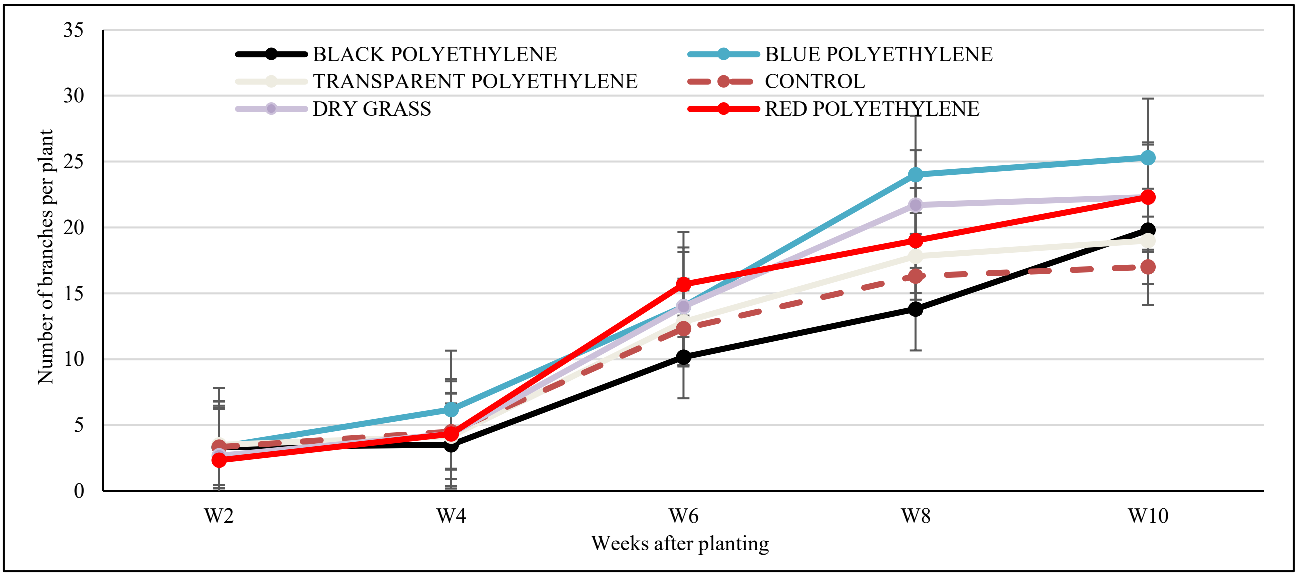

Figure 1: Effect of the mulch treatments on number of sweet potato branches.

