



## Overview of Agrochemicals Application Practices on Tomato Farm by Smallholders at Koka, Meki and Ziway, Ethiopia

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### ABSTRACT

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Promoting the agricultural sector with up-to-date technologies and inputs is convenient to enhance productivity. Production intervention is needed by introducing and adopting proper agronomic practices. Improved agricultural technologies increase production, quality, sustain food security, economic development and natural resource conservation. Koka, Meki and Ziway are known for their vegetable production as well as intensive agrochemicals consumption. Agrochemicals are applied on farm to enhance soil fertility, reduce pathogens, and induce plant growth. Tomato is one of the main commercial cash crops in these areas. Most commercially productive tomato varieties are highly sensitive to disease, vulnerable to nutrient deficiency, and other abiotic stress that requires rigorous agrochemical inputs. Ethiopian tomato production is very low due to various contributing factors including lack of improved varieties, diseases, pests, poor farming system, soil fertility maintenance as well as poor irrigation system. Farmers in the study areas applied inaccurate agrochemicals dose, rate, and application schedule that foster repeated spray. Intense agrochemical application leads to adverse environmental and health impacts due to deposit of toxic chemicals, residue leakage to water bodies and air pollution. It is important to practice proper agricultural inputs, reduce hazardous chemical residues, protect humans, other beneficial organisms and the environment. Moreover, developing IPM technology is recommended for better healthy agricultural production and sustainability.

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## Introduction

In Ethiopia, the agricultural sector is the main livelihood shareholder for more than 80% of the people. Most Ethiopian farmers are smallholders owned small, fragmented land and practice a traditional farming system that resulted in low productivity (Abera et al., 2020). Low productivity may perhaps result from lack of awareness, soil maintenance, poor farming/cropping system, totally dependent on annual rainfall, poor soil and water conservation practice, limited or no agricultural technology input, poor pest and weed management, harvesting methods and the likes. Almost all farmers plough their lands in the same manner, grow similar seasonal crops from year-to-year and cultivate once a year which is below its potential (Alemayehu et al., 2010).

Water resource (surface and underground water) as well as bimodal rainfall is available in most parts of Ethiopia. Nevertheless, farmers do not properly manage

and practice this important resource very well. Most important crops including export crops are produced in rainfed agriculture. Low agricultural productivity (Abera et al., 2020) results in food shortage, poverty, lessens farmers' income and affects the state's economy. In Ethiopia, practicing small-scale irrigation in a fragmented and traditional way has a long history. Limited amount of irrigation practices are implemented on government and private farmlands for vegetables, fruits, horticulture and crops production. Most of the irrigation practices are gravity methods (i.e. the water flows through gravitational force from higher levels to lower levels). Irrigation types in Ethiopia include: traditional small-scale operated by local community, modern communal scheme built by government, modern private scheme operated by private sectors and public scheme built in cooperation and operated by public enterprises (NBWRA, 2021).

Production intervention is needed by introducing and adoption of proper agronomic practices as well as water consumption techniques (Alemayehu et al., 2010). The Ethiopian agricultural minister and the research institutions have a vision to benefit people engaged in the agriculture and agri-related businesses with improved and appropriate technologies. Improved and appropriate agricultural technologies increase productivity, quality, sustain food security, economic development and natural resource conservation (Abate, 2007). Plenty of agrochemicals have been applied on farms to enhance soil fertility (Simtowe, 2015), reduce pathogens (Mergia et al., 2021) and induce plant growth. These agrochemicals include pesticides (Mars and Ballantyne, 2004), fungicides, bacteriocides, herbicides, nutrient supplements and growth promoting substances. Almost all agricultural inputs are imported from abroad both by private and public/government companies. Under the current constitutional arrangements, the Ministry of agriculture (MoA) and its counterparts in the agriculture bureau play a pivotal role in regulating, implementing, and monitoring pesticide policies, registration, importation, distribution and use (Mengistie, 2016). It is necessary to assess, control and take proper measures to minimize negative effects of these products.

