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Full Length Research Paper

Influence of different soil amendments on postharvest performance of tomato cv. power (*Lycopersicon esculentum*, Mill)

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The experiment was conducted to test the influence of different soil amendments types on postharvest performance of tomato fruits. The soil amendments were NPK 15-15-15 at 250kg/ha plus 'Asasewura' cocoa fertilizer (NPK 0-22-18 + 9CaO + 6s + 5MgO(s) at (250kg/ha), NPK 15-15-15 at 250kg/ha plus sulphate of ammonia (125kg/ha), poultry manure (1.1kg/ m²) and control (no amendment). Selected quality traits of tomato fruits harvested at the pink colour stage were evaluated after seven (7) days storage under average temperatures of 26.85°C and relative humidity of 85.75%. Fruit quality traits studied were fruit weight loss, firmness, general appearance, membrane ion leakage, pericarp thickness, decay, total soluble solids, pericarp weight, dry matter, moisture content and fruit shelf life. Significant differences among the soil amendments (P < 0.002) were observed in fruit quality traits studied. Fruits harvested from soil amended with NPK plus 'Asasewura' cocoa fertilizer recorded lower in weight loss, membrane ion leakage decay and moisture content and higher fruit firmness, general appearance, total soluble solids, dry matter and shelf life than fruits harvested from fields amended with NPK plus Sulphate of ammonia, Poultry manure and Control respectively. Significant correlations (P < 0.01 and P < 0.05) were observed among the quality traits evaluated. Fruit weight loss showed significantly but negative correlation between fruit firmness (-0.71) and shelf life (-0.71) but indicated significant but positive correlation between membrane ion leakage (0.63) and fruit decay (0.57) respectively. Fruit pericarp thickness showed significant but positive correlation between general appearance (0.69), pericarp weight (0.68) and total soluble solids (0.73).

Key words: Amendments, tomato, Asasewura cocoa fertilizer, postharvest, performance.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most widely used food crops in world vegetable economy (Chapagain and Wiesman, 2004). In Ghana, it is almost an obligatory ingredient in the daily diets of people across all regions. Compared to other vegetables used in Ghana, tomatoes are normally used in large quantities (Ellis et al., 1998). In most tomato production areas in Ghana a range of conventional fertilizers comprising NPK 15:15:15, NPK 20:20:0, sulphate of ammonia and urea (Ellis et al., 1998) and organic fertilizer such poultry manure (FAO, 2005), is being used as part of soil amendments fertilizers. Yet fresh tomato fruits do not meet the demand of the consumers since lots of losses are counted. Among the fertilizers found in Ghana is 'Asasewura', cocoa fertilizer (NPK 0-22-18 + 9CaO + 6s + 5MgO(s), usually used to amend cocoa growing fields, NPK (15-15-15), Sulphate of and Ammonia, Poultry

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Abbreviations: CONT, Control (no amendment) field; **GIPC,** Ghana Investment Promotion Council; **MM,** millimetres; **N,** Newton; **NPK + SA,** NPK plus sulphate of ammonia amended fields; **NPK+ CA,** NPK pus 'Asasewura' cocoa fertilizer amended fields; **ºC,** degree celsius; **PM,** poultry manure amended fields; **RH,** relative humidity.

(Chicken). Cultural practices such as nutrient application are claimed to be factors influencing quality of tomato before and after harvest (Watkins and Pritts, 2001). However, variations in fertilizer applications have being reported in major tomato production areas in Ghana (Adu-Dapaah and Oppong-Konadu, 2002). Post harvest losses are estimated to be about 20 to 50% (Kader, 1992) in countries like Ghana. These losses caused 650% increment in the importation of tomato paste between the years 1998 to 2003, (FAO, 2006). It is against these backgrounds that the present study is aimed at investigating the effects of two conventional and one organic fertilizer on post harvest quality tomato.

