EFFECT OF MULCHING MATERIALS ON WEED INTENSITY UNDER TWO TOMATO CULTIVARS IN BUNGOMA, KENYA

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(Received 05th September 2021; accepted 30th November 2021)

Abstract. Tomato (*Solanum lycopersicum* L.) is one of the main vegetables cultivated in Western Kenya by small scale farmers. It is grown as subsistence and cash crop, thus creates employment that generates household incomes and improves the farmers' living standards. Tomato yield is below potential in Western Kenya, which can be attributed to myriad challenges that farmers encounter during production. Among the notable bottlenecks is invasive weeds that compete with tomato for nutrients and space, besides being alternate hosts of virulent pests and diseases. The aim of this research was to investigate the efficacy of different mulching materials on growth intensity of weeds in tomato fields in Western Kenya. Field trials were carried out in 2015 and 2016 in short and long rainfall periods, respectively. The experiments were set up in Randomized Complete Block Design under split-plot layout, and replicated four times. Two tomato varieties, Tylka F1 (semi-determinate) and Cal J (Determinate) were sown on soil beds covered with different mulching matter, thus; black polythene paper, no mulch, and transparent polythene film and sugarcane trash. Data was collected from two 50cm × 50cm quadrates randomly laid per plot, on weed fresh and dry weights. The data was run for analysis of variance (ANOVA) using SAS software and means were separated at $\alpha=0.05$, using Fischer's Protected LSD. The results indicated that, mulching significantly influenced ($p<0.001$) the weight of weeds in both seasons. Both fresh and dry weeds weighed more (522g) and (36.5g) respectively for non-mulch treatment compared to mulched treatments in the short rain season. The same observation was made during long rain season in both tomato varieties ($P<0.001$). The study concludes that mulching with both organic and non-organic materials reduce weed intensity, and recommends mulching in open field tomato production to control weeds.
Keywords: *determinate and semi-determinate tomato, mulch, organic and inorganic soil covers, weed industry*

Introduction

Tomato (*Lycopersicon esculentum*) is a member of Solanaceae family and an important vegetable that is grown widely across the world. It is either eaten fresh or in processed formulations. These processed products include tomato juice, pulp, purée, paste, pickles, dried whole tomatoes or flakes, soup and sauce. On the other hand, tomato is commonly used as a model crop for different botanical studies such as physiology, biochemistry and genetics, because it has a relatively short life cycle and are comparably easier to grow and manipulate. Tomato is among the leading crops produced in Western Kenya, which includes Bungoma County. It ranks high among the most consumed vegetables. This is due to the favorable climatic conditions in the area of study. The vegetable is often grown during the rainfall off–season, thus supplemented with irrigation. The vegetable is generally grown in near dry swamps near riparian areas of water bodies like rivers, streams, and dams for ease of watering.

Consequently, the commodity then fetches premium selling price due to its high market demand, especially in the plains surrounding Mt. Elgon agro-ecological zone (AEZ) I, according to Braun (1980). Despite these favorable ecological conditions, productivity of tomato is still sub–optimal when compared with its full potential. Previous research has shown that the low yield in Bungoma County and areas beyond is a result of myriad challenges facing tomato production value chain, which include weeds, diseases such as; bacterial and *Fusarium* wilts (Saddler, 2005; Yabuuchi et al., 1995) and, bugs such as leaf miner (*Tuta absoluta*) and red spider mite (*Tetranynchus urticae*), and nutritional disorders, especially blossom end rot (Saure, 2001) and sun burn.

Further studies have documented weeds as one of the most economically important pests that significantly limit tomato production in Bungoma County (The Council of Governors, 2013). The weeds range from noxious broad–leaved annuals to perennial grasses and shrubs. These weeds compete with tomatoes for growth resources such as nutrients, moisture, sunlight, space as well as pollinators-bees. Besides, weeds play host to the many potentially virulent tomato pathogens (Baptista et al., 2006) and insect vectors such as whiteflies and aphids that cause and disseminates most crop diseases. To control these pests, farmers have adopted the commercially available weed control approaches which are expensive and beyond affordability by most small scale tomato farmers in Bungoma County, thus not sustainable. Besides, most of these chemical–based herbicides being applied by the farmers have broad spectrum mode of action, which indiscriminately kill beneficial microorganisms, thus endangering ecological balance of biodiversity (Wabwoba and Mutoro, 2019; Merwin et al., 1995). Some of these pesticides also have long residual effect in the soil because they are not easily biodegradable and have undesirable toxic effects on human health.

