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Effect of mulch and different pre-harvest fungicide spray regimes on shelf life of tomato (*Solanum lycopersicum* L.) in Tanzania

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ABSTRACT

In Tanzania, farmers excessively spray fungicides in order to improve tomato fruit shelf life. In this study the effect of three pesticide spray regimes on tomato shelf life was evaluated. The spray regimes included; farmers' practice (FP), spray when needed after scouting (IPM) and spraying as per manufacturers' recommendation (MR). The effect of mulch on shelf life of tomato was also studied. 'Tanya VF' and 'Tengeru 97' tomato varieties were used in this study. Field experiment consisting of a 2×2×4 factorial arrangement in a split-split plot design with three replications was conducted. Treatment factors comprised two varieties (main plot factor), mulching (subplot factor) and three fungicide spray regimes (sub subplot factor). The laboratory experimental layout was a CRD with three replications. The laboratory had a max/min temperature of $31^oC/19^oC$. Shelf life assessment was done weekly for six weeks. Results show that fruits loss under the three fungicide application regimes was lower ($p < 0.001$) compared to the control during the first week. MR reduced fungicide sprays by 100% compared to FP with no significant reduction in shelf life. In the second week shelf life of fruits from plants under IPM and MR were similar ($p = 0.05$) but differed with the control. However, FP spray regime had significantly ($p = 0.005$) longer shelf life. The use of mulch led to fruits with consistently longer shelf life for four weeks in storage ($p = 0.001$, $p = 0.008$, $p < 0.001$, $p = 0.037$, respectively). Considering the two varieties, 'Tengeru 97' consistently had lower ($p < 0.001$) fruit loss throughout the storage duration compared to 'Tanya VF'. It was also revealed that, harvesting at different maturity stages had significant influence ($p < 0.001$) on fruit shelf life. Harvesting at breaker stage is advantageous since there was low postharvest fruit loss encountered.

Key words: IPM, produce loss, harvesting stage

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is among the most widely produced vegetables in the world. It is also one of the most important cash vegetable crops in Tanzania, with an annual production of more than 255,000 tons [1]

In Tanzania, and Morogoro region in particular, production is undertaken by small-scale farmers. Land under tomato cultivation ranged from 0.25 to 6 acres with a mean of 1.4 acres per farmer [2]. It is a common practice for farmers to use a routine weekly spray regime of fungicide and sometimes a 'cocktail' of fungicides [3, 4] to control pests.. Some tomato growers spray fungicide less than 24 h before harvest, a practice claimed to minimize the extent of fruit rot, to improve fruit colour and shelf life [3] In most cases, farmers spray fungicides up to 24 times per crop cycle [2]

Tomato, like other horticultural produce, needs to reach consumers while fresh and with acceptable quality. This necessitates good agricultural practices and postharvest handling techniques to maintain quality [5, 6] and enhance shelf life. Tomatoes are especially susceptible to numerous fruit decays, from the field through postharvest handling and supply chain. *Botrytis cinerea* Pers. is a major cause of postharvest rot of perishable plant produce, causing severe rots on tomato [7]. Fruit infection occur either prior to harvest or during harvesting and subsequent handling or storage [8]

Worldwide, postharvest losses of fruits and vegetables have been estimated at 50% and much of this is due to fungal and bacterial infections [8] Postharvest fruit rots in tomato are among the most important factors that affect the quantity and quality of tomato fruits available in the market. In most cases approaches towards management of the problem involve pre-harvest application of fungicides. However, the use of fungicides beyond the recommended dosage and frequencies can hazardous to consumers and the environment. This also increases the cost of tomato production leading to low profit margin obtained by farmers [2,4,8] Tomato varieties with good shelf-life are important especially for small scale farmers and retailers who sell the produce in fresh state. Unfortunately, such varieties with a combination of other characters like high yielding, resistance to pest and diseases as well good market demand are difficult to find.

Post-harvest qualities of tomatoes partly depend upon preharvest factors such as cultural practices, genetic and environmental conditions [9]. The use of simple and cheap soil and crop management practices such as mulching can modify soil temperature and improve soil moisture status, consequently improving the growth and yield of tomato [10, 11]. Mulching was also found to significantly reduce fruit rots on tomato and hence increase percentage of marketable yield [12]. Extending shelf-life of tomato is very important for both domestic and export marketing [13]. This study was conducted in order to evaluate the effect of pre-harvest fungicide treatments and the use of mulch as cultural practices on the shelf life of tomato stored under room conditions.