MATERIALS AND METHODS

Soil samples were randomly collected from different cores at 0 to 15 cm and 15 to 30cm for analysis before and from 0 to 30 cm after the studies (from the different soil amendment fields) for the contents of organic carbon (OC), organic matter (OM), total nitrogen (N), exchangeable potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), available phosphorus and pH. Seedlings of tomato cultivar 'Power' were transplanted to randomized complete block design field in three (3) replications. Prior to application of 'Asasewura', cocoa fertilizer (NPK 0-22-18 + 9CaO + 6s + 5MgO(s) and sulphate of ammonia (21% N + 24s), NPK (15-15-15 + 2MgO + 3Zn) was applied at 5 g per plant two weeks after seedlings were transplanted. 'Asasewura', cocoa fertilizer (NPK 0-22-18 + 9CaO + 6s + 5MgO(s) and sulphate of ammonia (21% N + 24S) were applied at 5 and 3 g per plants respectively at two weeks after NPK (15-15-15 + 2MgO + 3Zn) application. Partially decomposed poultry manure (N = 2.85%, P = 2.38%, K = 24%, Ca = 15.60%, Mg = 2.50% and pH = 7.29) at 1.1 Kg/m² (applied to the soil three weeks on plots designated to be amended with poultry manure before transplanting) while control fields received no amendment.) Fruits at the pink stage were harvested (calyx attached) from plants marked on the field at three different harvests each in the morning within a month and two weeks from each plot and immediately placed under shade to maintain fruits temperature. Fruits were quickly transported to the laboratory where sorting and grading were carefully done and homogeneous colour developments were selected for further studies on qualitative parameters.

Quality parameters studied

Thirty six (36) pots containing ten (10) fruits from each plot were set up in the laboratory for each harvest in complete randomized design and stored for 7 days at ambient temperature of 26.85°C and relative humidity of 85.75%

Parameters studied

Weight loss (WL): Fruits were weighed daily for seven days and the difference in final weight loss expressed as a percentage of weight loss from the initial weight of five fruits sample.

Fruit firmness (FF): Fruit firmness was determined with a fruit tester (Effegi type Bishop FT 237). A circular portion of the peel of diameter of about 2 cm of each of the five fruits from each plot were removed before applying the plunger of the firmness tester in order to eliminate the effect due to the peel; and firmness was expressed in Newton (Batu, 1998).

General appearance (GA): Fruit general appearance was scored by overall rating that included freshness (green calyx), decay, firmness, defects, colour on a scale of 1 to 5 with: 0 to 1= Poor, 2 to 3= Good and 4 to 5= Very good.

Membrane ion leakage (MIL): Membrane ion leakage of fruit was determined using the method of Knowles et al. (2001) with some modifications. Ten (10) discs (10 mm in diameter) per cultivar were incubated in 20 ml distilled deionized at 5, 10, 15, 30 and 60 min intervals and conductivity measured and expressed as a percentage of the total electrolytes. Total electrolyte was also determined by freezing samples for 24 h after taking all readings (5 to 60 min). Samples were then thawed and dipped in boiling water for 20 min and conductivity measured. Conductivity meter (Hanna instrument) was used to measure membrane ion leakage.

Fruit decay (FD): Decay of fruit was recorded as soon as fungal mycelia appeared on the calyx or peel of the fruit. Decay was expressed as a percentage of the total initial fruit number stored.

Dry matter (DM): Dry matter content of fruits was measured by taking three (3) discs of 10 mm in diameter from the equatorial region of each of five fruits and oven dried at 105°C till constant dry weight was recorded according to AOAC (1990) and weight expressed as gram (g).

Moisture content (MC): Moisture content of fruits were determined by desiccation three (3) discs of 10 mm in diameter at the equatorial region of five fruits from each plot at 105ºC for 24 h. The difference between the fresh weight and dry weight was expressed as a percentage of the initial fresh weight of the three (3) discs at the equatorial region of five fruits (AOAC, 1990).

Total soluble solids (TSS): Total soluble solid was determined in the same five fruits tested for fruit firmness, by squeezing out juice from fruits on Abbe's hand held refractometer and reflections measured in percent Brix (Anon, 1984)

Shelf life (SL): The shelf life was observed from the starts of harvesting and extended up to the start of rotting of fruits (Mondal, 2000).

Data collected were subjected to statistical analysis by using GENSTAT Discovery edition 3.0. Analytical software. Means were separated by LSD test at 5% Correlation analysis was performed at 1% and 5% using Statistical Package for Social Science Students (SPSS) edition 18.

