JOURNAL OF AGRICULTURE & SOCIAL SCIENCES
ISSN Print: 1813–2235; ISSN Online: 1814–960X
09–065/AWB/2009/5–4–123–127
http://www.fspublishers.org

Full Length Article

Common Physiological Disorders of Tomato (*Lycopersicon esculentum*) Fruit Found in Swaziland

MICHAEL T. MASARIRAMBI[1], NORMAN MHAZO†, TAJUDEEN O. OSENI AND VICTOR D. SHONGWE
Horticulture Department, Faculty of Agriculture, University of Swaziland, P.O. Luyengo M205, Swaziland
†Agriculture and Bio Systems Engineering Department, Faculty of Agriculture, University of Swaziland, P.O. Luyengo M205, Swaziland
[1]Corresponding author's email: mike@agric.uniswa.sz

ABSTRACT

Physiological disorders of tomato fruit are abnormalities in fruit morphology, colour, or both which are not caused by infectious diseases or insects. The fruit abnormalities occur as a result of environmental stress on the plant. Reported causes of physiological disorders include genetic, environmental factors, nutrition and cultural practices such as watering practices, training and pruning. Physiological disorders encountered in this study included blossom end rot (BER), catface, cracking, internal white tissue, irregular ripening, puffiness, pox and fleck, rain check, zippering and sun scald. Ways of alleviating physiological disorders are suggested. Data was sought through content analysis, sample laboratory analysis, surveys in the various agro-ecological zones of Swaziland and brief interviews from key farmers in tomato growing communities.

Key Words: Physiological disorders; Tomato fruit; Post-harvest losses; Alleviating disorders; Climate change

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) family Solanaceae, is a very important fruit vegetable in the world. The plant originated in Central America, where it was used as an important vegetable by the ancient Incas and Aztecs. It was spread throughout the world by explorers. To date tomato is an important vegetable crop in all southern African countries including Swaziland.

Swaziland is located in south eastern Africa and covers an area of about 17, 364 km^2, lies between latitudes 25° 43′ and 27° 19′ S longitude 30^o 47′ and 32° 08′ E. Swaziland is a landlocked country: surrounded on the north, west and south by South Africa; and on the east by Mozambique (Thompson, 2005). The country is divided into four agro-ecological zones namely Highveld, Middleveld, Lowveld and Lubombo plateau See Fig. 1. Swaziland is considered a developing country, but not one of the least developed countries, although grappling with poverty problems (Zwane & Masarirambi, 2009) and the scourge of HIV and AIDS. Agriculture plays an important socio-economic role in Swaziland by contribution to GDP and providing employment to the population (Manyatsi, 2005).

Tomato is one of the most popular vegetable crops of Swaziland. It is produced mainly under irrigation and few are grown during the rainy season, because of the associated leaf and fruit diseases. Whichever seasons the crop is produced; it is subjected to a number of diseases and physiological disorders, which affects its profitable production. Most of the physiological disorders are often caused by environmental stress resulting from unpredictable weather conditions. These disorders drastically affect the production of the crop.

Tomato fruit quality for fresh consumption is determined by appearance (colour, shape, size, freedom from physiological disorders & decay) firmness, texture, dry matter and organoleptic (flavor) and neutraceptic (health benefit) properties (Dorais *et al*., 2001). Freedom of tomatoes from physiological disorders is very important not only from an appearance point of view but also because other attributes may be affected as well, such attributes include nutritional status and shelf life. Various physiological disorders of tomato fruit encountered in Swaziland will be discussed as a subject of special interest.

The objective of this review was to identify common physiological disorders of tomato fruit produced under Swaziland environmental conditions and suggest ways of alleviating these adverse conditions by situational/environmental manipulation and use of locally available resources.