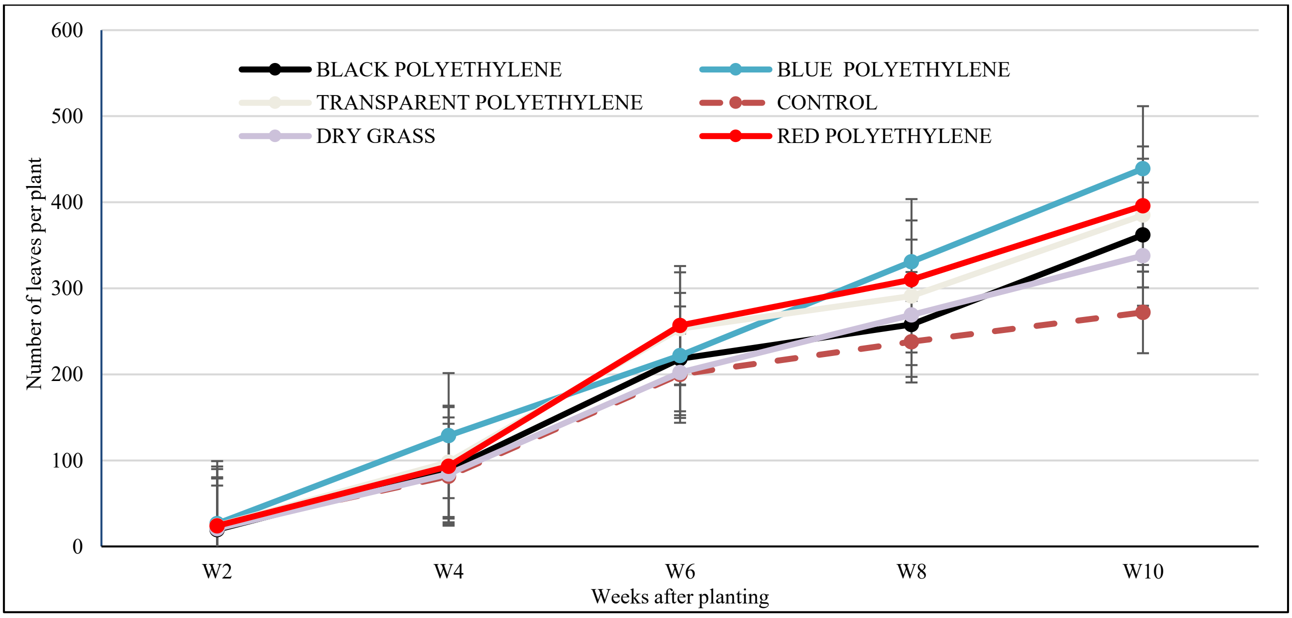

Figure 2: Effect of the mulch treatments on number of sweet potato leaves.

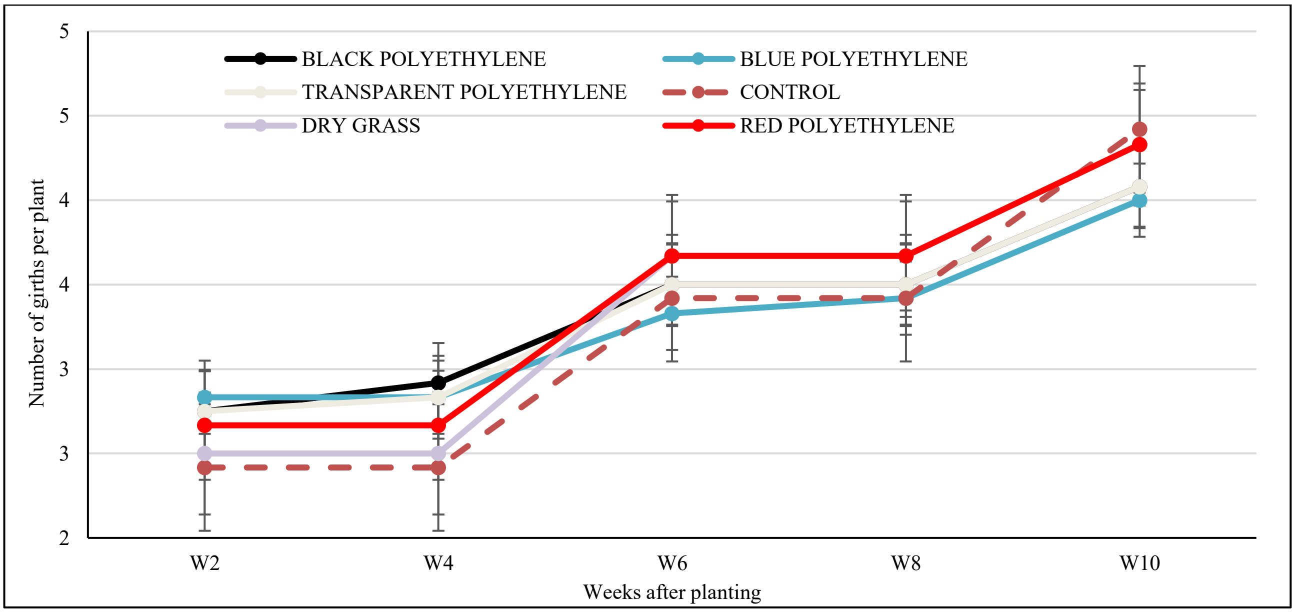

Figure 3: Stem girths per sweet potato plant as affected by mulch treatments at Nsukka, a derived savannah agroecology.