RESULTS

Tomato fruits were harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizer, NPK plus Sulphate of ammonia, Poultry manure and Control, stored for 7 days at 26.85°C and 85.75%RH to assess the influence of soil amendment types on postharvest performance in fruit. The analysis of variance indicated significant differences among soil amendment types in fruit weight loss ($P = 0.002$), fruits firmness ($P < 0.001$), general appearance ($P = 0.001$), membrane ion leakage ($P = 0.001$), fruit decay ($P = 0.038$), dry matter ($P = 0.002$), moisture content ($P < 0.001$) and total soluble solids ($P < 0.001$). Relatively low weight loss was recorded in fruits harvested from fields amended with NPK plus 'Asasewura'

Table 1. Means of fruit weight loss (WL), fruit firmness (FF), general appearance (GA), membrane ion leakage (MIL), pericarp thickness (PTK), fruit decay (FD),pericarp weight (PWT), dry matter (DM) moisture content (MC) total soluble solids (TSS), and shelf life (SL) of tomato fruits harvested from four different soil amendment after seven days storage at 26.85ºC and 85.75%RH.

Amendment	WL (g)	FF (N)	GA (1-5)	MIL (%EC)	PTK (g)	FD (%)	DM (g)	MC (%)	TSS (Brix)	SL (day)
NPK+CA	2.68^{b}	3.31^{a}	3.93^{a}	12.52^{b}	3.36	6.80^{b}	0.33^{a}	90.46^{b}	4.04^{a}	9.39^{a}
NPK+SA	3.44^{a}	2.80^{c}	3.44^{b}	13.87^{a}	3.09	8.80^{ab}	0.32^{a}	91.05^{b}	3.91^{a}	7.58^{b}
PM	3.36^{a}	2.91^{bc}	3.87^{a}	14.61^{a}	3.65	9.20^{a}	0.29^{b}	92.93^{a}	4.02^{a}	8.32^{b}
CONT	3.07^{a}	3.11^{ab}	3.07^{b}	14.61^{a}	2.74	10.40^{a}	0.25^{c}	90.96^{b}	3.42^{b}	7.92^{b}
CV %	4.9	2.0	2.8	4.8	4.6	16.1	4.1	0.4	1.5	3.1

Figures followed by the same alphabets are not significant at 0.5%.

cocoa fertilizer (2.68 g) while high weight loss was recorded in fruits harvested from Control (3.27 g) and fields amended with NPK plus Sulphate of ammonia (3.30 g) and Poultry manure (3.36 g). No significant differences in weight loss were observed between fruits harvested from fields amended with Poultry manure, NPK plus Sulphate of ammonia and Control (no amendment) (Table 1).

The highest firmness was recorded in fruits harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizer (3.31N) followed by Control (3.11N), Poultry manure (2.91N) and NPK plus Sulphate of ammonia (2.80N) amended fields. However, no significant differences were indicated between fruits harvested from fields amended with NPK + 'Asasewura' cocoa fertilizer (3.31N) and Control (3.11N) as well as NPK plus Sulphate of ammonia and Poultry manure respectively and also between Control (3.11N) and Poultry manure (2.91N) (Table1).

Fruits harvested from NPK plus 'Asasewura' cocoa fertilizer amended fields (3.93) and Poultry manure fields amended fields (3.87) showed relatively better in general appearance than fruits harvested from fields amended with NPK plus Sulphate of ammonia (3.44) and Control (3.07). However, no significant differences were observed between fruits harvested from fields amended with NPK plus 'Asasewura', cocoa fertilizer (3.93) and Poultry manure (3.87) as well as between NPK plus Sulphate of ammonia (3.44) amended fields and Control fields (3.07) (Table 1).

Comparatively, membrane ion leakage was prone in fruits harvested from fields amended with Poultry manure (14.61%), NPK plus Sulphate of ammonia (13.87%) and Control (14.61%) than fruits harvested from field amended with NPK plus 'Asasewura' cocoa fertilizer (12.52%). However, no significant differences were observed among fruits harvested from Control and fields amended with Poultry manure as well as NPK plus Sulphate of ammonia in membrane ion leakage (Table 1).