Physiological or abiotic disorders in general. Physiological or abiotic disoders are mainly caused by changing environmental conditions such as temperature, moisture, unbalanced soil nutrients, inadequate or excess of certain soil minerals, extremes of soil pH and poor drainage (Jarvis & McKeen, 1991; Khavari-Nejad *et al*., 2009). This involves the genetic factors also. Thus there is a genetic (G) and an environmental (E) interaction (G x E). This complex interplay of factors is poorly understood for most disorders

To cite this paper: Masarirambi, M.T., N. Mhazo, T.O. Oseni and V.D. Shongwe, 2009. Common physiological disorders of tomato (*Lycopersicon esculentum*) fruit found in Swaziland. *J. Agric. Soc. Sci.*, 5: 123–127

and in some cases contradictory results have been reported apart from numerous names for many disorders (Peet, 2009). Physiological disorders can be divided into groups: nutrient imbalances, especially between potassium (K) and nitrogen (N) or magnesium (Mg) (blotchy ripening, greywall); calcium (Ca) amount or movement into fruit (gold fleck or speck & blossom-end rot); genetic predisposition (green or yellow shoulder) and watering (cracking, russeting, rain check & shoulder check) (Peet, 2009). Various ways can be used to alleviate various physiological disorders like adequate supply of K to plants. K is known to reduce the incidence of physiological disorders in tomato fruits, which affect their marketing quality, such as puffiness, blotchy ripening complex, greenback, gold flecks and graywall (Kinet & Peet, 1997; Imas, 1999).

Blossom end rot (BER). Blossom end rot is a disorder that affects tomato, pepper, eggplant, squashes and melons. Symptoms of BER start out as a small spot, which grows larger and darker with fruit growth. Blossom end rot can most easily be identified by a discoloured, sunken spot at the blossom end of the fruit (Vanderlinden, 2009). Blossom-end rot has water soaked spots, which enlarge and can cover up to half the fruit or even whole fruit. The tissue turns light to dark brown. The spot then dries out and becomes leathery. It may be infected by secondary pathogens. Blossom-end rot occurs when fruit is one third to one half fully grown. Fruit affected by BER ripens prematurely resulting in inedible product.

The disorder usually affects the first few fruits of tomatoes growing in cold soils. This may be a result of low Ca levels in the soil, quite often it is the result of erratic watering (Vanderlinden, 2009). BER is caused by Ca deficiency in the fruit. When a plant does receive inadequate water or when there is excess water in the soil, a plant's capabilities of absorbing Ca are diminished. The disorder is usually most severe following extremes in soil moisture (either too dry or too wet). These conditions result in a deficiency of Ca available to the maturing fruit, at the spot, where damage becomes apparent (McLaurin, 1998). Cause of injury is due to localized Ca deficiency, which occurs during a critical phase of fruit growth. Waterlogging, excess ammonium, K, Mg ions interfere with Ca uptake. Bar Tal and Pressman (1986) reported that the development of BER was positively correlated to the leaf K: Ca ratio but weakly to the K: Ca ratio in mature fruits. The incidence of external and internal BER has been reported to strongly depend on ion activity ratios between K and Ca+Mg ($a_k/\sqrt{[a_{Ca}+a_{Mg}]}$) and between Mg and Ca [a_{Mg}/a_{Ca}] in the root zone at both moderate (3 to 6 mS cm^{-1}) and high (6 to 12 mS cm^{-1}) salinity levels (Willumsen *et al*., 1996). There is a positive correlation between higher risk of BER and higher activity ratios due to lower Ca uptake and its reduced availability in the fruit tissue, which may be caused by increased concentration of organic acids in fruit juice. By maintaining the ion activity ratios at optimum levels of about 0.1 for the first ratio and 0.2 to 0.4 for the second Willumsen *et al.* (1996) reported that it was possible to reduce or avoid BER occurrence when salinity of the root zone was increased to improve fruit taste. Ca distribution is associated with this problem; also Ca moves in xylem is not retranslocated moves more quickly to transpiring leaves than to basal end of developing fruit. Vigorous growth due to high N, long days and high light intensities aggravate the problem. Environmental conditions that promote rapid transpiration worsen the problem like drastic fluctuations in soil moisture.

