Experiences of Rain-fed Tomato Production in an Open Field

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Abstract: ***Tomatoes in Ethiopia are conventionally grown in an open field during dry periods using irrigation. Rain fed tomato production in an open field was considered difficult mainly because of disease attack leading to complete destruction of tomato plants since rain contact with the foliage favors development and spread of diseases. Seasonality of production and fluctuations in the supply of fresh tomatoes leading to market glut during in season and shortage during off season was also reported in many countries including Ethiopia, Kenya, Nigeria, Nepal and India. Rain fed tomato production in an open field is however successfully demonstrated with the use of appropriate integrated disease management (IDM) practices. Multiple strategies of using cultural, physical, mechanical, biological and chemical options help to limit development and spread of diseases. Control measures include the use of resistant varieties, seeds free from pathogens, seed treatment, improved drainage, proper sanitation, keeping cultivated fields clean and free from weeds and other foreign material that can serve as host for the pathogens. Appropriate field bed preparation, spacing, fertilization and destroying infected plants and throwing them away from the field are also vital. Site selection is an important initial step for IDM where well drained soil is preferred. Tomatoes benefit from crop rotation. Growing tomato in a field planted the previous season with tomato, pepper, eggplant, or other solanaceous crop should be avoided. Ridging and staking are also crucial specifically to drain excess water and to avoid foliage and fruit contact with the soil, respectively. It may also be critical to apply preventive and curative fungicides. Spraying fungicides namely, Agrolaxyl (3 kg/ha) and Ridomil Gold Mz 68 WG (3kg/ha), interchangeably at seven to ten days interval depending on the weather condition and disease incidence were found effective in mitigating the development of foliar fungal diseases at Woreta in Ethiopia. Scouting to monitor for plant disease symptoms and analysis of every hour weather conditions should be seriously considered, otherwise, tomato plants that appear healthy this morning or evening would be completely lost the other morning or evening for diseases such as late blight spreads very fast wiping away plants within a short time.***

Keywords: Fresh-tomato, IDM, irrigation, in-season, off-season

1. Introduction

Tomato (*Lycopersicon esculentum* Mill.) is the most widely cultivated and lucrative vegetable crop in Ethiopia in particular and in the Globe in general. According to Ibitoye *et. al* (2009), tomato is the second most important vegetable in economic importance and consumption in the World, second only to potatoes. It is the highest vegetable income earner in Kenya (Kirimi *et. al,* 2011).

Tomato is the most popular vegetable crop with versatile culinary uses. It can be eaten raw in salads or cooked, fried or sundried (ARC, 2013). Tomatoes provide micronutrients, fiber, vitamins and minerals essential for a balanced and healthy diet. Tomatoes are rich sources of vitamins A and C, potassium and fiber. They are rich in lycopene (Dimascio *et al*., 1989; Trinklein, 2010), the pigment that makes tomatoes red and has been linked to the prevention of or fight against many forms of cancer, especially the prostate cancer (Giovannucci *et. al*, 1995; Giovannucci, 1999 and Mills *et. al*, 1989). Several studies have also shown that tomatoes can help decrease the chance of getting lung cancer, because lycopene acts as antioxidant (Young *et al*., 1993). Furthermore, Tabasi *et. al* (2013) indicated that lycopene is the leading factor to health promoting ability of tomatoes.

Tomatoes are used as fresh vegetable, and also processed and canned as a paste, sauce, ketchup and juice (Muhammad & Singh, 2007). They are also a major source of cash income for smallholder as well as commercial farmers. Tomatoes are conventionally grown in an open field in Ethiopia during the dry periods using irrigation. With the expansion of irrigated farming, market oriented tomato production has been expanding in the last few years, enabling various actor including growers, merchants, consumers, middlemen, transporters, to take part and benefit in the value chain of this important horticultural sector.