Fruits harvested from fields amended with Poultry manure (3.88 mm), NPK plus Sulphate of ammonia (3.69 mm) and NPK plus 'Asasewura' cocoa fertilizer (3.36 mm) recorded higher pericarp thickness than fruits harvested from Control fields (2.86 mm), respectively (Table 1).

Decay was relatively high in fruits harvested from control (10.40%, poultry manure (9.20%)and NPK plus Sulphate of ammonia (8.80%) amended fields while relatively low percentage decay (6.80%) was observed in fruits from fields amended with NPK plus 'Asasewura' cocoa fertilizer. However, no significant differences were observed among fruits harvested from control poultry manure and NPK plus Sulphate of ammonia (Table 1).

Relatively high dry matter were recorded from fruits harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizer (0.33 g) and NPK plus Sulphate of ammonia (0.32 g) while relatively low dry matter content (0.28 and 0.25 g) were recorded from fruits harvested from fields amended with Poultry manure (0.28 g) and Control (0.25 g) respectively. No significant differences were observed between dry matter in fruits harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizer and NPK plus Sulphate of ammonia (Table 1).

Fruits harvested from Poultry manure amended fields recorded the highest moisture content (92.93%) followed by fruits harvested from NPK plus Sulphate of ammonia amended fields (91.05%), Control (90.96%) and NPK plus 'Asasewura' cocoa fertilizer amended fields (90.46%). No significant differences in fruit moisture content were observed among fruits harvested from NPK plus 'Asasewura' cocoa fertilizer, NPK plus Sulphate of ammonia amended fields and Control (Table 1).

Relatively high total soluble solids were recorded for fruits harvested from NPK plus 'Asasewura' cocoa fertilizer (4.04% Brix) and Poultry manure(4.02% Brix) amended fields while relatively low total soluble solids were recorded for fruits harvested from fields amended with NPK plus Sulphate of ammonia (3.91% Brix) and Control (3.42% Brix). No significant differences were observed between fruits harvested from NPK plus 'Asasewura' cocoa fertilizer, Poultry manure and NPK plus Sulphate of ammonia (Table 1).

The analysis of variance showed significant difference ($P < 0.002$) in fruits shelf life among the soil amendments. Fruits harvested from NPK plus 'Asasewura' cocoa fertilizer amended fields recorded the highest shelf life (9.39 days) followed by fruits harvested from fields

Table 2. Correlation values and P values between postharvest quality traits of tomatoes after seven days ambient (room) temperature (26.85ºC) storage.

FWTL	FWTL	FF	GA	MIL	FD	DM	FMC	TSS
FF	-0.71**							
GA	-0.44**	0.39*						
MIL	0.63**	-0.57**	-0.42*					
FD	0.57**	-0.60**	-0.40*	-0.46**				
DM	-0.36*	0.55**	0.54**	0.65**	-0.33^{NS}	0.39*		
FMC	0.31^{NS}	-0.62**	-0.28	0.22^{NS}	0.23^{NS}	0.23^{NS}	-0.80**	
TSS	-0.48**	0.27^{NS}	0.60**	0.73**	-0.40**	0.63**	0.37*	0.05^{NS}
SL	-0.71**	0.73**	0.55**	0.62**	-0.63**	0.48**	-0.34*	0.67**

*, **, NS = P < 0.05, P<0.01, not significant respectively. Fruit weight loss = (FWTL), fruit firmness = (FF), general appearance = (GA,) and membrane ion leakage = (MIL), fruit decay = (FD), dry Matter = (DM), fruit moisture content (FMC), total soluble solid = (TSS), and shelf life (SL).

amended with Poultry manure (8.32 days), NPK plus Sulphate of ammonia (7.92 days) and Control (7.58 days) fields. No significant differences in fruits shelf life were observed between fruits harvested from fields amended with Poultry manure, NPK plus Sulphate of ammonia and Control (Table 1).