BER has been observed in all agro-ecological zones of Swaziland. It has been difficult to relate soil nutritional conditions in agro-ecological zones of Swaziland to BER. Haque and Lupwayi (2003) assessed the fertility level of soils in Swaziland by measuring total N, exchangeable Ca, Mg, K and sodium (Na), phosphorus (P) fractions and available P, copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) contents of surface soils. Most soils of Swaziland probably have low N but adequate Ca and Mg contents, while P may be deficient in some of the low pH and low CEC soils in the Highveld (Haque & Lupwayi, 2003). However the authors failed to make correlations with crop uptake and yields thus subsequently quality.

Rainfall in Swaziland is mostly erratic and unevenly distributed and more so during the summer when tomatoes are produced. Manyatsi (2005) reported that the unreliability of rain dictated that land and water management have to be prioritized. At times there is shortage of irrigation water, which leads to irregular irrigation schedules. Erratic rains and irregular irrigation schedules contribute to BER of fruits.

Possible control measures include adding Ca to fruit by sprays or dips, however this is not very practical. For avoiding ion imbalance in soil and fluctuations in soil moisture and water logging, it is recommended to avoid root pruning during cultivation and to grow tomatoes on the ground rather than on trellis, Use of less susceptible cultivars has been advised. Providing even and adequate soil moisture, especially during fruit set has been reported to reduce the incidence of BER (Kennelly, 2009). More uniform soil moisture may be achieved by adopting a balanced irrigation programme and mulching to conserve moisture. Avoiding over fertilization of the plant with N, especially of the ammonia formulation and selection of cultivars that are less prone to BER have been reported as possible means of avoiding the disorder (Kennelly, 2009).

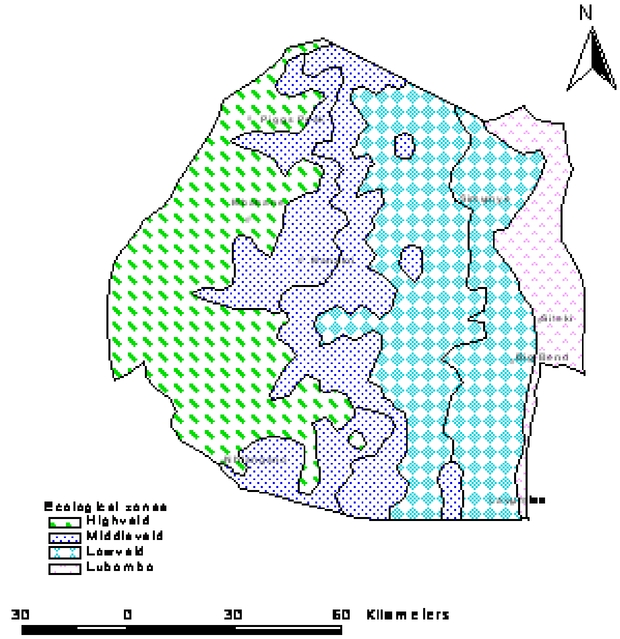
Catface. Catface is a disorder characterized by gross deformity of tomato fruit, which usually renders them unmarketable. The defect is usually located on the blossom end of the fruit. The deformity is caused by something (internal & external) that occurs during the formation of the flower that results in the fruit not developing normally (Olson, 2004; Peet, 2009). There is dearth of published information on the exact cause of this disorder. Catface is commonly observed in first harvest fruit. The symptoms include enlarged scars and holes in the blossom end. Cold weather occurring about 3 weeks before flowering begins has been identified as one of the causes (Kline, 2003; Peet, 2009). In Swaziland, some cold weather alternates with hot and these cycles are a predisposing factor for tomato catfacing. There is not much that can be done for control. Varieties should be selected that historically have had little problem with catfacing.