Several reports underlined that tomatoes are not grown in an open field in the rainy season because of disease problems. Disease attack is the primary reason challenging tomato production in the rainy period (Fentahun, 2009). According to Pandey *et al.* (2006) tomato production during rainy season in an open field condition is very difficult and the production during the season is very low in Nepal. Duncan *et al.* (2012) noted that rainy season brings a combination of high temperatures and humidity that favors development and spread of diseases and voracious insects in south west Asia. They further showed that desirable vegetables, such as lettuce and tomatoes, are difficult to produce under rainy season conditions without significant inputs such as plastic row covers and pesticides. Tomato cultivation is generally more restricted by diseases than pests in most locations in Nigeria (Arogundade *et al.* 2007). Given the right weather conditions and an early initial infection, the most devastating disease of tomatoes during the rainy period include early blight, late blights and *septoria* leaf spot.

Despite the importance of tomatoes in the daily diet of the Ethiopian people and ever increasing demand for this crop, fresh tomato supply during the rainy period is limited in many parts of the country and the price climbs up. On the other hand, fresh tomato supply is high in the dry season. Fentahun *et.al.* (2009) also showed that tomato production peaks towards the mid dry season causing a market glut and falling prices. Tomato production in Nigeria is done during the dry season (Ayoola, 2014) while its production is scarce during the rainy season because of high disease incidence associated with growing tomatoes. Critical periods of shortage for fresh tomatoes in many areas in Ethiopia especially in Amhara region is from June to October when prices are exorbitant (Getahun 2015). Likewise SSMP (2010) showed that the monsoon rains during the wet season (June–October), severely limit the type of crops that can be grown in open fields and they also restrict the production of seedlings.

Utilization of improved horticultural husbandry and disease management practices along with tolerant varieties can however help to produce tomatoes under rain fed. Since tomato is very expensive during rainy season, farmers could fetch good price (Pandey *et al,* 2006). Some tomato varieties may have tolerance or resistance to those major diseases. Other strategies to control those diseases include frequent application of preventive and therapeutic fungicides. This is sometimes difficult due to the emergence of new resistant strain of, for instance, late blight. Greenwald (2013) also underlined the importance of multiple strategies to limit development and spread of diseases in an open field rain fed tomato production. These may include growing resistant plant varieties, conduct regular disease scouting, monitoring the weather for disease favorable environmental conditions, remove nearby weeds and discarding live weed plant material in the Nightshade family, use preventative fungicide applications, immediately remove diseased plant material at first sign (burn or burry), and discard harvested fruit from infected plants. The use of furrow or drip irrigation or soaker hoses can lessen the amount of water splashing on foliage of plant and limit the spread of the inoculums.

Field experiments conducted at Fogera in Ethiopia in 2014 and 2015 revealed that varieties Melka salsa and Melka shola significantly tolerated disease attack and ultimately yielded significantly high marketable yield than other varieties including Bishola, Fetan, Miya and Chali (Getahun, 2015). It is also demonstrated that application of appropriate crop management practices including selection of a well-drained field, rotation away from solanaceous crops for at least three years, improvement of soil fertility, planting tomatoes as far away from potato field as possible, ridge planting, staking and spray plants in the field regularly with protective and curative fungicides when once infected were critical for successful tomato production during the rainy season.

Application of best field management practices including the use of effective preventive and curative fungicides, depending on disease incidence and weather condition, help to minimize or control diseases. Integrating various practices, in addition to controlling diseases, would help to lower cost of production and minimizes hazard to the environment. The use of appropriate integrated disease management (IDM) practices is therefore critical to produce tomatoes under rain fed. It is also critical to scouting for disease symptoms and to rogue infected plants as soon as they are detected (Arogundade *et al*, 2007). Not only monitoring for plant disease symptoms is crucial, but also analysis of every hour weather conditions should be seriously considered to learn to recognize the weather conditions that foster the spread of diseases.

