VALIDATION OF RESEARCHED ECOLOGICAL ORGANIC AGRICULTURE' TECHNOLOGIES

Prepared by Miss Rehema Erasto Mwaipopo

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Rehema Erasto Mwaipopo (MSc.) Date

(Researcher)

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Janet, Maro Date

(Director SAT)

EXECUTIVE SUMMARY

Seed treatment is an important practice as it ensures a good start up of seedlings and later on reduce crop losses. For example, bacterial leaf spot (BLS) caused by seed-borne xanthomonads is a serious disease of tomato (*Lycopersicon esculentum*) and other solanaceous crops, causing significant losses in both yield and quality. To validate effectiveness of recommended plant extracts against the disease, we evaluated crude extracts from 2 plant species in plant assay for antibacterial activity against BLS of tomato and sweet pepper. The most effective seed treatments were obtained with extracts from *Aloe vera* + *Coffee arabica*. Seed treatment of tomato and sweet pepper with these extracts highly inhibited BLS the assay. Treatment of seeds with these extracts had a positive effect on the number of normal seedlings. These results indicate that plant extracts from A. *vera*, C. *arabica* are promising candidates for seed treatment against seed-borne xanthomonads of solanaceous crops.

Mulching and fertilizer application are important agronomic practices for soil conservation and improvement of soil fertility respectively. These practices have a great advantage on enhancing crop productivity. In validating the usefulness of mulching material and fertilizer types recommended to be used in EOA, organic mulches (rice husks and dry grasses) and organic fertilizers (poultry/cattle manures and rock phosphate/Minjingu nafaka fertilizer) were used. Application of those technologies resulted to positive effect on growth and productivity of the crops. This indicate that mulching and soil fertilization are important practices for improving crop productivity.

ACKNOWLEDGEMENT

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LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
BLS	Bacterial Leaf Spot
EOA	Ecological Organic Agriculture
NOARA	Network of Organic Agriculture Research in Africa
SAT	Sustainable Agriculture Tanzania
SUA	Sokoine University of Agriculture
TOAM	Tanzania Organic Agriculture Movement

VALIDATION OF ECOLOGICAL ORGANIC AGRICULTURE (EOA) TECHNOLOGIES IN TANZANIA

1.0 Introduction

1.1 Background

Nowadays, there have been unprecedented increase in the use of synthetic agricultural inputs, particularly chemical pesticides, inorganic fertilizers and irrigation systems. These have resulted to negative impacts on human health, soils and biodiversity in general (Mondelaers et al. 2009). On efforts to cover up the negative impacts associated with conventional agriculture, Ecological Organic Agriculture (EOA) seems to be useful. EOA combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. It involves the use of fertilizers of organic origin like manures and puts emphasis on techniques like crop rotation, mixed cropping, biological pests and diseases control. This type of agriculture relies on ecological processes, biodiversity and cycles adapted to local conditions rather than the use of inputs with adverse effects. But also, under EOA, inputs with less chemicals like copper, elemental sulfur and rock phosphate fertilizers can be used (Seufert et al., 2017).

Sustainable Agriculture Tanzania (SAT), one of EOA's ambassador, plays a big role on researching, educating and supporting farmers about EOA production system. This helps in sustaining health of people, soils and ecosystem. But from several studies and evaluations which have been done, results show that, organic farming farmers do not benefit as much as per projections. Implication is that there is inadequacy of effective and efficient technologies to be used by these farmers for huge net return.

Under EOA, crop productivity seems to be low. This implies a huge demand of organic products in both local and export market. Therefore, there is a need to invest more on inventing effective and feasible EOA technologies to be used for intensive production of organic produces while taking care of human health, soil and biodiversity conservation.

1.2 Justification of the study

Most of organic farming farmers have been investing a lot on the EOA, but the potentiality (net gain) of what they are doing is not appreciated as much as it is projected to be. This does not mean that they are doing non-paying type of agriculture, the major challenge is that they lack effective and affordable technologies. Several researches on EOA have been done and impacted new technologies which seem to be of many benefits to organic farming growers. But before being validated, those technologies cannot be disseminated for application to farmers. So, in order to bring the technologies in use, validation studies for few technologies were conducted in Morogoro and Zanzibar under support from EOA initiative under SAT's umbrella.