MATERIALS AND METHODS

Nursery establishment and field experiment

Tomato cultivars ‘Tanya VF’ and ‘Tengeru 97’ which are determinate and semi indeterminate respectively were used in this experiment. Seedlings were raised at the Horticultural Unit at Sokoine University of Agriculture (SUA-HU), Morogoro (6^{o}05’S, 35^{o}37’E and 525 m above sea level). Seedlings were pricked 5 days after emergence then grown further on soil blocks (5cm×5cm×5cm) made from compost placed in a high plastic tunnel with sunscreen netting which allowed 60% of the sunlight to pass through. Seedlings were transplanted to the field 3 weeks after pricking.

The field experiment was conducted from May - September, 2010 at the Crop Museum Unit of the Sokoine University of Agriculture. The experimental layout was 2×2×4 factorial arrangement in a split-split plot design with three replications. The treatment factors were comprised of variety (main factor), mulching (subplot factor) and fungicide spray regimes (sub-subplot factor). During field establishment, plots of 420 cm×280 cm were prepared using hand hoes. Seedlings were transplanted into the plots at a spacing of 70 cm between rows and 70 cm between plants with four rows per plot and 24 plants per plot. There were three fungicide application programs including plots sprayed weekly (farmers’ practice (FP)), sprayed when needed (when weather condition was favorable for disease development and or insect pests at threshold levels found after scouting (IPM) and spraying as per the manufacturers’ recommendation (MR). Unsprayed plots (F0) were included as control. The fungicide Ridomil GOLD® (Mancozeb + Metalaxyl), which is commonly used in tomato production in Morogoro, was used for control of fungal diseases. For FP, MR and IPM the fungicide was sprayed 14, 7 and 4 times per crop cycle respectively. Selecron® (Profenofos), a broad spectrum insecticide, was used to control insect pests sprayed 14, 5 and 3 times for FP, MR and IPM respectively For the mulched plots, dry grasses (*Panicum* sp.) were applied as mulch three days after transplanting (3DAT). The grasses were chopped to approximately 25 cm long, laid down by hand at a thickness of about 10 cm, making sure the soil was completely covered.

Compound fertilizer in the form of NPK (20:18:18) was top-dressed at a rate of 102 kg ha^{-1} two weeks after transplanting and at fruit-set stage. Plants were irrigated individually with water pumped from a nearby reservoir once a week using a hose pipe with a shower nozzle attached at the end.

Shelf life assessment

Fruits were harvested early in the morning and taken to the laboratory for evaluation and storage. Fifty fruits without visible damages were randomly selected and placed in a plastic basin according to respective harvesting stage. The experimental layout consisted of completely randomized design (CRD) in a split-split plot arrangement replicated three times. The room had a max/min temperature and relative humidity of $31^{o}/19^{o}$C and 71%/54% respectively recorded using digital relative humidity/temperature meter (Dickson TH550, Dickson Company). Fruit quality assessment was done weekly for six weeks discarding those fruits found with unacceptable market quality (shriveled, fungal growth, water soaked)

Data analysis was carried out using Genstat v.3 Statistical package (VSN International). Analysis of variance (ANOVA) was performed and when significant differences existed ($p < 0.05$), the Least Significant Difference (LSD; α=0.05) test was used as a means separation procedure.

RESULTS AND DISCUSSION

Loss of fruits sprayed using the three fungicide application regimes (IPM, FP and MR) was statistically lower ($p < 0.001$) compared to control during the first to third week of fruit storage (Table 1). The results shows further that using farmers practice (FP) the loss was not significantly different compared to the manufacturers' recommended spray regime (MR). This indicates that MR is as effective as the FP. However, with MR fungicide sprays was reduced by 100% compared to FP (from 14 sprays to 7 sprays) with no significant reduction in produce shelf life. Due to heavy fungicide sprays for the FP there was evident fungicide contamination on fruit surface (Figure 1)

Fig. 1: Visual cleanliness comparison between tomato fruits obtained from FP and IPM spray regimes

Tomato fruits with evident fungicide contamination on FP managed plot (left), at Morogoro market (center) and cleaner fruits on an IPM managed plot (right)

The results shows that, plants sprayed using FP regime had during the second week produced fruits which had statistically significant ($p = 0.005$) longer shelf life, with only 11.8% of the produce being lost compared to the Control, IPM, and MR (Table 1). Tomato shelf life in the second week harvested from plants sprayed using IPM and MR was not statistically significant different (p=0.05), but differed significantly to the control. This indicates that, the use by farmers of excessive sprays enable the produce stay for at least two weeks before significant deterioration can occur. The longer shelf life though it is an opportunity to farmers, transporter/whole sellers and retailers, it occurs to the expense of the health of the consumers and even the famers themselves.