Open field tomato production under rain fed is thus possible with close follow up at least two to three times daily. Tomato plants that appear healthy this morning or evening would otherwise be completely lost the other morning or evening. Cloudy or rainy weather conditions for several hours will favor development and spread of infection with explosive disease development leading to complete destruction of plants unless strategies are followed to mitigate disease progresses. Whenever weather conditions are favorable for disease development, preventive fungicides need to be sprayed or else curative fungicides should be applied whenever symptoms are observed on a single leaf of a single plant. Based on research results from Fogera Research Center and experiences from Ethiopian Institute of Agricultural Research (EIAR) and elsewhere in the World, practical recommendations for successful tomato production in an open field during the rainy season are depicted below.

2. Seed and variety selection

Since seed is the initial stage for the success of a production process, care should be taken in selecting seeds. Securing pure and healthy seeds with high viability leads to high yield and quality production. Choosing a suitable variety depending on a season and purpose of production is also crucial. Types of tomatoes are generally categorized into two, depending on purpose, i.e, varieties for fresh consumption and processing. Based on growth habit, two types of tomatoes are commonly grown. Most commercial varieties are determinate. These “bushy” types have a defined period of flowering and fruit development causing the vine to quit growing at a certain height. Determinate plants are usually earlier to mature, because, once flowers are formed they divert all energy into filling and producing a uniform crop. Determinate types are more often used where seasons are shorter and just one crop is produced. In comparison, greenhouse tomatoes are indeterminate types producing flowers and fruit throughout the life of the plant and the vine keeps growing until frost or something else kills it. Such a crop, if maintained, can make better use of an extended season.

Research result at Fogera in 2014 and 2015 revealed that varieties Melka shola and Melka salsa (both are of determinate type and can be used for dual purposes) were suitable for open field tomato production in a rainy season in Ethiopia. Variety Melka salsa was the earliest in attaining 50% flowering within 47.67 days after transplanting while Melka shola took 52.67 days (Getahun, 2015). Menberu *et al.* (2012) have also shown variations among varieties and intra-raw spacing in achieving 50 per cent flowering. In spite of regular fungicide spraying by closely monitoring tomato plants in the field, infection and development of symptoms of diseases were observed almost on all varieties considered in this study. Varieties Melka shola and Melka salsa, however demonstrated significantly negligible infection and disease development ultimately producing the highest marketable yield.

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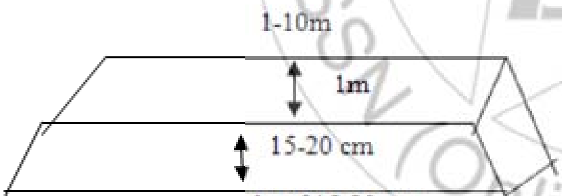
Nursery bed preparation and seedling raising

Choosing a well-drained, un-shaded area not recently cropped with a solanaceous crop is the first step to successful production. Burning straw and other plant debris on the seedbed before digging the soil can reduce soil borne disease problems. Digging soil deeply and breaking large clods is required. Applying 3-5kg of well decomposed manure per m^2 and mixing it with soil thoroughly is also important. Soil solarization (covering the soil with plastic sheet after watering) during the hottest months can also help to kill /reduce pathogens and weed seeds in the soil.

A fine seedbed is indispensable to produce healthy and strong seedlings. The soil should be thoroughly prepared, loose and in good tilth. The bed should be about 15 to 20 cm high from the soil surface. The width of the bed is one meter, while its length could vary from one to ten meter length depending on the quantity of seedlings required. Seeds need to be drilled on rows with ten cm inter-row spacing. It should be covered lightly with fine soil or compost (0.5cm deep) and lightly mulched with dried grass or straw until emergence. Since termite is a serious problem around Fogera in Amhara region in Ethiopia, eucalyptus leaves are preferred to grass because straw or grass aggravates damage from termites. According to Panday *et. al* (2005), IDM package in nursery beds comprised soil solarization, use of neem cake, bioagents application, nylon netting and streptocycline spray.

About 125 g of seeds for a determinate variety are required to produce enough seedlings to plant one hectare (Hanson, et.al, 2000). The soil should not be allowed to dry and form a crust on the surface that might hinder seedling emergence. The seedbed needs to be regularly watered so that it is moist but not waterlogged. Seedlings will emerge within 4-7 days at the optimal soil temperatures of 20–30°C.