1.3 Objectives

1.3.1 Overall objective

Validation of ecological organic agriculture (EOA) technologies recommended from different researches/studies.

1.3.2 Specific objectives

i. Testing feasibility of the recommended practices of EOA through field experimentation

ii. Disseminating practices of EOA to other farmers (representative farmers be as ambassadors)

2.0 METHODOLOGY

2.1 Validated technologies

2.1.1 Seed treatment

The use of botanical extracts in biological control of diseases especially bacterial black spot disease in solanaceous crops.

2.1.2 Soil fertility management

The use of rock phosphate (Minjingu nafaka) fertilizer and poultry/cattle manures to improve soil fertility.

2.1.3 Mulching

The use of organic mulches (rice husks and dry grasses) in soil conservation.

2.2 Materials

Coffee (*Coffee arabica*) collected from Mbeya and Aloe vera collected from Morogoro and Zanzibar were used as organic pesticides for seed treatment. Rice husks and dry grasses collected from Morogoro and Zanzibar respectively were used as organic mulches. Organic based fertilizers (Minjingu nafaka collected from Morogoro agro-shops, poultry and cattle manure collected from Morogoro and Zanzibar) were used for soil fertility.

Tomato (*Lycopersicon esculentum*), okra (*Abelmoschus esculentus*) and sweet pepper (*Capsicum annuum*) were used as test crops.

But also, there were other raw materials for preparation of pesticides and foliar fertilizers/organic boosters. These were; Hot pepper, ginger, garlic, sisal, ash, neem leaves, drumstick leaves, vinegar, milk, methylated spirit and soap.

Plate 1: Source of plant extracts **a)** Coffee b) Aloe vera

Plate 2: Organic mulches a) Rice husks b) Dry grasses

Plate 3: Test crops a) Tomato b) Sweet pepper c) Okra

Plate 4: Source of organic pesticides

2.3 Location and duration

The validation work started on 2020 by introduction of EOA technologies to five (5) selected organic farming farmers. They were from Menge, Mvomero-Morogoro; Mayanga, Mvomero-Morogoro; Mikese-Morogoro and Bungi, Unguja-Zanzibar. Execution of the work was march, 2021.

2.4 Methods

2.4.1 Specific objective 1:

Testing feasibility of the recommended practices of EOA through field experimentation.

2.4.1.1 Seed treatment

2.4.1.1.1 Preparation of botanical/plant extracts

Coffee beans were roasted then ground to get coffee powder. Then crude extract was made by mixing 5g of coffee powder into 50mls of clean water to get 10% w/v, the mixture was left for 12hrs then filtered using double layered muslin cloth. Extract was ready for seed treatment.

Aloe vera leaves were cut into small pieces, then extraction was done by grinding leaves using mottle and pestle. 5mls of Aloe juice were mixed with 50mls of clean water. The mixture was left for 12hrs then filtered using double layered muslin cloth. Extract was ready for seed treatment

Plate 5: plant extracts' preparation a) Aloe vera b) Coffee c) Seed treatment preparation

2.4.1.1.2 Treating seeds

Tomato, sweet pepper and okra seeds were soaked in ready-made extracts for 12hrs, then was air dried for 1hrs then they were sown.

Plate 6: Nursery establishment. a) Nursery preparation. b) Tomato and Sweet pepper seedlings

2.4.1.2 Mulching

To study the effect of mulching materials on growth of fruit vegetables (tomato, okra and sweet pepper), field experiments have been conducted. Okra (*pusa sawani*), tomato (Rio grande and Malkia F1) and sweet pepper (*California wonder*) were planted and organic mulching materials (Rice husk and dry grasses) were applied.