A pesticide is a chemical or biological agent that deters, incapacitates, kills or otherwise discourages pests to protect plants or plant products from harmful organisms (Mars and Ballantyne, 2004; Singh and Singh, 2019). Pesticides are good to control pests and diseases, but most smallholder farmers are accompanied by misuse (Mengistie, 2016; Mergia et al., 2021) that results in health as well as environmental effects (Alemayehu et al., 2010). Developing IPM technology is recommended for better healthy agricultural production and sustainability.

Similarly, fungicides have vast applications in agriculture to kill or prevent (Worku and Sahela, 2018) the growth of fungi and fungal spores. They are important to protect young plant parts, matured vegetables, fruits, and enhance seeds storage. Fungicides classified as biological and chemical based on their active ingredients composition. Some fungicides are dangerous to humans and the environment. Certain chemical fungicides may not be biodegradable eventually result in residue deposition in soil or water that cause toxicity on humans (Singh and Singh, 2019) and other beneficial organisms.

It is necessary to promote the agricultural sector with up-to-date agricultural technologies and inputs for production intervention. These include application of improved varieties, knowledge-based farming systems, agricultural innovations, remote sensing, specific soil and crop-based agrochemicals input, crop rotation, intercropping, well established irrigation system, enhanced harvesting, transporting and storing mechanisms. There are different types of agrochemicals in Ethiopia that are legally registered to be distributed or permitted for market access including fertilizers, pesticides, herbicides, and improved seeds. Fertilizer is one of the most significant inputs for agricultural sector (Simtowe, 2015). It is a chemical material which needs special care, control and follow-up to confirm the standard during manufacturing, import, handling and storing (Federal Negarit Gazeta, 1998). Tracking is essential for importing, supply timing, quality, marketing, distribution and application of fertilizers to the

required quantity/rate. Not only synthetic fertilizers but also biofertilizers like N<sub>2</sub>-fixing microbes, PSB and *Mycorrhiza* can be recommended satisfactorily for specific crops to improve soil nutrients and sustainable agriculture. Efficient beneficial microbial strains employed as a biofertilizer improve productivity with a plus of enhanced nutrient content and environmental protection.

## Method and Approach

The study was conducted in Oromia region, East Shewa zone at Koka, Meki and Ziway schemes which are convenient for irrigation because of available water resources with a plus of conducive environment. The areas are located near Koka dam, Meki river and Ziway lake with midland (weyna dega) agroecology, semi-arid climate with biannual rainfall, alongside mixed agriculture production (Girma and Awulachew, 2007). The main soil type is sandy loam experiencing with salinity and alkalinity problems. These areas are known for their vegetables production as well as agrochemicals and pesticide consumption (Mengistie, 2016). Mixed farming (livestock, crop and horticulture) system practiced in the study areas. Relatively, a large number of horticultural crops (like tomato, onion, cabbage (Alemayehu et al., 2010), shallot, flowers, and green pepper), fruits like grape, strawberry and papaya produced using irrigation. According to CSA (2020), cabbage and pepper took the line share of vegetable production (about 73% and 18% respectively). In the rainy season, farmers basically produced grains including maize, teff, wheat, sorghum, and haricot bean.

In Ethiopia, especially in the Rift Valley and Awash River basin, tomato production is exponentially grown because of its high-income generation (Worku and Sahela, 2018), fast growing, productivity, conducive environment (Abera et al., 2020; Lemma, 2002), access for transportation, irrigation and market proximity. Tomato is one of the most intensive agrochemicals demanding cash crop. Most commercially productive varieties are highly sensitive to disease, vulnerable to nutrient deficiency, and other abiotic stress like drought. Due to its cultivation expand, nutritive value, sustainability, potential cash crop (Worku and Sahela, 2018), employment potential, market outlet, and adaptability for diverse agroecology zones (Abate, 2007) tomato was selected for this survey project. Therefore, on this specific report the information and elaboration is limited to agrochemical consumption including fertilizers, fungicides and pesticides for tomato production at Koka, Meki and Ziway farmlands, Ethiopia. These research sites were selected because of significant tomato production and intensive agrochemical application experience.