Correlations Fruit weight loss indicated a high correlation with fruit firmness (-0.71), shelf life (-0.71), membrane ion leakage (0.63), fruit decay (0.57), (P < 0.01) but showed no significant correlations with fruit moisture content and fruit pericarp weight (Table 2). Fruits firmness indicated high correlation (P < 0.01) with fruit decay (-0.60), fruit moisture content (-0.62) and shelf life (0.73). General appearance revealed significant positive correlation (P < 0.01) with fruit and shelf life (0.55). Membrane ion leakage indicated high correlation (P < 0.01) with fruit decay (0.61) and shelf life (-0.67) but showed no significant correlation with fruit dry matter (-0.28), moisture content (0.24) (Table 2). Fruit dry matter (0.65), total soluble solids (0.73) and shelf life (0.62) but show no significant correlation with moisture content. Fruit dry matter indicated correlation (P < 0.01) with fruit moisture content (-0.80) (Table 2).

DISSCUSION

Fruits harvested from fields amended with NPK plus ‘Asasewura’ cocoa fertilizer recorded significantly the lowest weight loss (2.68 g) among fruits from fields amended with NPK plus Sulphate of ammonia (3.44 g), Poultry manure (3.36 g) and Control (3.07 g) fields. This might be due to the relatively high and readily available calcium in ‘Asasewura’ cocoa fertilizer which is characterised by the ability to increase cell formation and reduce respiration rates. This might have contributed to the reduction of weight loss in fruits harvested from NPK plus ‘Asasewura’ cocoa fertilizer amended fields. Sharma et al. (1996) in their observations confirmed calcium’s ability to reduce respiration, which is an indication of weight loss (Kays, 1991).

Fruit firmness is a criterion often used to evaluate fruit quality as it is directly related to fruit storage potential. It is also related to the likelihood of bruising when fruits are subjected to impact during handling (Lesage and Destain, 1996). Relatively low nitrogen levels in NPK plus ‘Asasewura’ cocoa fertilizer amended fields might have caused the availability of calcium for plant utilization to increase fruit firmness (3.31N) than fruits harvested from Poultry manure (2.91N) and NPK plus Sulphate of ammonia (2.80N) amended fields where nitrogen level were relatively high. Findings of research of Siddiqi et al. (2002), Akl et al. (2003), Heeb et al. (2005b) have shown that nitrogen dominated supply may markedly increase the incidence of depression of calcium uptake which could lead to decreased firmness in fruits harvested from fields amended with poultry manure and NPK plus sulphate of ammonia. Crisosto et al. (1995) reported that, excess nitrogen during the pre-harvest stage can reduce fruit firmness.

General appearance of fruits plays an important role in making purchasing decisions (Kays, 1999). Colour, cracks, bruises, firmness, etc are factors mostly used to assess general appearance which double as important factors in the consumer preference of tomatoes. Relatively high and readily available calcium levels in ‘Asasewura’ cocoa fertilizer might have increased fruit firmness and also lower biosynthesis in carotenoids which are responsible for tomato fruit colour. This could have improved general appearance of fruits harvested from NPK plus ‘Asasewura’ cocoa fertilizers fields (3.93) more than fruits harvested from fields amended with NPK plus Sulphate of ammonia (3.44) and Control (3.07). Studies conducted by Kays (1991), indicated that insufficient calcium supply will increase the biosynthesis of carotenoids, which are responsible for tomato fruit colour (Dorais et al., 2001).

The best general appearance in fruits harvested from Poultry manure amended fields (3.87) than those from Control (3.07) and NPK plus Sulphate of ammonia fields

(3.44) could probably be due to adequate calcium and magnesium levels which has the ability to reduce defects such as shoulder cracks, increase fruit firmness and to increase overall fruit quality respectively. Hao and Papadopoulos (2004) reported that, under conditions of severe magnesium deficiency the size and overall appearance of the fruit may be reduced, unless accompanied by a commensurate increase in calcium supply.

Above and beyond wilting and dehydration of horticultural products during storage, deterioration of plant tissues is also of great concern to food and horticultural scientists. Evidence gathered supports membrane damage as the key event leading to a cascade of biochemical reactions culminating in tissues deterioration (Maalekuu et al., 2005).

Probably, the readily available calcium levels in NPK plus 'Asasewura', cocoa fertilize amended fields might have caused relatively low loss of membrane integrity resulting from membrane damage. This could have caused the lowest weight (water) loss rate which might have also led to low membrane ion leakage of fruits harvested from fields amended with NPK plus 'Asasewura', cocoa fertilizer (12.52%) than those from fields amended with Poultry manure (14.61%), NPK plus Sulphate ammonia (13.87%) and Control (14.61%) respectively. Boros-Matovina and Blakes (2001) reported that, membrane ion leakage is a measure of loss of membrane integrity resulting from membrane damage which leads to water loss and loss of other membrane-bound solute.