Plate 7: Mulched crop plants

2.4.1.3 Soil fertility management

Poultry and/or cattle manure collected from farmers' areas (Both Morogoro and Zanzibar) was applied before seedlings' transplanting (for tomatoes and sweet pepper) and before seed sowing for okra. Minjingu nafaka fertilizer (from Morogoro agro-shop) was applied when seedling were 2 weeks old at main field.

Plate 8: Poultry/cattle manure and Minjingu nafaka fertilizer for soil fertility improvement

2.4.1.4 Experimental design

Factorial experiment laid down in RCBD was used, where factors were; Seed treatment (Aloe vera + coffee, Aloe vera, coffee and control/none), Mulching materials (rice husks, dry grasses and control/none) and fertilizers (Poultry/cattle manure + Minjingu nafaka fertilizer, Poultry/cattle manure and control/none).

2.4.1.5 Data collection

2.4.1.5.1 Seed treatment

Data on germinated seeds/emerged seedlings, dead seeds, seedlings vigor (fresh weight of seedlings, seedling' width, root length, shoot length), disease incidence and severity (plants/seedlings with black bacterial spots, leaves with black bacterial spots), normal and abnormal seedlings were collected to measure efficacy of the used botanical treatments to prevent bacterial spots and improve seeds germination and seedlings vigor hence improved crop productivity.

2.4.1.5.2 Mulching

For okra: data on growth and yield variables (% germination, number of pods, pod length, plant height (cm), pod's weight and fresh weed biomass); **For tomatoes and sweet pepper**; data on plant height, number of fruits per plant, fruit weight, number of marketable fruits per plant, fruits damaged by insect pests (American boll worms), fruits rot per plant, fruits with blossom end rot and weed fresh mass were collected and significantly shown to be affected by mulching materials.

2.4.1.5.3 Soil fertility management

Data on plant height, number of leaves per plant, and number of branches per plant, number of fruits per plant and weight of fruits per plant were collected.

Plate 9: Growth data collection

Plate 10: Yield data collection

Plate 11: Weed data collection

Plate 12: Fruit damage data collection

2.4.1.6 Data analysis

All collected data were subjected to analysis of variance (ANOVA) using Genstat software (16th edition) and means were separated using Tukey's test at 95% confidence interval. Obtained results were used to plot graphs (another way of data/results presentation) using Microsoft excel 2016.

2.4.2 Specific objective 2:

Disseminating practices of EOA to other farmers (representative farmers be as ambassadors).

Several organic and non-organic farmers visited validation plots where they learned the respective EOA practices. This was one way of disseminating the technologies to farmers. But also, farmers participated in validation work are now ambassadors of the technologies to their fellow farmers.

3.0 RESULTS AND DISCUSSION

3.1 Seed treatment

3.1.1 Germination

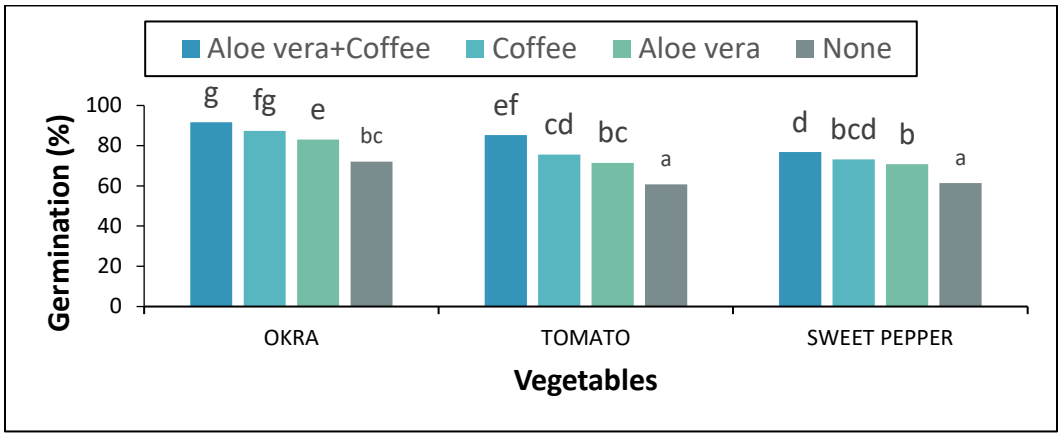

Fig. 1: Germination of treated vegetable seeds

Results show that, for each crop type, seeds treated with Aloe vera + coffee had a good germination percentage followed by those treated with coffee and Aloe vera while none treated seeds ranked the last. This may be due to the fact that, pre-soaking seeds influences pre-germinative activities in the seeds hence good seed germination percentage and rate. But also, plants synthesize a number of compounds with antibiotic and antimicrobial properties, so the use of botanicals as seed treatment help in inhibiting seed-borne pathogens which cause seed deterioration.