Internal white tissue. Fruit affected by this disorder usually show no apparent symptoms. When ripe fruits are cut, white hard areas especially in the vascular region are present in the outer walls (Olson, 2004). This disorder is more of a problem on fruits, which ripen on the vine. Most tomatoes produced in Swaziland are vine ripened and the problem is severe during hot weather. Under severe conditions fruit may also show white tissue in cross-wall and center of fruit. The problem may be reduced by adequate K fertilization (Imas, 1999; Olson, 2004; Peet, 2009) or use of less susceptible cultivars especially the highly colored ones (Olson, 2004).

Pox and fleck. Pox is described as small cuticular disruptions whose number can vary from a few to many found at random on the fruit surface (Olson, 2004). Fleck also known as gold fleck, develops as small irregular shaped green spots whose number can vary from a few to many at random on the surface of immature fruit, which become gold in color as fruit ripens (Olson, 2004). Both disorders are found together in most cases when fruit is affected but should be considered as separate. Severely affected fruits are not marketable and thus contribute to postharvest losses of tomato. However under Swaziland conditions, such fruit can be sold as least grade in local areas of production or can be used for home consumption. The real cause of pox and or fleck is not clearly understood. However both conditions seem to be genetic in nature (Dorais *et al*., 2001; Olson, 2004) but are difficult to breed out of a variety since the disorders only show up under certain environmental conditions (Olson, 2004). Differences of opinion exist as to the real conditions or genetic makeup lead to susceptibility to pox and fleck. Because of these differences and uncertainty shrouding these physiological disorders, further research is clearly warranted.

Puffiness. Puffiness refers to the existence of open cavities between the outer walls and the locular contents in one or more locules (Grierson & Kader, 1986) and is also known as hollowness or boxiness. Puffer fruit are not appreciated by consumers, because they lack gel in the locules and do not ship well, because of their relative softness. The quantity of fruit affected is determined by genotype and growing conditions that result in improper pollination (Grierson & Kader, 1986). This problem is caused by any factor that affects fruit set, including inadequate pollination, fertilization or seed development (Olson, 2004). Too high or too low temperatures are common causes of this problem in Swaziland. Like growth cracking, low K and high N or rainy weather have been reported to cause puffiness (Imas, 1999; Olson, 2004; Peet, 2009).

Fig. 1. Ecological zones of Swaziland



Watery fruit. Watery tomato is a physiological disorder resulting from an imbalance between plant water absorption and ambient climatic conditions (Dorais *et al*., 2001). Excessive root pressure results in the massive influx of water into the fruit and increases the volume of cells and sometimes damages the cells. This disorder develops after over-irrigation under a situation, where there is development of a strong root system, which triggers an elevated root pressure. Shelf life of such fruit is reduced and organoleptic quality is negatively affected. Maintaining plant leaf area index at a reasonable level during summertime helps reduce root pressure and minimize the incidence of this physiological disorder (Dorais *et al*., 2001).

Sunscald. This disorder can cause serious damage to fruit especially during the very hot South African (Sakata, 2009) and Swaziland summers. Symptoms of this disorder include bleached patches on green tomato fruit accompanied by rapid desiccation, which leads to sunken areas. Tomato fruit exposed to direct sun were found to be affected by this disorder. The situation is aggravated when there is insufficient leaf cover, trellising and susceptible varieties (due to certain genetic predisposition). This disorder may be controlled by avoiding any factor that causes leaf loss, such as diseases, insects and abiotic factors like hail damage may also be responsible for the problem. Control measures should be aimed at avoiding leaf loss by what ever environmentally friendly means possible.

Rain check. Rain check is characterized by tiny cracks that develop on the shoulder of the fruit. Cracks vary from a few to complete coverage of the shoulder. Green fruits are most susceptible, followed by breakers, while ripe fruits are not affected at all. Damage occurs quite often on exposed fruit after rain, however the exact cause is not known, but appears to be related to exposure of fruit to water (Olson, 2004). The problem of rain check is aggravated by heavy rains after a long dry spell, typical of weather conditions experienced in Swaziland during the summer period or as a result of irregular irrigation due to water shortage. Rain check can be alleviated by use of resistant cultivars with good leaf coverage, which protect fruit from rain or poor irrigation scheduling.