Among the principal causes of post harvest losses is decay (Steven and Celso, 2005). Comparatively higher nitrogen levels during the pre harvest period as characterised by poultry manure might have increased the susceptibility to decay of fruits harvested from Poultry manure (9.20) field than fruits from fields amended with NPK plus' Asasewura' cocoa fertilizers (6.80). Bechmann and Earles (2000) indicated the possibility of produce stressed by high rate of nitrogen to be susceptible to post harvest decay (diseases) in fruits.

Again, relatively high nitrogen levels available in Poultry manure amended fields might have foster calcium (a cell forming nutrient) deficiency to the plant, hence leading to week cell formation and easy degradation of cells in fruits which could increase decay incidence of fruits more than those harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizers, where nitrogen levels were moderately low. Studies conducted by Siddiqi et al. (2002), Akl et al. (2003) and Heeb et al. (2005b) associated increase in fruit decay (rot) with high nitrogen levels dominated nutrients, an effect which is attributed to a depression of calcium uptake.

Attack by most organisms that cause deterioration in fruits follows physical injury or physiological breakdown. The relatively high decay recorded in fruits harvested from control (10.40%) fields than those harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizer may be due to additional calcium levels in 'Asasewura' cocoa fertilizer which is characterised to reduce the incidence of shoulder cracks and other physiological disorders that lead to deterioration of fruits. Lichter et al. (2002) who reported on the ability of calcium to reduce the incidence of shoulder check crack, and other physiological disorder that leads to deterioration in fruit quality.

High dry matter or low water content of the tomato has also been reported to affect fruit taste positively because the major components of tomato taste; sugars and acids, are more concentrated (Auerswald et al., 1999), which fits well with consumers' demand for high quality produce (El-Saeid et al., 1996). The relatively high dry matter in fruits harvested from fields amended with various fertilizers NPK plus Sulphate of ammonia (0.32 g), Poultry manure (0.29 g) and NPK plus 'Asasewura' cocoa fertilizer (0.33 g) than fruits harvested from control (0.25 g) fields may be mainly due to the additional plant nutrients for plant utilization supplied by the fertilizers used to amend fields which could improve cell formation to increase fruits dry matter.

Fruits and vegetables contain large quantities of water in proportion to their weight. Norman, (1992) indicated that, tomato fruits contain about 93% moisture.The significantly high moisture content recorded from fruits harvested from fields amended with Poultry manure (92.93%) than those harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizer (90.46%), NPK plus Sulphate of ammonia (91.05%) and Control (no amendment) fields (90.96%) respectively may be due to the ability of Poultry manure (organic fertilizer) to retained more moisture (water) for plants utilization over relatively long period than fields amended with inorganic fertilizers and control. Barrett et al. (2007) who indicated that significant differences in moisture content between tomatoes produced under conventional and organic production systems where in a case, the organic tomato moisture content was higher, and in two cases, the moisture content of conventional tomatoes was higher.

Total soluble solids are known to increase fruit quality (Loboda and Chuprikova, 1999), which fits well with consumers' demand for high quality produce (El-Saeid et al., 1996). The higher total soluble solids recorded from fruits harvested from the fields amended NPK plus 'Asasewura' cocoa fertilizer (3.93) over fruits from control and NPK plus Sulphate of ammonia amended fields may partly be due to the higher dry matter content recorded from fruits harvested from NPK plus 'Asasewura' cocoa fertilizer than other amended fields. Increased in total soluble solid of fruits harvested from fields amended with Poultry manure (3.87) over fruits harvested from control (3.07) and NPK plus Sulphate of ammonia (3.44) fields may be as a result of probably higher biosynthesis or degradation of polysaccharides during storage in fruits harvested from fields amended with Poultry manure.

Artes et al. (1999) in their studies in tomato associated increment of total soluble solids to degradation of polysaccharides.