3.1.2 Seedlings vigor

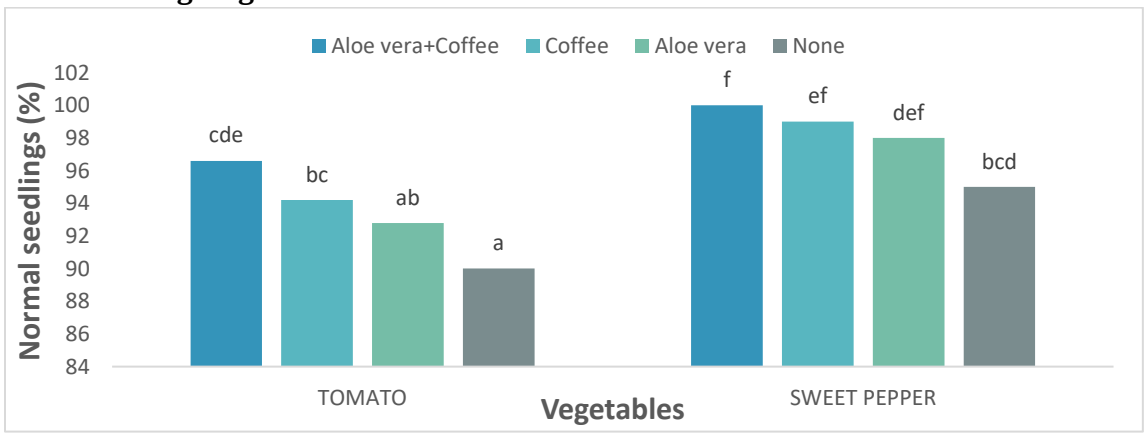

Fig 2: Seedling vigor

Percentage of normal seedlings was observed to be high from seeds treated with Aloe vera + coffee followed with those treated with coffee and Aloe vera. A combination of Coffee and Aloe vera appeared to give best results, since apart from antimicrobial activity these plant extracts have, Aloe

vera has growth stimulant activity, so a synergy resulted to good results.