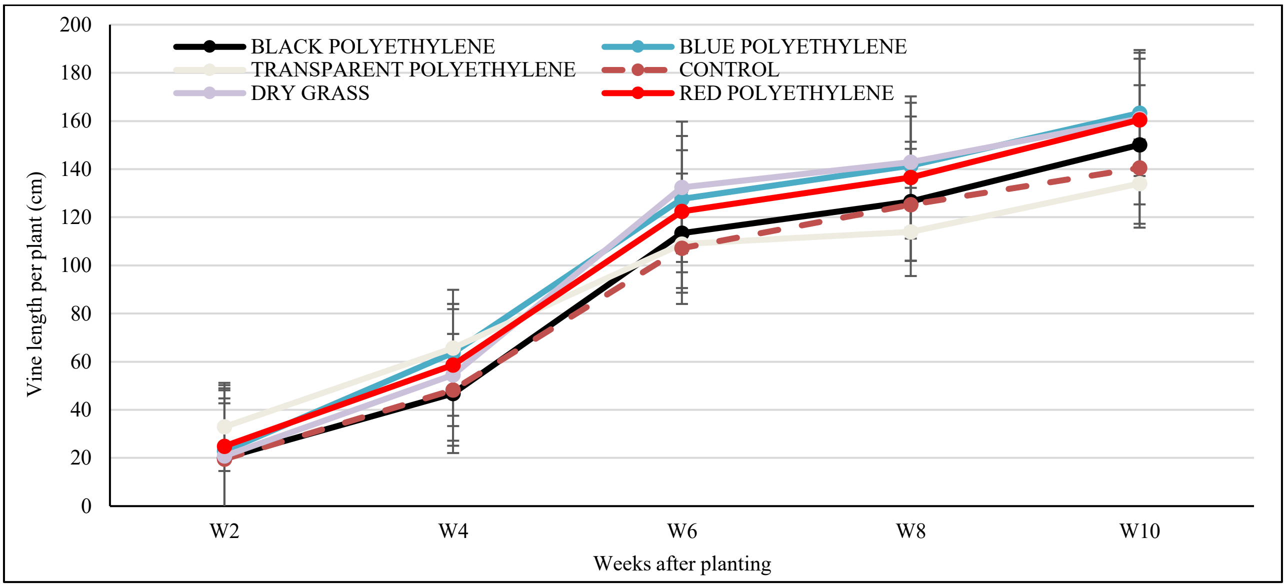

Figure 4: Effect of the mulch treatments on number of sweet potato vine length.