In the light of this, it is justified to find other cheaper but effective and sustainable substitutes for weed control. One of these approaches is to find ways to manipulate the crop environment (Chawla, 2006) such that it does not favour weed establishment (Read, 2007). Studies have shown that mulching is among the most sustainable methods of weed management especially for smallholder farmers (Bhardwaj, 2011). Mulches protect tomato crops against the negative effects of long droughts that are caused by climate change phenomenon, and can result in significant crop losses (Wabwoba and Mutoro, 2019). These disastrous effects of climate change are already evident in most across the world. The soil cover materials should be affordable, freely accessible by the farmers and biodegradable, thus environment-friendly (Filippi et al., 2011; Awodoyin et al., 2007). These types of covers include, but not limited to the live or dead plants and manufactured substances such as polythene and textile products. It is worthwhile to note that each of these soil covers has a varying degree of efficacy on weed control as well as its durability, both of which dictate its adoption and sustainability for mulching by farmers. Some materials can be re–used for two or more cropping seasons, while others especially the organic ones normally do not last beyond one season. Despite the fact that polythene has been shown to have higher weed management efficacy (Yamaguchi et al., 1996), their main shortcoming is that they are non-biodegradable, thus pose as an environmental pollution threat that requires special solid waste disposal mechanism.

Notwithstanding this high threat of the invasive weeds menace to tomato production, the degree of documented research on influence of assorted kinds of soil covers on weed suppression in Western Kenya is minimal. It is against this backdrop thus, that trials were undertaken to assess the efficacy of different covers on weed count and suppression in Bungoma County. Recommendations from the findings of this research shall inform stakeholders in tomato value on appropriate types of sustainable mulching materials that are both economical and environment sound.

Materials and Methods

Study area

Trials were conducted in Bungoma County at the Mabanga Agriculture Training Centre (ATC) in the rainfall short-season of 2015, and long-season in 2016. The site are Mabanga ATC is situated at coordinates 0°35'56.9"N, 34°37'18.1"E at an elevation of 1,360 meters above sea level, with a mean monthly temperature of 18.2 °C (The Council of Governors, 2013). The Mabanga ATC farm is located eight kilometers on the Eastern part of Bungoma town center on the Malaba-Eldoret Great North road. The average rainfall in the area ranges is 1800 to 2000 mm per annum. This rainfall pattern is bimodal, with short rains from October to December and long rains from March to June with a mean monthly temperature of 22.5 °C. It is classified under AEZ II (Braun, 1980), which covers areas like Webuye, Chwele, Kimilili and Kitale. The soils are well drained, deep, and red-brown in colour, with sandy-loam texture. The pH is acidic with low organic matter content and available nitrogen. These soils and climate characteristics favour the growth of sugarcane, bananas, maize sweet potato as well as exotic and indigenous vegetables (The Council of Governors, 2013). On the other hand, this climate is also ideal growth of wide variety of noxious weeds that can cause significant drop in crop yields.

Experimental design

The field trials were set up in a Randomized Complete Block Design (RCBD) arranged as split-plots and replicated thrice. On the main plots, there were two varieties of tomato treatments, thus; Cal J and Tylka F1, whereas the sub-plots entailed different soil covers, namely; black polythene film, white polythene film, sugarcane trash spread at rate of 3 kg m^{-2}, and control (no mulch). Allotment of these different treatments to the different sub-plots was done with the aid of random number table to minimize human bias (*Figure 1* and *Figure 2*).

Figure 1. *Field layout of first and second season at Mabanga Agricultural Training Center, Bungoma County.*

Figure 2. *Field layout of first and second season at Mabanga Agricultural Training Center, Bungoma County, based on block 1, block 2 and block 3.*

Field operations

For the first and second season, certified tomato seeds were sown in plugs on the 21st August and 17th December, 2015 respectively, and the seedlings nurtured under greenhouse for four weeks. The field was fine tilled by plowing and harrowing and 2 kg/m^2 of well decomposed cattle manure spread out uniformly on the soil surface, and incorporated into the soil (*Figure 3*). Two weeks later, beds were raised in readiness for transplanting in order to enhance soil drainage. Transplanting was done in the open field when seedlings were at the 5-7 leaf stage across the two seasons. Soil sampling and analysis was undertaken appropriately, and the crop managed accordingly, with manure and fertilizer management done following the laboratory soil test advice. Being a semi-determinate variety, Tylka F1 was trained to two stems by nipping and excising all emerging lateral shoots, unlike Cal J was left unpruned because it is determinate. The plots were mulched prior to transplanting in both seasons. The trial plots were covered with sugarcane trash at 3 kg/m^2, black polythene paper and white polythene paper of 30 and 50 micron thickness respectively, by mulching the entire space between the planting stations and as well as rows. However, a hole of 10 cm diameter was left open between adjacent mulch strips as room for transplanting. Others cultural practices are include seedling hardening, irrigation, pruning, staking, pest control and deflowering were done uniformly, except for weeding that was the test treatment. The common weeds at the trial site include couch grass (*Elymus repens*), *Bidens pilosa*, *Tagetes* spp, *Commelina* spp. and *Galinsoga parviflora*.