Fruits shelf life during storage is an important feature from a producer's and a distributor's point of view, allowing the determination of risks arising from the loss of commercial value of fresh fruit in trade turnover (Radajewska and Borowiak, 2002). Significantly higher fruits shelf life (9.39 days) of fruits harvested from NPK plus 'Asasewura' cocoa fertilizer amended fields than those harvested from Control (7.58 days), Poultry manure (8.32 days) and NPK plus sulphate of ammonia (7.92 days) amended fields may be due to the relatively high and readily available calcium levels (which has the ability to extend fruit shelf life) in NPK plus 'Asasewura' cocoa fertilizer amended fields for plant utilization. Sharma et al. (1996) in their research conducted supported the ability of calcium nutrients to extend shelf life of fruits. Also other desirable characteristics of calcium such as its ability to delay ripening and senescence, reduce respiration, increase firmness and reduce physiological disorders as reported by Sharma et al. (1996) could probably have affected the shelf life of tomato fruits stored possibly.

Results obtained from correlation analysis are of great concern in determining the relationship between postharvest qualities of tomato (*L. esculentum* Mill.) fruits after storage. Fruit weight loss indicated high significant correlation with fruit firmness (-0.71), membrane ion leakage (0.63), general appearance (-0.44), shelf life (-0.70) respectively is an indication that, increase in weight loss in fruits could directly decrease fruit firmness. Weight (water) loss is the principal cause of fruit softening (Wilson et al., 1999). Increase in fruit weight loss probably increased membrane ion leakage directly. Membrane ion leakage which is an indicator of loss of membrane integrity was found to increase in pepper genotypes susceptible to high rates of water loss (Maalekuu et al., 2005).

Fruit general appearance is negatively affected by weight (water) loss since increase in fruit water loss reduces fruit firmness, increases shriveling which are important criteria for accessing fruit general appearance qualities. Water loss is the principal cause of fruit softening and shriveling (Wilson et al., 1999). Increase in weight loss is an indication of increase respiration rate which arises from the breakdown of carbon compounds by metabolism plant products hence decrease in fruit shelf life.

Fruit firmness indicating high significant correlation with fruit shelf life (0.73) and fruit decay (-0.60) respectively is a signal that, increased in fruit firmness which may have resulted from low respiration rate which is directly proportional to increase in fruit shelf life. Increase in fruit firmness leads to harden of the dermal system of the fruits making them insusceptible to decay pathogen infestation which could lead to decrease in fruit decay.

The significant negative correlation of membrane ion leakage with fruit decay (-0.61) and shelf life (-0.67), signifying the death of fruit cells which perhaps affects the enzyme-substrate interaction thus leading to reduced starch hydrolytic activity as cause by leakage of membrane. Loss of membrane integrity resulting from membrane damage leads to water loss and loss of other membrane-bound solutes (Boros-Matovina and Blakes, 2001), an indicator for predicting fruit shelf life and decay. Fruit dry matter (0.65) indicated positive correlation with shelf life (0.63) and total soluble solids (0.73) explain why fruit with highest dry matter, total soluble solids, shelf life of fruits. Fruit dry matter indicated high correlation with fruit moisture content (-0.80), this explains why fruits with higher dry matter had lower moisture content.

Conclusion

The study revealed that, pre harvest (soil amendment and cultivar types) practices can influence post harvest performance of tomato (*Lycopersicon esculentum* Mill.) fruits. Fruits harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizer performed best among the soil amendments on post harvest quality of tomato studied. However, fruits harvested from all fertilizer (NPK plus 'Asasewura' cocoa fertilizer, NPK plus sulphate of ammonia and poultry manure) amended fields on average performed better than fruits harvested from control (no amended) fields.

Fruit weight loss had indirect consequence on fruit firmness, general appearance and shelf life but direct effect on increased membrane ion leakage in tomato cultivar studied. Membrane ion leakage influenced fruit decay negatively in tomato cultivar studied.

Based on the study, both exotic and local types of tomato should be promoted with emphasis on the exotic types such as Royal which performed comparatively better with regard to postharvest quality. Moreover, tomato farmers are encouraged to amend their fields with NPK plus 'Asasewura' cocoa fertilizer to ensure higher yield and fruit quality.

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