## Methods of Tomato Production

Tomato is one of the largest vegetables produced due to short growth duration, elevated yield and economical importance (Abera et al., 2020). In the study areas, three types of tomato production systems were practiced namely: open field/on farm (the largest production system for commercial local supply), garden production (very limited production that used for household consumption) and greenhouse production (limited companies involved and produce for export market and factory). In this report only

the principal open field production system was emphasized because of several smallholder farmers' participation in the production and its most important contribution to the local fresh tomato market.

Farmers in these areas produce different cereal crops and vegetables using rainfall in the wet (meher) season and using irrigation in the dry season (De Putter et al., 2012). Irrigation is basically done manually with generators from surface or underground sources. Most of the time farmers (landowners) produce crops in the rainy season (CSA, 2020) and rent the land during the dry season (Alemayehu et al., 2010). Massive tomato production is held in the dry season using irrigation (Lemma, 2002). Landowners rent the land for different reasons including lack of capital to purchase inputs (De Putter et al., 2012) lack of technical skills, preoccupied by land rent extra cost, poor motivation, failure to avoid traditional agricultural practice, and weakness to confront risks or challenges in production, irrigation, pest management as well as market finding. They use the simple traditional rainfed cropping system and are satisfied with the extra income from rent in the dry season. They don't want to invest their energy and money for irrigation farming instead they prefer safe rent of the land. Almost all land rent is subjected to contract until the rain season comes, most probably ending at the end of May or early June.

Landowners benefited from tenant's elevated rate of fertilizer application residuals with a plus of deep soil plough with tractors (Alemayehu et al., 2010). Since agriculture is the main sector for their livelihood, they prepared to rainfed season crops that were basically used for household consumption and somehow for commercial crops. Once they complete harvesting, they immediately rent the land for interested producers until the beginning of next summer. With this common understanding, the two parties sign the contract agreement with no boundary for the types of crops to be planted. However, tenants who subjected to produce tomato inquire at least a year back history of the land what kind of crop harvested and status of productivity or fertility. Tenants explained the reason that if the land continuously planted tomato, green pepper, and potato the productivity of the new tomato planting and fertility of land deteriorated as well as enhanced pest infestation occurred. This indicates a good understanding of spores and cysts hidden in the soil from the previous plants and aggressively invading the new plant that required extra expense for treatments. In addition, if the land is used to repeatedly produce tomatoes, which is the most intensive agrochemical consumer, severely, the previous applied dosage of chemical residues affects freshly planted young tomatoes and minimize production. HGIC (2021) also explained that tomato and related vegetables like potato and pepper should not be cultivated on the same land more than once in three years. It is defined that most agrochemicals including fertilizers, fungicides and pesticides are misused (inappropriate dose and repetition). Therefore, previous plant history and productivity play a pivotal role on the rent price determination.

Despite the fact that transplantation is susceptible for transplantation shock and increases uncertainty (De Putter et al., 2012), tomato producers in the study areas used transplanted young tomatoes (2-3 true leaves and 12-15cm length) from delivery agents which have a high establishment and growth success rate. Almost all respondents confirmed more than 85% growth success of

transplanted tomato from nursery to farmland. However, Lemma (2002) reported direct sowing revealed some important features like better fruit production and 15-20 days earlier maturity than transplanted tomato but required continuous irrigation and weeding. Producers have sufficient understanding of windbreak (protect plants with fences using local materials and crops like corn and sorghum), staking with cheap ropes, and try to maintain plant and row spacing.

Observation from tomato field management indicates producers exercise poor irrigation, weak conservation practice, limited access to improved seed or nursery for transplanting from seedbed, weak pests, diseases and weed management, lack of awareness on soil fertility, improved agricultural production, proper harvesting (Abera et al., 2020), and transporting are limiting factors for tomato production. Additionally, it was observed that lack of proper store led to the exposure of tomato fruit for sunburn that minimizes market acceptability and lowers the price or cost loss.