3.1.3 Bacterial spots incidence and severity

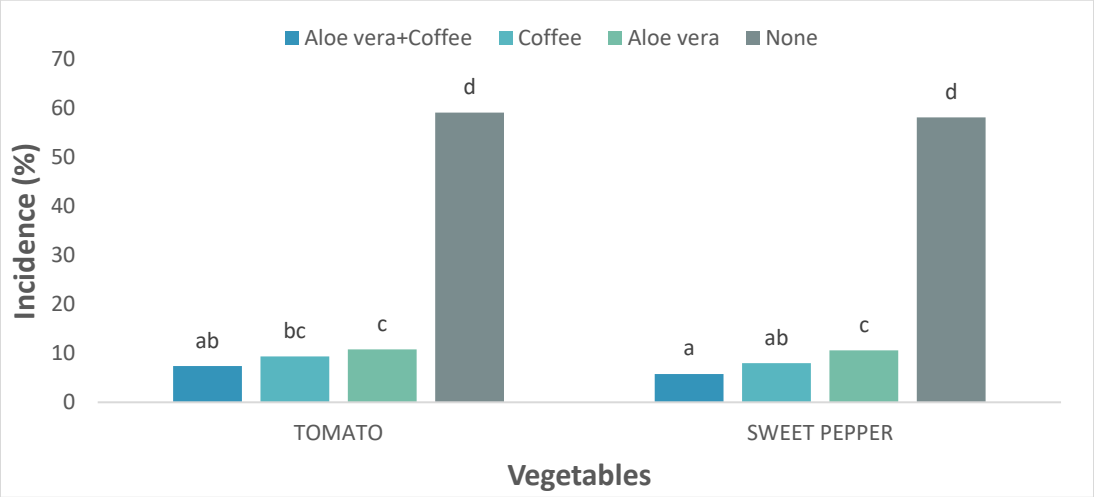

Fig 3: Disease incidence

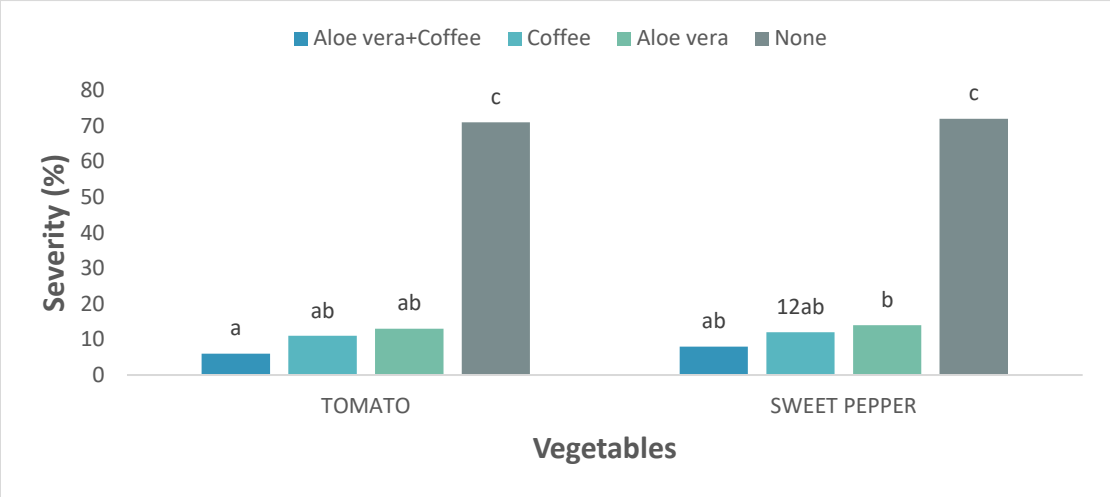

Fig 4: Disease severity

When seeds were treated with Aloe vera + coffee, the incidence and severity of bacterial spots was low compared to seeds treated with coffee and Aloe vera separately. This implies the presence of bactericidal compounds in the used plant extracts, but also the Aloe vera + coffee treatment looks to have synergism in inhibiting the pathogen's effect.