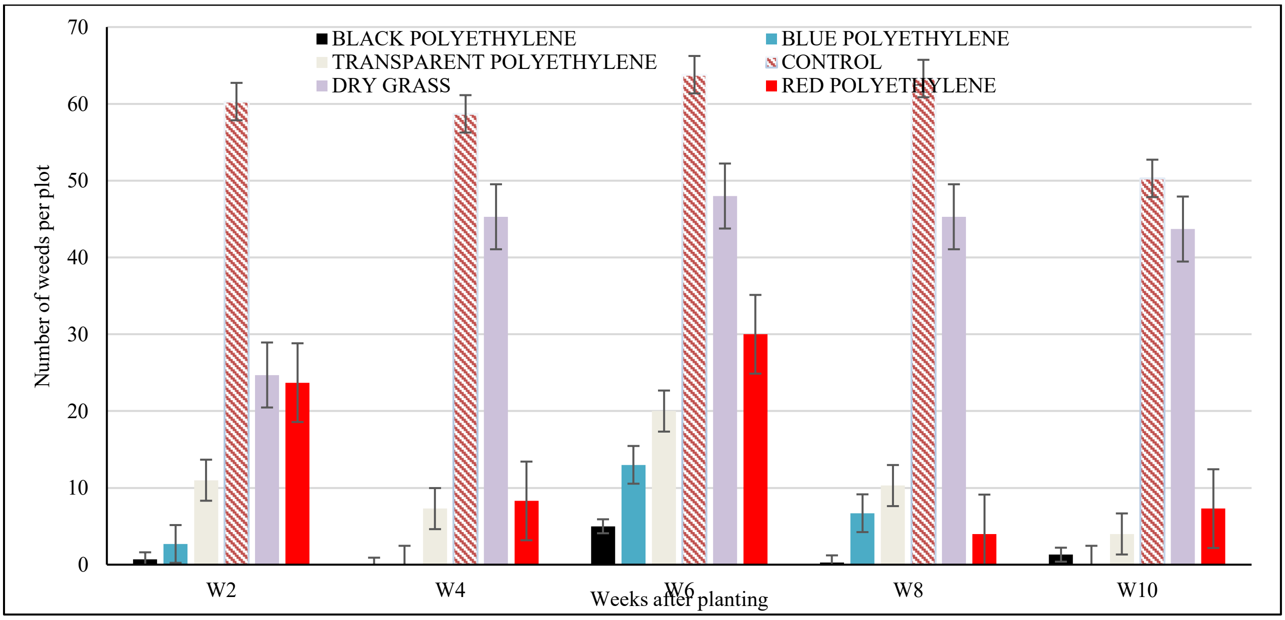

Figure 5: Effect of the mulch treatments on number of weeds on the sweet potato plots.

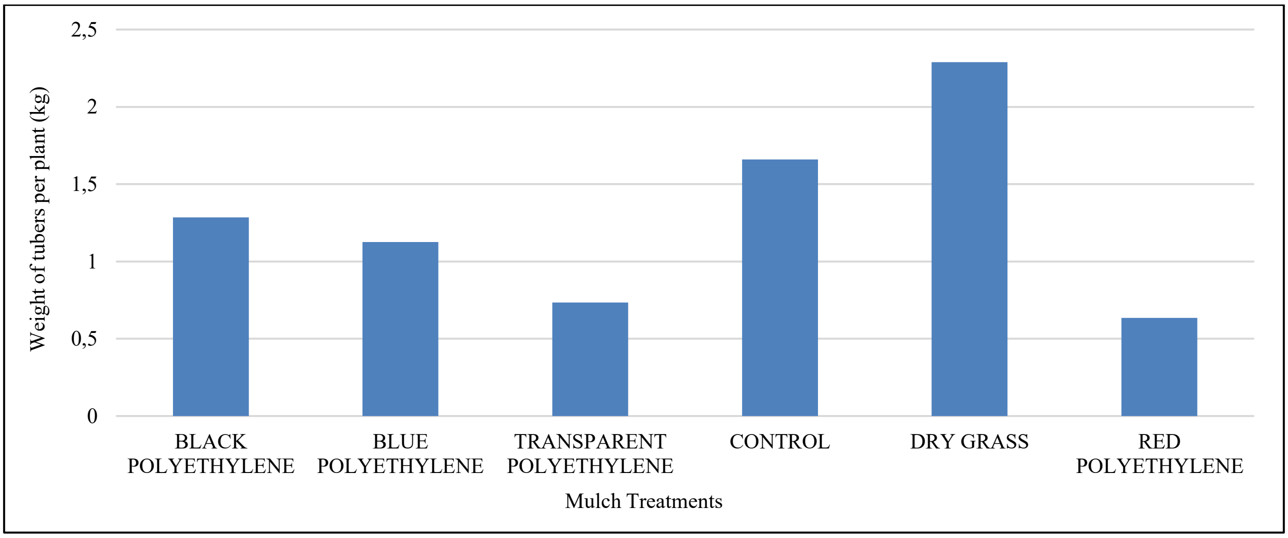

Figure 6: Weight of harvested tubers yield per plant in kg of the sweet potato farm as affected by mulch treatments at Nsukka, a derived savannah agroecology.

However, the blue polyethylene mulched plots had plants with the highest stem girth at 2 WAP, black polyethylene mulched plots had plants with the highest at 4 WAP, dry grass and red polyethylene mulched plots had plants with highest at 6 and 8 WAP, respectively, and control had the highest at 10 WAP. The control had the plants with the lowest values at 2 and 4 WAP, blue polyethylene mulched plots had plants with the lowest at 6 WAP, control had plants with the lowest value at 8 WAP, and blue polyethylene mulched plots had plants with the lowest at 8 and 10 WAP.