Nursery bed with a height of 15-20 cm

Mulching with leaves of Eucalyptus leaves

Immediately after seedling emergence, mulch is removed and replaced by white plastic cover. Plastic shelter at one meter height from the surface of the seed bed should be constructed to avoid rain contact with foliage of seedlings. Seedlings need to be free from weeds, and thinning seedlings is required 2–3 days after the first true (non-cotyledon) leaves appear. Seedlings will then be allowed 1-3cm distance within plants (intra-raw spacing). Seedlings generally attain transplantable size in four weeks.

A. Seedling raising under plastic shelter during the rainy season

B. Transplanted seedlings flourishing on ridges while furrows or ditches facilitating drainage

Seedling trays can also be used to raise seedlings. Direct seeding is also used if seeds are not expensive and sufficient rain fall is available. Seeds will be drilled on rows of well prepared beds and lightly covered with soil.

Main bed preparation and seedling transplanting

Tomatoes must not be grown on the same land that had potatoes, eggplant, peppers and tomatoes in the last 2-3 years. Crop rotation can avoid some diseases, and improve soil fertility. Select a well drained site with good exposure to the sun and wind to promote drying of the folliage after rain or dew. After selecting a well drained place, the land should be thoroughly plowed or dug to 2-3 times, followed by preparation of beds or ridges. If experience is lacking to grow tomatoes in the rainy season, it is the first time to grow tomatoes in rainy season, it is recommended to make a bed next / close to ones house for easy and frequent monitoring. The importance of close follow up of tomato plants every day at least twice for any infection and symptom development, and analysis of every hour weather condition is critical.

Hardening the seedlings by slightly reducing water and exposing them directly to sunlight about a week before transplanting is one of seedling handling practice in tomato production. It is also critical to thoroughly water the seedlings about 12 hours before transplanting to the field. Using good seedlings in the four- or five-leaf stage (about pencil size) that are vigorous and stocky are preferred for transplanting. It is advisable to transplant in the late afternoon or on a cloudy day to minimize transplant shock, and carefully insert the seedling in a hole so the cotyledons are above the surface. It is required to press the soil firmly around the root, and water around the base of the plant to settle the soil. The field should also be irrigated the field as soon as possible after transplanting.

For rainy season production, planting on ridges or beds is preferred to flat land, since tomatoes are sensitive to water logging and ridges or beds can easily drain excess water. After thoroughly preparing the field, preparation of ridges with 20- 35 cm height is recommended for Fogera and to other areas with similar soil and climatic conditions. Raised beds / ridges are used to facilitate furrow irrigation and to improve drainage. Field management practices such as planting on sides of ridges could have further helped for the performance of tomatoes by draining excess water.

Spacing

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Plant spacing depends upon cropping system, soil type, and plant habit. A spacing of 40 cm and 100 cm intra- and inter-row, respectively, is recommended for rain-fed tomato production at Fogera in Ethiopia (Getahun and Dejen, 2015) where as for dry season production under irrigation 30cm X 100cm is recommended

The use of appropriate spacing helps to improve yield and quality and is critical to reduce disease development and dissemination. Spacing affects growth, yield and quality of tomatoes as well as pest and disease prevalence. According to Abdel-Mawgoud *et al* (2007) and Lemma *et al* (1992), spacing is among the management practices which greatly influence tomato fruit yield in both fresh market and processed tomatoes. Likewise, Godfrey-Sam-Aggrey *et al* (1985) and Mehla *et al* (2000) reported that yield parameters in tomato to have been highly influenced by spacing. Appropriate spacing can help to mitigate attack from disease and is help full to obtain early or delayed harvest depending on the demand and market price. According to Ara, N. *et al* (2007) wider spacing (60 cm X 50 cm) gave higher marketable yield (82.39 t/ha) than closer spacing (60 cm x 40 cm). Gajanana, T.M et al (2006) also indicated that wider spacing of 90 cm × 60 cm is one of the components of integrated disease management (IDM) technology in tomato. Wider spacing minimizes competition for nutrients, water and radiation (Wasserman, 1985; Cochlar & Joseph, 1986). Muhammad & Singh (2007) further showed that greater circulation of air and interception of light by plants resulting in lower incidence of diseases and pests at wider spacing. The spacing of tomato plants is an important component for healthy productive plants. Appropriate spacing is however in relation to , soil fertilization and other cultural practices, including season of production. Trinklein (2010) further showed that proper spacing and staking are essential for healthy plants and good fruit production. He further reported that ideal spacing for home garden tomatoes is generally 24 -36 inches.