Table 1: The effect of fungicide application regimes on tomato shelf life

Spray regimes	Cumulative produce loss (%)					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Control	14.17^a	27.4^a	45.0^a	61.2	72.5	83.8
IPM	6.25^b	18.5^b	37.9^b	63.3	72.1	81.7
FP	2.50^c	11.8^c	35.0^b	63.3	73.3	85.4
MR	2.92^c	20.8^b	37.5^b	63.8	72.1	81.7
LSD	3.12	6.42	6.71	8.30	6.71	6.86
p-value	< 0.001	0.005	0.027	0.931 ^{NS}	0.980 ^{NS}	0.644 ^{NS}

Means within a column followed by the same superscript are not different (p< 0.05); LSD = Least significant difference; NS = Non significant

Mulching has shown to be a beneficial practice in tomato production for improvement of yield and yield components [3, 14, 15]. The use of mulch led to fruits with consistently significant longer shelf life for four weeks in storage ($p = 0.001$, $p = 0.008$, $p < 0.001$, $p = 0.037$, respectively) [Table 2]. The use of mulch therefore has significant impact on maintaining produce shelf life. This effect may be due to the fact that mulch protects the fruits from being in contact with sun-heated soil, minimizes abrasion caused by soil particles and associated pathogens, as well as shielding the fruits from direct contact with soil borne pathogens.

Table 2: The effect of mulch on shelf life of tomatoes

Mulch	Cumulative produce loss (%)					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Without Mulch	8.33^a	22.5^a	44.2^a	66.0^a	74.4	84.6
With Mulch	4.58^b	16.2^b	33.5^b	59.8^b	70.6	81.7
LSD	2.20	4.54	4.75	5.87	4.75	4.85
p-value	0.001	0.008	< 0.001	0.037	0.119 ^{NS}	0.234 ^{NS}

Means within a column followed by the same superscript are not different (p< 0.05); LSD = Least significant difference; NS = Non significant

Tomato can be harvested at different stages, depending upon distance and time needed to market the fruit. For long distance transport, fruit can be harvested at the breaker stage (not more than 10% of the surface is tannish-yellow) [Figure 2]. Fruit for local sale can be harvested at red ripe stage for immediate consumption.

Fig.2: Tomato fruits ('Tanya VF') harvested at different ripening stages

Tomatoes at mature red stage (left) and breaker stage (right)

The different maturity stages have influence on tomato shelf life. Results shows that, harvesting tomato at breaker stage is advantageous since there was low postharvest loss encountered (Table 3). This practice can be adopted by small scale farmers to have their produce in the market for a longer time without necessarily using fungicides to boost shelf life. Tomatoes harvested at breaker stage attained attractive good colour (as in mature red) a week following storage. This will be a good practice to be advocated by retailers to farmers as a way to mitigate short tomato shelf life and consequently reduce produce loss. Table 3 shows that, tomato harvested at breaker stage had consistently longer shelf life which was statistically different compared to those harvested at mature red stage.

Table 3: The effect of harvest maturity stage on shelf life of tomatoes

Harvesting stage	Cumulative produce loss (%)					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Mature Red	11.46^{a}	31.9^{a}	56.5^{a}	82.7^{a}	88.1^{a}	95.6^{a}
Breaker	1.46^{b}	6.9^{b}	21.2^{b}	43.1^{b}	56.9^{b}	70.6^{b}
LSD	2.202	4.54	4.75	5.87	4.75	4.85
p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	4.85

Means within a column followed by the same superscript are not different (p< 0.05); LSD = Least significant difference

From our previous study; 'Tengeru 97', a semi-indeterminate cultivar, was less productive compared to 'Tanya VF' (Mtui *et al.,* 2013 *in press*). However, our current finding shows that 'Tengeru 97' had a longer shelf life compared to 'Tanya VF' which could be among the reasons why some farmers prefer to grow 'Tengeru 97'. In the first week for example, 'Tanya VF' deteriorated three times faster than 'Tengeru 97'. In this study, 'Tengeru 97' consistently had significantly lower ($p < 0.001$) produce loss throughout the storage duration (Table 4).

Table 4: The effect of variety on shelf life of tomatoes

Variety	Cumulative produce loss (%)					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
'Tanya VF'	9.79^{a}	25.2^{a}	48.1^{a}	77.9^{a}	90.4^{a}	94.6^{a}
'Tengeru 97'	3.12^{b}	13.5^{b}	29.6^{b}	47.9^{b}	54.6^{b}	71.7^{b}
LSD	2.202	4.54	4.75	5.87	4.75	4.85
p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Means within a column followed by the same superscript are not different (p< 0.05); LSD = Least significant difference.

CONCLUSION

Heavy pesticide sprays as a way to prolong produce shelf life is economically not feasible, environmentally unfriendly and also poses health risks to both producers and consumers. It is therefore critical time to device alternative measures that can improve tomato shelf life without posing health risks to consumers. The use of mulch and application of pesticides according to the recommended rates only as necessitated by the likelihood of disease occurrence or pest damage constitute good component of IPM strategies for tomato. Reduction in pesticide use will improve farmers profit and also avail a safer produce to consumers.

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