Zippering. Zippering can be described as a fruit having thin scars that extend partially or fully from the stem scar area to the blossom end (Olson, 2004), the scar transverses the longitudinal section. Occasionally open holes in the locules accompany the zipper scar. Some people feel that a zipper is formed when the "blooms" stick to the fruit and do not shed properly but this may interfere with proper fruit development and cause subsequent damage (Olson, 2004). Good cultural practices, which avoid fruit stressing and use of less susceptible cultivars can alleviate the problem of zippering.

Zebra stripe. Zebra strips can be characterized as a series of dark green spots arranged in a line from the stem end to the blossom end (Olson, 2004), the spots may coalesce resulting in elongated markings. The problem is genetic in nature as shown by the fact that it is variety related. It is probably a genetic defect that only develops under certain environmental conditions and may be linked to pox and fleck (Olson, 2004).

Tomato irregular ripening. Tomato irregular ripening (TIR) is a disorder, which occurs on tomato fruit, which have been fed upon by silver white fly (SWF) (*Bemisa argentifolii* Bellows & Perring) (Olson, 2004). This is a secondary effect of SWF insects. Symptoms of this disorder appear as uneven color as fruit develops rather than appearing on the leaves that are fed on. Plants infested with SWF can develop with external longitudinal white or yellow streaks resulting in unmarketable fruit. Internal symptoms are characterized by lack of internal coloring of the fruit, resulting in reduction of postharvest quality. The mechanism (s) underlying TIR are not fully understood, however control can be achieved by preventing SWF from feeding on tomato plants.

Chilling injury (CI). The temperature range under which chilling injury (CI) occurs is 0-12.5^{0}C and may be initiated in the field before harvest. Tomatoes are chilling sensitive at temperatures below 10^{o}C if held for longer than 2 weeks or at 5^{o}C for longer than 6-8 days (Suslow & Cantwell, 2009). There is a time–temperature relationship. Lower the temperature, longer the time the more the injury, which results. Symptom development depends on stage of growth of the fruit. Consequences of CI are failure to ripen and develop full color and flavor, irregular (blotchy) color development, premature softening, surface pitting, browning of seeds and increases decay (especially Black mold caused by *Alternaria* spp.) (Suslow & Cantwell, 2009).

Fruit stage of development is a factor in how it is affected by CI. Mature green fruit are injured more than pink fruit. Mature green fruit fails to ripen normally, because of less pigment formation and are characterized by relatively less flavor, increased susceptibility to disease, delayed or blotch coloration, pitting, shriveling and softening.

Chilling injury has a cumulative effect. It can occur in the field, during transit or in storage, CI is not observable, while at low temperature, it is only visible when tomatoes are moved to higher temperatures. Tomato fruit ripening as measured by color development was reversibly inhibited at high temperature (30^{o}C & above) but resumed when transferred to lower temperatures of about 20^{o}C (Masarirambi *et al*., 1995).

Blotchy ripening. This disorder also known as graywall, is recognized as grayish appearance caused by partial collapse of the wall tissue; hence the term graywall (Olson, 2004). The affected areas remain green or yellow are usually found nearly at the stem end of the tomato fruit. The cause is not clearly understood but is associated with the environment. Symptoms include irregular areas on the fruit with lack of red color. Cultivar differences low K, high N (Imas, 1999), low temperature and low light intensity and excessive soil moisture are among causal factors. This disorder may be controlled by avoiding conditions previously described as causal factors.