Fertilization

Tomato is a heavy feeder of plant nutrients including nitrogen, phosphorus and potassium and it responds well to organic fertilizers. In addition to improving soil fertility, application of organic (green /animal manure) fertilizer improves water holding capacity and drainage. The amount of fertilizer applied is influenced by fertility status of the soil, season and the variety.

Tomato plants have a moderately high requirement of nitrogen. Nitrogen promotes better growth and better flower and fruit set. Adequate levels of potassium also result in improved color, taste, firmness, sugars, acids and solids of the fruit. Plant cells are also strengthened. Phosphorus promotes root development, early flowering and fruit set and ensures more vigorous growth. Tomatoes also require micronutrients for growth and development. Deficiencies of magnesium, calcium, and molybdenum are common in acid soils while boron and copper deficiencies are not often found in tomatoes. However, boron deficiency, if it occurs, results in fruit cracking, pitted and corky areas, deformed shape, malformation and uneven fruit ripening. Iron has been found to be deficient on calcareous, alkaline soils or after heavy applications of lime. Manganese deficiencies are mainly found in calcareous soils. In the tropics, common fertilizer application rates are 60–120 kg N/ha, 60–140 kg P2O5 /ha, and 60–120 kg K2O/ha (Hanson, et.al, 2000). It is further recommended that half of the fertilizer will be applied as a basal dose and the remaining fertilizer be added at first fruit-set.

Tomato plants at Fogera Research Center performed best with the application of Diamonium phosphate (DAP) (18:46:0) and urea (46:0:0) at the rate of 150 kg/ha and 100 kg/ha (kilogram per hectare), respectively. DAP is applied at transplanting while urea is applied in two splits, the first a week after transplanting and the second one and half months after transplanting. Observation of symptoms of blossom end rot also indicates the necessity to apply calcium.

Tomatoes also benefit from crop rotation. Growing tomato after paddy rice, for example, reduces the incidence of disease and nematodes (Hanson, et.al, 2000). The use of green manure crops such as *Tithonia* is also advised for it accumulates a large amount of nitrogen and phosphorous from the soil, therefore makes a very good organic fertilizer.

Staking to support tomato plants and furrows draining excess water Rice grown as wind break in between tomato plants Planting fast growing plants in between tomato plots or replications or fields or in the gangways is helpful to mitigate spread of wind borne pathogens from one to the other field or replication. Rice was grown as wind break in between tomato plots at Fogera Center. In addition this helps to maximize return per unit of land and will help to avoid risk of production.

Staking

Staking (support tomato plants using stick and/or rope or trellises) is among desirable field management practices for rain fed tomato production. Supporting tomato plants using stick , bamboo and/or rope or wire (staking and stringing) would help to keep the foliage and fruit off the ground. It allows good air movement around the plants, allows for more uniform spray coverage, improves fruit quality and makes harvesting easier. It helps to avoid branch/foliage and fruit contact with moist soil that may otherwise cause fruit rotting. Staking needs to be done before flower initiation starts.