In ***Figure 4***, it was observed that the different mulch types had varying effects on vine length of the sweet potato. The transparent polyethylene mulched plots had plants with the longest vines per plant at 2 and 4 WAP, dry grass had plants with the longest vines at 6 and 8 WAP, and blue polyethylene mulched plots had plants with the longest vines at 10 WAP. The control had plants with the shortest vines at 2, 4 and 6 WAP and transparent polyethylene mulched plots had plants with the shortest vines at 8 and 10 WAP. Data as collected at 10 WAP showed that blue polyethylene mulched plots had plants with the longest vines that are up to 163 cm, followed by the dry grass and red polyethylene mulched plots with plants showing vine lengths of 161 cm. The shortest vines were observed in plants grown in plots mulched with transparent polyethylene and the control which were 134 cm and 141 cm, respectively. The observed longer vines, larger stem girths, and increased number of branches and leaves in this study concurs with the report by Mamkagh (2009). In that report, use of mulch materials to cover the soil surface resulted in increased observable morphological features in comparison with the bare soil. These increases can be due to increased soil temperature resulting from its improved ability of water use efficiency (Kouwenhoven et al., 2002).

In this study as shown in ***Figure 5***, the differing mulch types affected the number observed of the weeds on the sweet potato plots; therefore, this was significantly affected ($p < 0.05$) significantly by the treatments. Control had plants with highest number of weeds per plant at 2, 4, 6, 8 and 10 WAP while black polyethylene mulched plots had plants with the lowest values at 2, 4, 6 and 8 WAP while blue polyethylene mulched plots had plants with the lowest value at 10 WAP. There were significantly higher values of weed density recorded on the control plots when compared with the mulched plots. This shows that without covering of the soil surface with mulch, greater spreading of weed seeds would occur leading to more weed growth. The synthetic polythene mulches provided sufficient weed control. These synthetic mulches were able to suppress the weeds to almost 100% at the end of the experimentation of 10 WAP. Furthermore, light exclusion as was the case with the dark plastic mulch has the tendency of preventing massive weed growth and development. This observation concurs with that reported by Zhu et al. (2021) where the black colored polyethylene film was a near-perfect weed control technique. This is because it absorbs the most sunlight and heats up the soil. The heat helps suppress weed germination and growth by creating an inhospitable environment for weed seeds. However, the control had up to 50 weeds per plot at 10 WAP, while dry grass mulched plots had 44 weed plants at the same period.

Treatment had significant influence on the total weight of harvested tubers for each individual plant (***Figure 6***). The dry grass mulched plots had plants with the highest value which did not differ significantly from the transparent mulched plots. The red polyethylene mulched plots had plants with the lowest value for total weight of tubers yield per plant. The organic mulch gave the best yield followed by the control. The positive influence of organic mulch on tuber yield of sweet potato grown with conventional tillage in this study is despite the fact it is not known to promote earthworm burrowing activity under this tillage system in the study environment (Obalum & Obi, 2010), and so may not lead to loosening of the root zone for greater tuberization. However, there have been many similar reports of grass mulching increasing tuber yield of sweet potato (Musie et al., 2015; Iqbal et al., 2020; Wang et al., 2022). Among the synthetic mulch types, the black polyethylene gave the best yield when compared with others. This is attributed to the ability of black polyethylene to create a warm microclimate around plants, increasing soil temperatures and conserving moisture (Swenson et al., 2004). It also prevents weed growth, which can compete with sweet potato plants for space, nutrients and water. From this study the total weight of harvested tubers when ranked according to the mulching treatments are in the following order dry grass > control > black polyethylene > blue polyethylene > transparent polyethylene > red polyethylene.

Conclusions

This study was conducted to evaluate the influence of organic mulch and polythene mulches of contrasting colour on sweet potato growth and development. Different inorganic mulches used were very beneficial in managing weeds, especially black polyethylene. Weed control could lead to the decrease of the costs of labour for final crop production. However, this black polyethylene gave lower yield of sweet potato compared to dry grass and control. Organic mulch was the treatment that favoured the yield of sweet potato compared to other mulch materials. While the black polythene mulch helped in weed suppression compared to the others, organic mulch promoted sweet potato production more than others. Therefore, this research recommends the use of organic mulch in growing sweet potato or preferably this tuber crop should not be grown with surface mulch in this agro ecological zone as this approach produced similar yields, and also considering the cost implication of mulching. Although from this study it is obvious that Nsukka area of Nigeria is suitable for sweet potato production, its greatest limitation is non-involvement of different cultivars of sweet potato. Therefore, further studies are needed to fully evaluate mulching effects in this region using cultivars that differ genetically. Such studies should be of multi-location trials, and should delve into the economics of using different mulch materials for producing sweet potato in the area.

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