Figure 3. *White plastic in one of the plots.*

Data collection

To investigate the efficacy of the treatments, weed fresh and dry weight were measured both at 30 and 60 days after transplanting. The samples of weeds were collected from two randomly laid quadrants per plot, with each quadrant measuring 2,500 cm^2. The samples were then weighed and recorded. All weeds were cut at the soil surface, identified by taxonomic name, and whole plant-fresh weight taken using electronic weighing scale. The samples were then oven-dried for 48 hours at 80 ˚C before dry weight was taken to define the dry matter. All samples were kept in a safe custody in case there would be need for a repeat measurement.

Statistical analysis

Data was tabulated appropriately in Excel and cleaned as outlined by Lomet and Sarawagi (2000). Once prepared, this data was run under SAS version 9.2, for analysis of variance, whereby means were separated at $P \leq 0.05$ confidence level. Fischer's Projected Least Significant Difference test was applied to determine significant differences among the different treatments. Data was presented using both figures and tables that were generated using Excel and R-software version 3.4.1 for easiness of results interpretation.

Results and Discussion

Mulching significantly influenced the intensity of weeds in the tomato field ($P<0.01$) in the first season (*Table 1*). Among the different mulching materials evaluated, black polythene was the best weed suppressor with the least weight of fresh weeds (4 g and 3 g) under Cal J and Tylka F1 tomato varieties respectively (*Table 1*). White polythene mulch was the second in suppressing weed growth at 30 g and 41 g fresh weed weight for Cal J and Tylka F1 respectively (*Table 1*). Organic mulch (sugarcane trash was the least in suppressing weeds in tomato fields and fresh weeds from the plots mulched with sugarcane trash weighed 57 g and 70 g for Cal J and Tylka F1 tomato varieties respectively. The control treatment which had no mulch material had the highest weed intensity with fresh weed weighing 522 and 436 g for Cal J and Tylka F1 respectively (*Table 1*). The interaction between tomato varieties and different mulching materials was significant at $P<0.05$ (*Table 1*).

***Table 1**. Effect of different mulching materials on the fresh and dry weed weights under two tomato varieties at Mabanga ATC during the short rains of 2015..*

Variety	Treatment	Fresh weed weight	Dry weed weight
Cal J	Black polythene mulch	4d	0.3d
	No mulch	522a	36.5a
	Sugarcane trash mulch	57c	4.0c
	White polythene mulch	30c	2.1c
Tylka F1	Black polythene mulch	3d	2.1c
	No mulch	436b	30.5b
	Sugarcane trash mulch	70c	4.9c
	White polythene mulch	41c	3.0c
	Standard error	57.1	3.995
	p-value	<0.001	<0.001
	Variety X treatment	*	*

** means followed by the same letter in each column are significantly different at p≤0.05.*

In the second season, mulching significantly influenced fresh weight of weeds P<0.001 (*Table 2*). The black cover had the least weight of fresh weeds at 3 and 2 g respectively for Cal J and Tylka F1. The control treatment (no mulch) had the highest weed intensity with fresh weed weight of 288 and 301 g for Cal J and Tylka F1 varieties respectively (*Table 2*). The interaction between mulching materials and tomato varieties was significant at P<0.05 (*Table 2*).

***Table 2**. Effect of different mulching materials on the fresh and dry weed weights under two tomato varieties at Mabanga ATC during the long rains of 2016..*

Variety	Treatment	Fresh weed weight	Dry weed weight
Cal J	Black polythene mulch	3c	0.2c
	No mulch	288a	23.0a
	Sugarcane trash mulch	27b	2.2b
	White polythene mulch	30c	2.1c
Tylka F1	Black polythene mulch	17b	1.4b
	No mulch	2c	0.2c
	Sugarcane trash mulch	301a	24.1a
	White polythene mulch	38b	3.0b
	Standard error	10.13	0.81
	p-value	<0.001	<0.001
	Variety X treatment	*	*