3.1.4 **Growth: Plant height**

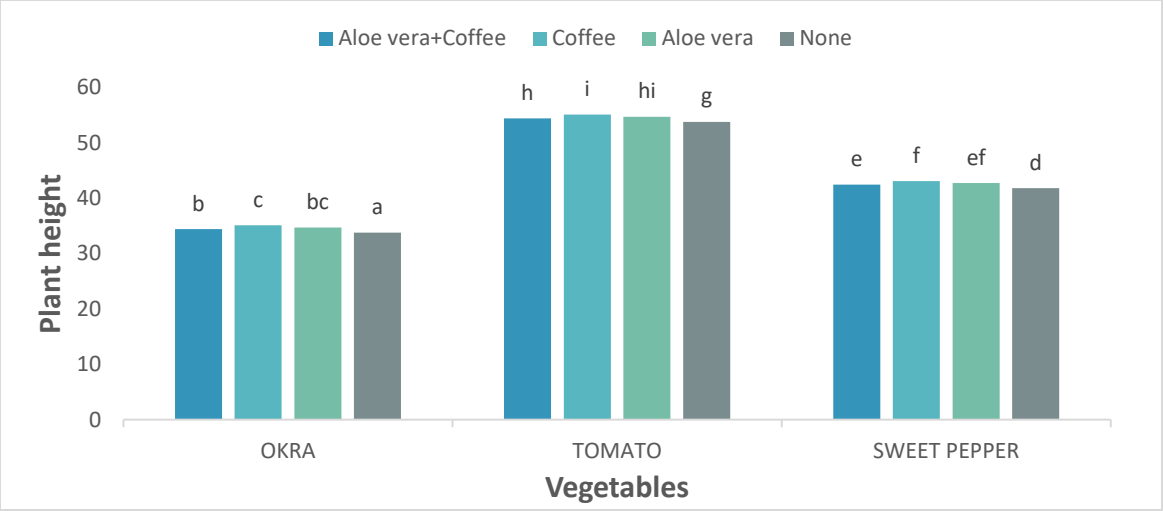

Fig 5: Plant height of vegetable crops, a growth parameter

There was no significant difference among the treatments, but there was a slight variation in height between non-treated seedlings and seedlings resulted from botanically treated seedlings. This is because, when a seedling arises from healthy seed, its growth becomes better than the one resulted from un-treated/unhealthy seeds. In addition to that, the plant extracts used have a positive impact on stimulating growth of plants.

3.1.5 Yield

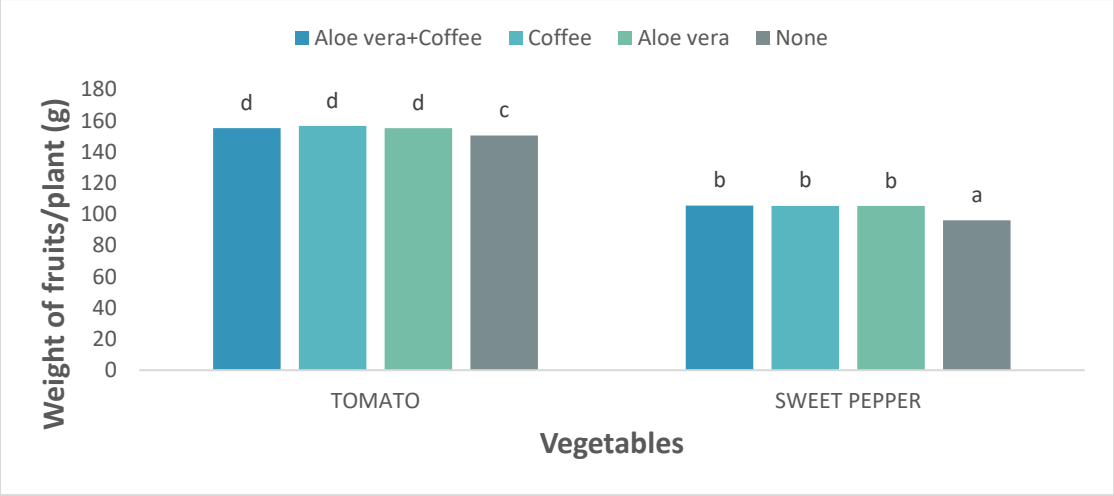

Fig 6: Yield of Tomato and Sweet pepper

There was a significant difference between treated and non-treated seed in terms of yield performance for both crops. But for treated seeds, there was no significant difference in yield. This means, seed treatment gives healthy plants which later will give good yield.