### What are the Most Common Tomato Diseases?

Pests (arthropods, diseases and weeds) will pose a significant loss on agricultural development and production (Abate, 2007). Root, stem, leaf and fruits of tomato can be infected by different organisms (HGIC, 2021) including fungi, bacteria, virus, nematodes, flies, insects, birds etc. Though, the incidence and production loss vary; almost all these tomato damaging organisms are observed in the study areas. The most economically important tomato diseases include leaf spot (*Septoria lycopersici*) early blight (*Alternaria solani*), Wag or late blight (*Phytophthora infestans*), powdery mildew (*Leveillula taurica*), viral infection and root nematodes alongside transmission from related crops like potato are dominant especially in the Rift Valley Region (Lemma, 2002). Diseases spread accelerated by temperature, humidity, wind and rain (HGIC, 2021).

### How to Improve Tomato Production?

There is high local and foreign market demand for tomato production. Local fresh tomato market acceptance depends on shape, color, size, quality and storability (Abera et al., 2020; Lemma, 2002). In the study areas, two familiar varieties (Gellille and Hawassa) are widely grown due to their potential productivity and relative resistances. Compared to other tomato growing regions, in Ethiopia, production (5.8ton/ha (CSA, 2020)) is very low (Worku and Sahela, 2018) including the irrigated areas with average production of 3.5ton/ha at Upper Awash basin and 1.2ton/ha at Guder area (Girma and Awulachew, 2007). However, unusual tomato yield was reported by De Putter et al. (2012) stated the average productivity of tomato is 31.6 ton/ha in Dugda, and 16.3 ton/ha in Adami Tulu Jido Kombolcha districts. There are many contributing factors (Worku and Sahela, 2018) for undermined yield. Therefore, its production improvement is essential to satisfy the ever-increasing market demand and for efficient resources (land, water and conducive weather) utilization. Many challenges are mentioned but then there are plenty of opportunities to be deemed to improve tomato production.

Tomato production in Ethiopia possibly enhanced by implementing an improved agricultural production system by the producers/farmers and the respected actors. These include: (1) use improved varieties, (2) apply soil chemistry-based fertilizers rates, (3) follow proper crop rotation (especially with none Solanaceous family crops (HGIC, 2021) like corn or beans, (4) apply proper pesticides as per recommended rate with correct diagnosis, (5) proper weed management/control, (6) maintain proper plant distance (Lemma, 2002) and remove/defoliate old as well as infected leaves, (7) improve harvesting and storing (Abera et al., 2020), (8) extend enhanced irrigation system and participate more farmers, (9) technical support, supervision, mentor and improve farmers' awareness, (10) promote updated production mechanisms, inputs and agrotechnology, (11) promote proper soil and water conservation (12) promote efficient biofertilizers and biocontrols for sustainable production. Apparently, it should be improved farmers practice of rejecting or throwing cracked, infected and fermented seeds as well as old or infected plant debris on the farm.

### Overview of Agrochemicals Applied in the Study Areas

Various agricultural chemicals exercised in Koka, Meki and Ziway farmlands. Farmers applied different infestation treatments based on the disease's invasion (starting from early plant stage to final harvesting and storing) and fertilizers. Disease's treatment application is most of the time a trial-and-error method due to poor identification that is circumvented with tentative guess, previous personal experiences, neighbour/other farmers recommendation and in a limited way by retailer (Mergia et al., 2021). Some of on farm observed chemicals include BOSS 72% (fungicide recommended for potato), More 720 WP (fungicide recommended for potato late blight), Omaxim (fungicide recommended for potato late blight), Mancolaxyl 72% WP (fungicide recommended for variety crops including tomato), SNIPER LFR (liquid fertilizer and control pests), Fungicide Famoxadone 22.5% + Cymoxalin 30% + WDG Dolar 52.5% (recommended for late and early blight of potato and tomato), and Revolution 325SC (fungicide recommended for onion). Similarly, Mergia et al. (2021) reported small-scale vegetable farms consume intensive fungicide and insecticide in Ziway.