** means followed by the same letter in each column are significantly different at p≤0.05.*

Weed is a major pest to tomato production in Western Kenya contributing significantly to yield loss. Small holder farmers incur high costs to control these invasive weeds using herbicides and repetitive manual weeding-these approaches are not sustainable. Several Olericulture studies have shown that the first six weeks after transplanting is the most critical window of weed competition. Adigun (2002) who worked on efficacy of chemical weed control in tomato reported that out of optimum harvestable 30 mg Ha^{-1} fruit yield, farmers lose a significant 40-60 % as a result of weeds. A number of studies have been published in tropical and sub-tropical countries to evaluate crop residues use as mulch. These include research by Akhtar et al. (2019), Shashidar et al. (2008) and Palada et al. (2003) who have shown that soil cover positively influences soil health, replenishes plant nutrients by increasing organic matter

(Farjana et al., 2019; Ferdous et al., 2017), and promotes biodiversity of both *fauna* and *flora*. Other studies by Massaccesi et al. (2020), Akhtar et al. (2019) and Chalker-Scott (2007) have shown that mulches modify the plant microclimate by moderating temperature of the rhizosphere and conserving soil moisture (Gudugi et al., 2012).

Mulching is a major component of climate-smart agricultural approaches—a topic that has drawn global attention, and is featuring in climate crisis conversations around the world today. As a result, Wabwoba and Mutoro (2019) documented a review that covering the soil with organic materials such as *Mucuna pruriens* is beneficial in that, it forms a physical barrier that reduce soil moisture evaporation, suppress emerging weeds (Ossom, 2001; Merwin et al., 1995), and enhance soil structure due to dry matter deposition as well as promote soil health. Soil cover mitigates against global warming and it is one of the adoption mechanisms to negative effects of climate change, especially by smallholder farmers. This finding is corroborated by Mintah (1998), who documented that growing *Mucuna pruriens* on field plots recorded the lowest weed count compared to no mulch plots. All these soil aspects contribute to healthy crops and higher yields (Lamont, 2005; Ngouaajio and Ernest, 2004; Nkansah et al., 2003; Moitra and Ghosh, 1998) in tomato. Mulching also protects soil and crops from non-point source contaminants, especially translocated in surface run-off water. Organic mulches are those derived naturally from animal and plant materials, which if effectively utilized, these natural residues can be as beneficial the other kinds of mulches (Massaccesi et al., 2020; Gandhi and Bains, 2006; Lamont, 2005). Conversely, clear mulches have been observed to have negligible effect on weed growth (Waterer, 2000) although it promotes soil warming, whereas coloured polythene such as black or brown effectively prevent emerging weeds (Norman et al., 2011; Gordon et al., 2010; Ngouajio and Ernest, 2004; Ossom et al., 2003; Brault et al., 2002; Bond and Grundy, 2001) and earlier crop maturity (Ibarra et al., 2001).

Research has shown that covering the soil with organic matter in both dry and rainy seasons significantly suppresses growth of weeds. In a related study, Eneji et al. (2003) found that organic mulching cuts down weed intensity and promotes crop-plant heath as well as the ultimate yield. The increase in crop output can be attributed to the effect of reduced tomato to weed competition for nutrients and other factors of plant growth, as a result of weed smothering (Gangawar et al., 2000). Some of these works was reported by Roe et al. (1993). In an experiment to study the effect of types of soil covers yield and growth characteristics of tomatoes in Ghana, Nkansah et al. (2003) reported that rice straw, rice husks, grass straw, saw dust mulch reduced fresh weed weight significantly. Moreover, whereas the most intense weed infestation was found in no mulch plots, grass straw which is organic mulch significantly decreased the fresh weight of weed. According to Norman et al. (2011) dry grass and sawdust mulches suppressed weed growth significantly.

Conclusion

Different soil covers suppress weeds to a varying extent, which also depends on the type of weeds under consideration. From this study, the highest efficacy on weed control was observed under inorganic black polythene cover. Thus, it can be deduced that inorganic film has higher efficacy compared to the organic soil cover in managing weed levels on tomato plots. Nonetheless, the use of organic soil covers achieved significant effect on weed control. Soil cover is a major pillar of climate smart agriculture that include conservation agriculture and should be adopted among small holder tomato and other vegetable farmers in Bungoma County.

Acknowledgement

The authors are grateful to the Principal and staff of Agricultural Training Centre at Mabanga, Bungoma County, for providing the field sites for this study as well as labour and security. Additionally, we are indebted to the Lecturers and administrative staff of the Department of Agricultural, Science and Technology at Kenyatta University that directly participated towards successful completion of this research work. Lastly, we thank you all to any other parties that may have been involved in one way or another in the execution of this project, but whose names are not mentioned in this acknowledgement.

Conflict of interest

Authors wish to authoritatively declare no conflict of interest whatsoever in the outcome of this study, and remain committed to upholding high standards of statistical ethics and integrity.

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