3.2 Soil fertility improvement and mulching

3.2.1 Growth

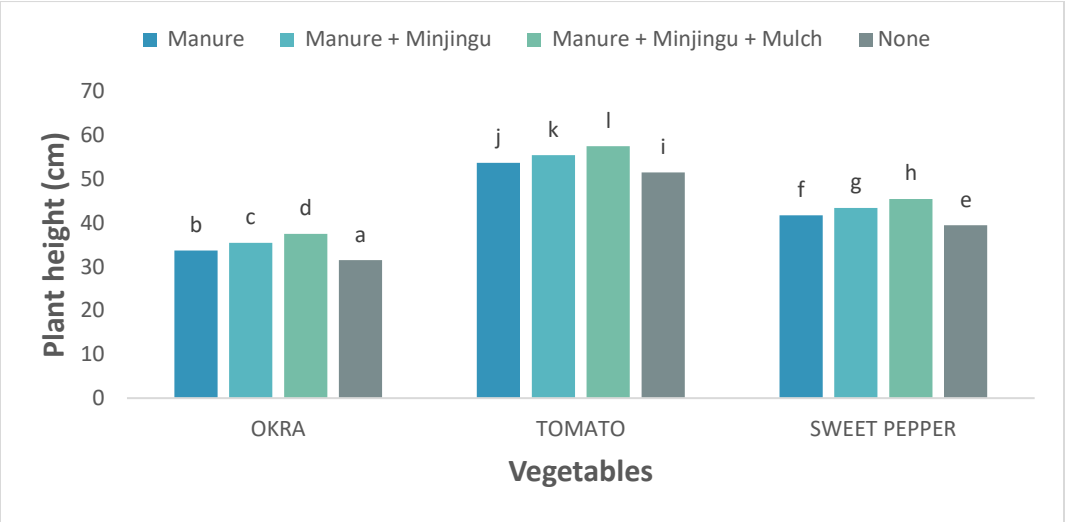

Fig 7: Effect of mulching and soil fertilization on plant growth (Morogoro)

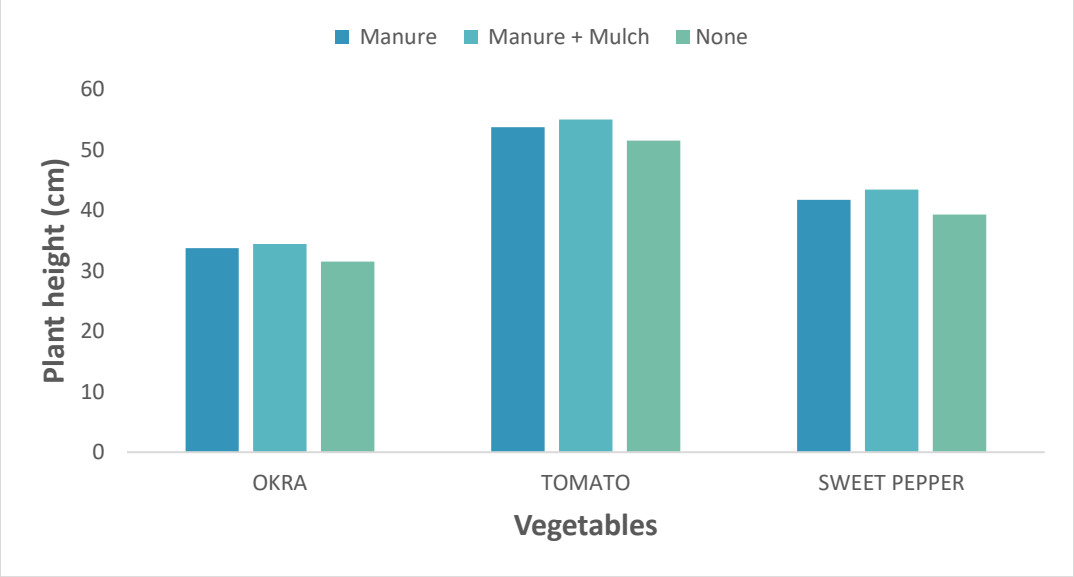

Fig 8: Effect of mulching and soil fertilization on plant growth (Zanzibar)

A combination of fertilizers and mulching materials was observed to be the best option in promoting growth of both crops followed by application of fertilizers alone without mulching. This is because, fertilizers provide nutrients to plants and mulching reduces weed-crop competition for nutrients, space and other growth determining resources.