Fruit cracking. Several types of fruit cracking injury have been reported: radial cracking (star shaped & originating from the penducle), fruit bursting, concentric cracking (circular cracks originating from the peduncle) and cuticle cracking also known as russeting (Peet, 1992; Peet & Willits 1995; Dorais *et al*., 2001; Olson, 2004; Kennelly, 2009). Fruit cracking occurs due to rapid growth when there is abundant water and high temperatures, especially when these conditions prevail following periods of stress. The described conditions occur in Swaziland especially during the transitional period from the cool season to the warm rainy season i.e., from August to November. Fruit cracking is generally associated with rapid movement of water and sugars towards the fruit when cuticle elasticity and resistance are weak (Dorais *et al*., 2001). Bakker (1988) reported that this disorder generally occurred six to seven weeks after fruit set. An imbalance between water supply (influx) and water loss (efflux) has been implicated in the fruit cracking phenomena (Dorais *et al*., 2001).

Fruit cracking disorder can be controlled by using the cultivars that are less prone to cracking, provision of even water and balanced nutrition (Kennelly, 2009). The cause of this disorder is under genetic control. Some of the preventative measures include avoiding large variations in water availability in the soil. Sudden water availability; cause too rapid fruit expansion resulting in subsequent fruit cracking.

Limiting fruit exposure to sun through foliar disease management, proper trellising and staking have been reported to alleviate this problem, Some studies have reported that the application of Ca and gibberellins lessened the problem (Larson *et al*., 1983; Peet, 1992).

Gold spots/specks. Gold specks are characterized by tiny yellowish or golden spots, which are regular and often observed around the calyx and shoulders (De Kreij *et al*., 1992). Gold specks are shown to be cells containing some granular mass of minute calcium oxalate crystals (De Kreij *et al*. 1992; Den Outer & Van Veenendaal, 1988). Possible causes of gold spot/gold speck include excess fruit Ca and or high Ca/K ratios (Imas, 1999), high P, high relative humidity, high average temperature, cultivars resistant to BER. The presence of gold specks affects the aesthetic appearance of tomato fruit (Goossens, 1988) and reduces their subsequent shelf life. Possible control measures include preventing excess Ca uptake.

CONCLUSION

Global warming effects that are already setting in are likely to increase the incidence of tomato abiotic disorders as the climate changes. Therefore growers should learn to positively identify the various physiological disorders that occur in their agro-ecological zones/areas and be able to manipulate the environment and to use locally available resources to control particular disorders. Evaluation of cultivars adaptable to the different agro-ecological zones coupled with sound horticultural practices will go a long way towards alleviating the devastating effects of physiological disorders of tomatoes in Swaziland. Further work is envisaged.

REFERENCES

Bakker, J.C., 1988. Russeting (circular cracking) in glasshouse tomatoes in relation to fruit growth. *J. Hort. Sci*., 63: 459–463

Bar Tal, A. and E. Pressman, 1986. Root restriction and potassium and calcium solution concentrations affect dry-matter production, cation uptake and blossom end rot in greenhouse tomato. *J. American Soc. Hort. Sci*., 121: 649–655

De kreij, G., J. Janse, B.J. Van Goor and J.D.J. Van Doesburg, 1992. The incidence of calcium oxalate crystals in fruit walls of tomato (*Lycopersicon esculentum* Mill.) as affected by humidity, phosphate and calcium supply. *J. Hort. Sci.* 67: 45–50

Den Outer, R.W. and W.H.L. Van Veenendaal, 1988. Gold specks in tomato fruits(*Lycopersicon esculentum* Mill.). *J. Hort. Sci.,* 63: 645–649

Dorais, M., A.P. Papadopoulos and A. Gosselin, 2001. Greenhouse tomato fruit quality. *In*: Janick, J. (ed.), *Hort. Rev*., 5: 239–319

Grierson, D. and A.A. Kader, 1986, Fruit ripening and quality. *In*: Atherton, J.G. and J. Rudich (eds.), *The Tomato Crop: A Scientific Basis for Improvement*, pp: 241–280. Chapman and Hall, London-UK

Goossens, H., 1988. *Uitgangspunten Goudspikkels*. Internal communication of the auction, Westland-Zuid