Chemical spray done by a daily labourer with no special technical training, mentor or supervision by experts and without safe clothes. Apparently, dilution and formulation of chemicals also not accurately operated as per the manufacturer recommendation. In their first round they strongly diluted below the rate whereas if the infestation does not last, next phases, utilize highly concentrated treatments and sprayed repeatedly. This kind of application affects the efficacy of the treatments and increases chemical residues accumulation in the soil and water bodies. Part of the accumulated residuals in soil dissolved and flow through running water to the low land areas and water bodies at various time, therefore, the environmental risks and pollution amplified in the lake Ziway.

Soil nutrient can be enhanced for better crop yield by applying well decomposed farmyard manure/compost and synthetic fertilizers (lemma, 2002). Fertilizer dose and type recommendation vary (Simtowe, 2015) based on soil

chemistry, crop, method of farm practice, stage of the plant and cropping season. In the study areas, exhaustive synthetic chemical fertilizers application was observed. These include urea, DAP, in some cases NPK (like Agri care<sup>+</sup>) and other supplements along with biocontrol like Sniper (water soluble fertilizers containing humic acids for mites biocontrol and rich in P, Mg and Br). Fertilizers are added at the different tomato growth stages starting from early stage to late growth (flowering and fruiting) to enhance yield (Lemma, 2002). Most of the time our observation confirmed that fertilizers applied beyond the recommended rate and in some cases sub-optimal dosage. This is because most tomato growers are tenants as a result, they assumed that maximizing fertilizer application would enhance their production and productivity. However, field/farm observation indicated that young tomato plants showed deformed and depleted growth due to fertilizers dose (usually urea) and poor irrigation management. In some farmlands, observation fertilizers were wrongly sprayed at the upper shoot of the plant.

### Pesticide Application Trends

Pesticides are considered a good, economical and safe plant protector coupled with enhancing farm products (Singh and Singh, 2019). They are used massively around the globe (Mars and Ballantyne, 2004). In Ethiopia, pesticides imported by private and public companies (Mengistie, 2016) and application increased exponentially. Despite the fact of prices, farmers frequently exercised broad-spectrum pesticides and fungicides. Farmers increase pesticide application and impose a negative impact on the environment and human health (Mergia et al., 2021; Singh and Singh, 2019). It is crucial to take strict measures as well as develop proper diagnosis, rate and schedule to reduce residual toxicity. This kind of esteemed regulation effort reported by Abate (2007) indicated that strict regulation was undertaken on pesticides residues and quarantine for intensified private agricultural industry, especially on greenhouse production.

According to the FDRE constitution under proclamation of *pesticide registration and proclamation of 674/2010* there are legal requirements to be fulfilled starting from composition labelling until final application and disposition. Namely: formulation of biological active ingredients, nature, substance, means of promotion, banned pesticides due to health or environmental reasons (not granted), basel conventions including waste disposal and transboundary, biological control agents (natural enemy, competitor, or antagonistic), certificate of competence, disposal, distribution, formulation, hazard, quality, storage, trade name and so on (Federal Negarit Gazeta, 2010).

Abuse of agrochemicals leads to adverse environmental implication and health impacts (Mergia et al., 2021) due to deposit of poison chemicals, residue leakage to water bodies and air pollution. A report from Mengistie (2016) strengthens this explanation that surface water from agricultural farms at Ziway and Meki was found contaminated by pesticide residues. Hazardous chemicals affect human health due to their existence in the environment, unexpected contamination or entry to the body along with food, drink or air. Toxic pesticides

adversely affect human health (by means of direct exposure, inhalation, ingestion or dermal absorption) and nontarget beneficial organisms (Mars and Ballantyne, 2004; Singh and Singh, 2019).

In Ethiopia, farmers increased their agrochemical consumption, but regulation, monitoring, and implementation governance is weak (Mengistie, 2016). In the study areas, most tomato producing farmers have paid no or very little attention for agrochemical effects on the environment as well as on the local community (Alemayehu et al., 2010). On field observation, there were inappropriate applications of agrochemicals and farm management. Most importantly, farmers neglect to follow proper guidelines, spraying pesticides beyond (most commonly) or below the recommended rate, application of overdose synthetic fertilizers, release of excess irrigated water, and use pesticides for plants that are not recommended by the producing company. Users are typically found to have failed in proper use of pesticides, store, apply, dispose and packing.