Weed control and cultivation

Weed competes for light, water, and nutrients. It sometimes hosts pathogens that cause tomato diseases, such as tomato yellow leaf curl virus. Weeds can be controlled chemically or mechanically. Chemical weed control can be used by applying registered chemicals. Mechanical cultivation should be shallow and not too close to the plant; this will prevent damage to the plants. Hand-hoeing is a common practice with tomato production in Ethiopia in general and in Amhara region in particular. Mulches also suppress weed growth on the beds.

3. Disease Management

Major tomato diseases observed at Fogera were damping off (*Phythium spp, Rhizoctonia solani and Phytopthora spp*.), early blight (*Alternaria solani*), late blight (*Phytophthora* infestans), septoria leaf spot (*Septoria lycopersici*), fusarium wilt (*Fusarium oxysporum*), bacterial wilt (*Rlstonia solanacearum* formerly known as *Pseudomonas solanacearum*), powdery mildew (*Leveillula taurica* (*Oidiopsis taurica*), *Erysiphe orontii* (*E. cichoracearum* and *E. polyphaga*)) and viral diseases such as tomato yellow leaf curl virus (TYLCV) and tomato spotted wilt virus (TSWV). Diseases usually observed around Fogera in Ethiopia are described below.

Damping-off is a disease of seedlings that causes seedling death or poor growth due to fungal infection. Affected plants usually occur in patches in nursery beds or in lower parts of sloped fields. In level fields, affected plants are generally found in scattered areas. Symptoms of damping off include reduced germination, dark brown or black water soaked lesions develop rapidly and involve the entire seedlings; and /or a dark colored and soft lesion develops around roots. There are two types of damping off: pre-emergent and post-emergent. Pre-emergent damping-off: seeds rot in the soil or seedlings decay before they push through the soil and Post-emergent damping-off: seedlings sprout, but then pale, curl, wilt, or collapse at the soil line. The stem is water-soaked and turns gray, brown or black before disintegrating. According to Panday *et. al* (2005), tomato crop in India is severely damaged by damping off, bacterial blight, alternaria blight and tomato leaf curl virus.

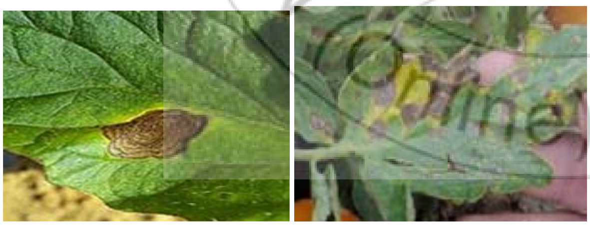
Fungicides, such as Ridomil Gold (mefenoxam), can be applied to the seedbed at or before seeding to control pythium damping-off. Seed can be treated with broad spectrum fungicides, such as captan and/or thiram to reduce losses from damping-off (AVRDC, 2000).

Damping off

Late blight

Late blight is a very destructive disease of tomatoes. Fortunately, around Fogera, the disease is not a problem most years since it only occurs when weather is cool and wet. Symptoms appear as large, irregular, greenish or water-soaked lesions on the leaves, stems and fruit. Rapid blighting of entire plant is the characteristic of the disease. Early detection and a timely disease control program will prevent substantial crop losses that could result from this disease.

Early blight is promoted by warm, wet conditions and heavy dews. The appearance of circular or irregular dark spots on the lower, more mature leaves is one of the first symptoms of infection. Eventually, the spots enlarge into a series of concentric rings surrounded by a yellow area. The entire leaf may be killed and will drop off the plant. Early blight can result in extensive defoliation, exposing fruit to sunscald and reducing yields. This disease typically progresses from the base of the plant, upward. According to Shamiyeh, et.al (2001) the major commercial control strategies for both early and late blight have been a preventive spray program with fungicide applications made on seven day schedule depending on weather conditions.



Early blight

Septoria leaf spot

Septoria leaf spot usually appears on the lower leaves after the first fruit sets. Spots are circular with dark brown margins and tan to gray centers with small black fruiting structures. Characteristically, there are many spots per leaf. This disease spreads upwards from oldest to youngest growth. If leaf lesions are numerous, the leaves turn slightly yellow, then brown, and then wither. Fruit infection is rare.