Haque, I. and N.Z. Lupwayi, 2003. Soil nutrients in agro-ecological zones of Swaziland. *African Crop Sci. J*., 11: 245–257

Imas, P., 1999. *Quality Aspects of K Nutrition in Horticultural Crops.* Paper Presented at IPI-PRII-KKV Worksop on: Recent Trends in Nutrition Management in Horticultural Crops. 11-12 February 1999, Dapoli, Maharashtra, India

Jarvis, W.R. and C.D. McKeen, 1991. *Tomato Diseaes*. Agriculture Canadian Publication, 1479/E. Ottawa-Canada

Kennelly, M., 2009. *Tomato Leaf and Fruit Diseases and Disorders*. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.www.ksre.ksu.edu

Khavari-Nejad, R.A., F. Najafi and C. Tofigi, 2009. Diverse responses of tomato to N and P deficiency. *Int. J. Agric. Biol*., 11: 209–213

Kinet, J.M. And M.M. Peet, 1997. Tomato. *In*: Wien, H.C. (ed.), *The Physiology of Vegetable Crops*, pp: 207–258. CAB International, New York, USA

Kline, W., 2003. *Physiological Disorders of Tomato, Plant and Pest advisory,* Vol. 9. (17), p: 2. Vegetable Crops Edition, Rutgers Co-operative Extension Bulletin

Larson, F.E., R.J. Fritts, K. Patten and M.E. Patterson, 1983. Sequential sprays of gibberellic acid and calcium may reduce cherry cracking. *Good Fruit Grower.,* 34: 26–28

Manyatsi, A.M., 2005. Land and water management: Swaziland country situational analysis. *In*: Nhira, C. and A. Mapiki (eds.), *SADC Land and Water Management Applied Programme and Individual Country Authors*, pp: 113–126. SADC SecretariatGaborone-Botswana

Masarirambi, M.T., J.K. Brecht, S.A. Sargent and C.A. Sims, 1995. Tomato color development following exposure to ethylene at high temperatures. *Proc. Fla. State Hort. Soc*., 108: 268–272

McLaurin, W.J., 1998. Blossom-end rot. *Hortic. Fact Sheet*, H-98-036: 1–4

Olson, S.M., 2004. *Physiological, Nutritional and other Disorders of Tomato Fruit University of Florida IFAS Extension HS-954*. EDIS website at http://edis.ifas.ufl.edu

Peet, M.M., 1992. Fruit cracking in tomato. *Hort. Tech*., 2: 216–223

Peet, M.M., 2009. Physiological disorders in tomato fruit development. *Acta Hort*. *(ISHS)*, 821: 151–160

Peet, M.M. and D.H. Willits, 1995. Role of excess water in tomato cracking. *Hort. Sci*., 30: 65–68

Sakata, 2009. *Fortress, F1 Hybrid Determinate Salad Tomato.* Technical Bulletin, www.sakata.com

Suslow, T.V. and M. Cantwell, 2009. *Tomato: Recommendations for Maintaining Postharvest Quality*, pp: 1–5. Tomato Produce Facts, Postharvest Technology Reserch and Information Center. UC, Davis-CA

Thompson, C.F., 2005. *Swaziland Business Yeear Book*. Christina Forsyth Thompson, Mbabane-Swaziland

Vanderlinden, C., 2009. *Identifying and Controlling Blossom End Rot*. http://organic gardening.about.com/od/disease/p/blossomendrot.htm

Willumsen, J., K.K. Petersen and K. Kaack, 1996. Yield and blossom-end rot of tomato as affected by salinity and cation activity ratios in the root zone. *J. Hort. Sci*., 71: 81–98

Zwane, P.E. and M.T. Masarirambi, 2009. Kenaf (*Hibiscus cannabinus* L.) and allied fibres for sustainable development in Swaziland. *J. Agric. Soc. Sci.,* 5: 35–39

(Received 05 October 2009; Accepted 23 October 2009)