Smallholder vegetable farmers in Ziway and Meki districts are the most pesticide and fungicide users in Ethiopia (Alemayehu et al., 2010; De Putter et al., 2012; Mengistie, 2016). Majority of farmers in the study areas sprayed repeatedly (for example tomato sprayed up to 20-30 times) per cropping season. Mergia et al. (2021) elaborated the intensive (most farmers apply 12<sup>+</sup>) spraying and the related human health impacts of pesticides by small-scale vegetable producers. This might be probably due to the poor/traditional diagnosis method, efficacy of chemical, spray interval (Worku and Sahela, 2018) and wrong pesticide application. Lemma (2002) similarly stated repeated application of pesticides practiced by farmers depending on weather conditions and disease intensity. A remarkable reflection also reported on mixing application of different pesticides together (Mengistie, 2016) as well as timing inconsistency that leads to inefficiency of the pesticide and development of the most resistant diseases. Since pesticide spraying was done by untrained manpower in a traditional way, there was no consistency in spraying each plant line by line and addressing each row. This kind of negligence probably leads to rehabilitation of the diseases, unnecessary spray repetition, over chemical consumption, imposition of other chemicals application and extra economic destruction.

For safety precaution schemes national regulation is available to control, use, sale and restriction of pesticides (Mars and Ballantyne, 2004). The Ethiopian Ministry of Agriculture (MoA) has been mandated by legislation to adopt regulations, promote the correct use of pesticides, improve awareness, provide technical support, conduct inspection, participate in monitoring or evaluation of stakeholders and overall regulation. Sellers, farmers and daily labourers neglect proper chemical handling guidelines and most of them were found to pay little attention to precautions set by the manufacturer. However, a supportive finding from Mengistie (2016) fortifies our observation that weak regulation by the respective authorized body promotes illegal pesticide sellers, inappropriate packaging, measuring, mixing, diluting, opening and exposure to air as well as curtailing including at open market in the study areas. This kind of loose control leads to illegal exchange, contraband promotion,

prohibited chemical circulation/application, substandard pesticides application, economical loss and outshine the most important impacts on human and environmental health. A report from Mergia et al. (2021) also supported this finding that most (53%) farmers in Ziway purchased pesticides from other farmers and household shops with a plus of poor storing experience.

Maximum chemical consumption recorded in the main rainfed (meher) cropping season. During this time infestation excels, possibly due to conducive environment and moisture available for the pathogens (Lemma, 2002). Nevertheless, the applied chemical is rinsed by the rain before getting effective contact with the pathogen, consequently, low efficacy of the pesticide, promotion of repeated application and possibly resistance pest developments could result. Workers applied pesticides without personal safety clothes and protectors. Mergia et al. (2021) reported more than 94% didn't wear gloves, boots, eye protector and masks as well as they feed in the farm without proper washing or removal of these toxic chemicals.

## Conclusion

Availability of a conducive environment and suitable resources help smallholder farmers to produce different crops and vegetables including tomato. Tomato production required intense agrochemical application to maintain soil fertility and to respond to diseases infestations. Intense agrochemicals application leads to adverse environmental and health impacts due to deposit of toxic chemicals, residue leakage to water bodies and air pollution. Observation from tomato farm management indicated weak resources conservation, poor pest management, and inaccurate agrochemicals consumptions exercised. Smallholder farmers applied enormous agrochemicals, especially pesticides and fungicides which results in residual accumulation in soil and water bodies. These problems resulted from inappropriate pathogens identification, inaccurate treatments application, limited access to improved varieties, lack of awareness, lack of technical support and limited regular regulation. Weak interaction and cooperation among respected government officials, agriculture actors, private sectors, educators and researchers are other impediments for agricultural sector. It is important to practice proper agricultural inputs, reduce hazardous chemical residues, protect humans, other beneficial organisms, and the environment protection. It is highly recommended to improve farmers awareness, accurate plant diseases identification, practice correct treatments application, enhance fertilizers rate application, supervision/monitoring, motivate the state actors, proper regulation, traditional agro-systems, and irrigation systems.

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