Fusarium wilt is soil-borne promoted by warm weather and wet soils. It attacks the plant through the roots and causes plugs to form in the vascular tissue. The plugs restrict the uptake of water and nutrients, resulting in wilting and yellowing. Foliar yellowing usually start on lower leaves, often on one side of the branch. A discoloration is also observed on the vascular tissue.

Bacterial wilt is also soil-borne promoted by warm weather and wet soils. It infects the roots and the stem. Infection causes sudden wilting with no yellowing or necrosis. The stem pith gradually decays and leaves a hollow stem.

Bacterial wilt *Fusarium* wilt

Powdery mildew is characterized by a dusty-white to gray coating and talcum powder-like growth commonly infecting plant's leaves. It begins as circular, powdery-white spots that turn yellow-brown and finally black. Powdery mildew is commonly found on the upper side of the leaf. Warm and dry conditions favor disease development. Infected seeds and planting materials and overcrowded plants aggravate the problem.

Tomato Yellow Leaf Curl Virus (TYLCV) is spread by vector -whiteflies (Bemisia tabaci).

Symptoms of TYLCV infection include severe stunting, reduction of leaf size, upward cupping /curling of leaves, chlorosis on leaves and flowers, and reduction of fruit production.

Powdery mildew TYLCV TSWV

Symptoms of tomato spotted wilt virus (TSWV) differ among hosts and can be variable in a single host species. Stunting is a common symptom of TSWV infection, and is generally more severe when young plants are infected. An infected tomato has a number of visible characteristics including bronze-colored or dark-spotted leaves, stunted growth, dark streaking in the plant's terminal stems, and possible die-back of the plant's growing tips. The fruit may be deformed or wilted, with a reduction in fruit quality and yield. Although TSWV is not seed transmitted, it may cause the discoloration of seed produced on infected hosts. Thrips contract the virus while they are in the larval stage and feed on infected plants, such as weeds, and then transmit the virus as adults, flying from infected plants to healthy plants.

4. Physiological Disorder

Blossom-end rot (BER) which causes a dark, sunken area on the lower (blossom) end of tomato is frequently observed in the vicinity of Fogera. The discoloration is usually tan, brown, or black and should not be confused with sunscald, which causes a whitish or translucent discoloration.

Blossom end rot starts when the demand for calcium in the expanding fruit exceeds the supply. However, it is not a case of a simple calcium deficiency, but is much more complex. Adding calcium to the soil rarely alleviates the problem. BER involves a low level of calcium in the fruit, but often the supply may be more than adequate in the plant or soil. In terms of management, blossom-end rot is primarily a water issue. It is most severe following drought stress or wide fluctuations in soil moisture. BER is usually an early season problem, and the first fruits are most severely affected

5. Insect pest management

Tomato fruit borer (*Helicoverpa armigera*) is one of the most destructive pests of tomato. Moths deposit eggs on tomato foliage. Upon hatching, larvae will initially feed on foliage for a short time before boring into fruit. Control tactics should therefore aim to kill larvae as they hatch from eggs and before they bore into fruit. The larva bores into the fruit making it unfit for marketing. According to Gajanana *et al* (2006), tomato fruit borer, Helicoverpaarmigera (L) is the most important insect pest in Karnataka state, India and further showed that, in spite of regular spraying of insecticides, its incidence in farmers' field varied from 10 to 20 per cent and at times, this pest causes yield loss up to 40 per cent.

Tomato fruit borer Physiological disorder

Cutworms, the black cutworm (*Agrotis ipsilon*) and variegated cutworm (*Peridroma saucia*) both can cause damage at the larval stage. They cut off the stems of young plants at or near ground level. Cutworms gobble up stems of tomato seedlings. They work mostly at night to do their damage, cutting off seedlings or recently transplanted tomato plants at the soil line, causing stand loss. Later in the season, cutworms nibble holes on the surface of tomatoes. Tomatoes near the ground are most vulnerable. During the day, worms hide under clods or debris on the soil surface. If disturbed, they curl up. At night, they munch through tomatoes.

Tomato is also attacked by several kinds of aphids. Severe infestations under dry conditions may result in premature die-back of plants. Thrips also attack tomato but *Thrips tabaci* is the most important one. Thrips chafe the surfaces and suck the sap from broken cells on flowers and young fruit. Additional damage includes blossom drop, scarring of fruit and malformation of the leaves. Thrips also act as vectors of spotted wilt virus.

The use of integrated pest control measures are advisable. This includes appropriate crop rotation, proper sanitation of keeping cultivated fields clean from weeds and other foreign material that can serve as host for the killer pest. Destroying infected plants and throw them away from the field and spraying registered insecticides are important.

Plant extracts /botanicals such as from *Tephrosia Vogelii* can also be used as an insecticide (Kareru, et. al, 2013). In addition, *Tephrosia vogelii* can be grown to improve soil fertility, for firewood, as an insecticide against storage pests and mites on tomato plants. It can also be used as a medicine for skin diseases and internal worms. Extract of *Tephrosia* leaves can be used for the control of pests such as termites, ants, beetles, aphids, cutworms, various bugs and weevils, stalk borers, flies and so on in the field, in storage or on domestic animals. It leaves no residue on crops because rotenone breaks down within 3 - 5 days after application.

6. Harvesting

Tomato can be harvested at different stages, depending upon the demand from the market. The end-use of the produce and the distance to the market will determine when to start harvesting. Harvesting can be done from pale green stage (when the fruits have a pale green color, particularly around the blossom end of the fruit and when the hard dry appearance of the fruit has disappeared) to red or ripe stage (when the greater part of the fruit has a full red color and when the fruit is firm with no signs of softening). Fruit to be transported long distance is harvested at a less mature stage, while fruit for local sale can be picked at later ripening stages. Poor care of fruit after harvest will lead to poor fruit quality. It is necessary to avoid fruit injury and not to mix damaged and undamaged fruit. Harvest during cool periods, such as late afternoon or early morning, and shading the harvested fruit and avoiding exposing fruit to temperatures above 25°C are advised. If possible, storing the fruit in a ventilated place with a relative humidity of 85–90% to slow water loss is recommended.

7. Summary

Direct contact of plants to rain drops, coupled with other predisposing factors such as high temperatures makes the micro environments around the tomato plants suitable for the development and spreading of diseases thereby limiting full yield potential. Tomato production in the rainy season requires attentive daily follow up of both the plant as well as the weather conditions. The importance of integrated disease management practice for rain fed tomato production is therefore crucial. Control measures include the use of resistant varieties, seeds free from pathogens, seed treatment, improved drainage, proper sanitation, keeping cultivated fields clean free from weeds and other foreign material that can serve as host for the pathogens. Destroying infected plants and throwing them away from the field, the use of registered chemicals and crop rotation are also vital.

Site selection is also an important initial step for IDM. Preferably using well drained soil which has not been used for tomato and similar crops production in the last two to three years is advisable. Planting tomato in a field planted the previous season with tomato, pepper, eggplant, or other solanaceous crop should be avoided. These crops share some insect and disease problems. Crop rotation can avoid some diseases, and keep fertility. A three-to four year-rotation program with non-related crops is recommended to reduce build-up of pests and diseases. Ridging and staking are also crucial specifically to drain excess water and to avoid folliage and fruit contact with the soil, respectively. Among disease management measures were using preventive and curative fungicides. Spraying fungicides namely, Agrolaxyl (3 kg/ha) and Ridomil Gold Mz 68 WG (3kg/ha), interchangeably at seven to ten days interval depending on the weather condition and disease incidence are used to effectively mitigate the development of foliar fungal diseases at Woreta. Mancozeb is also sometimes used as preventive fungicide. According to Shamiyeh et al. (2001), frequent fungicide applications, usually within seven to ten days interval are imperative for acceptable disease control and successful tomato production.

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