3.2.2 Yield

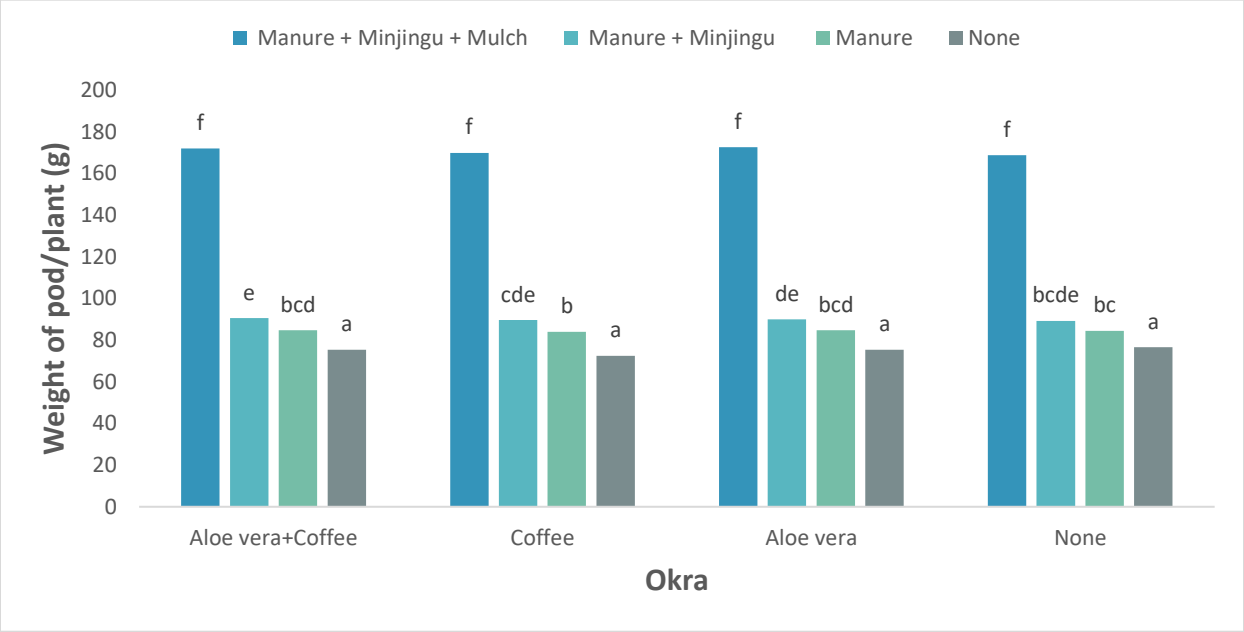

Fig 9: Effect of mulching and soil fertilization on okra yield (Morogoro)

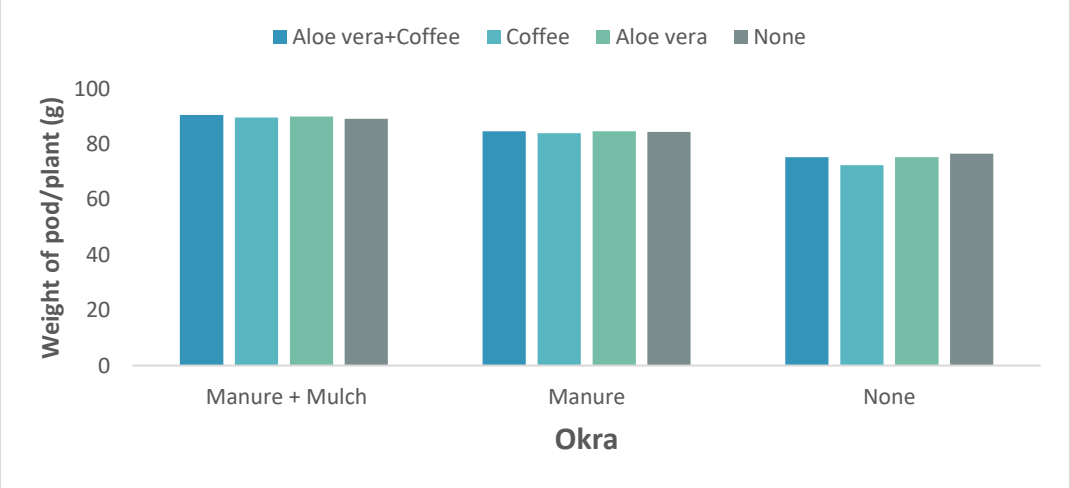

Fig 10: Effect of mulching and soil fertilization on okra yield (Zanzibar)

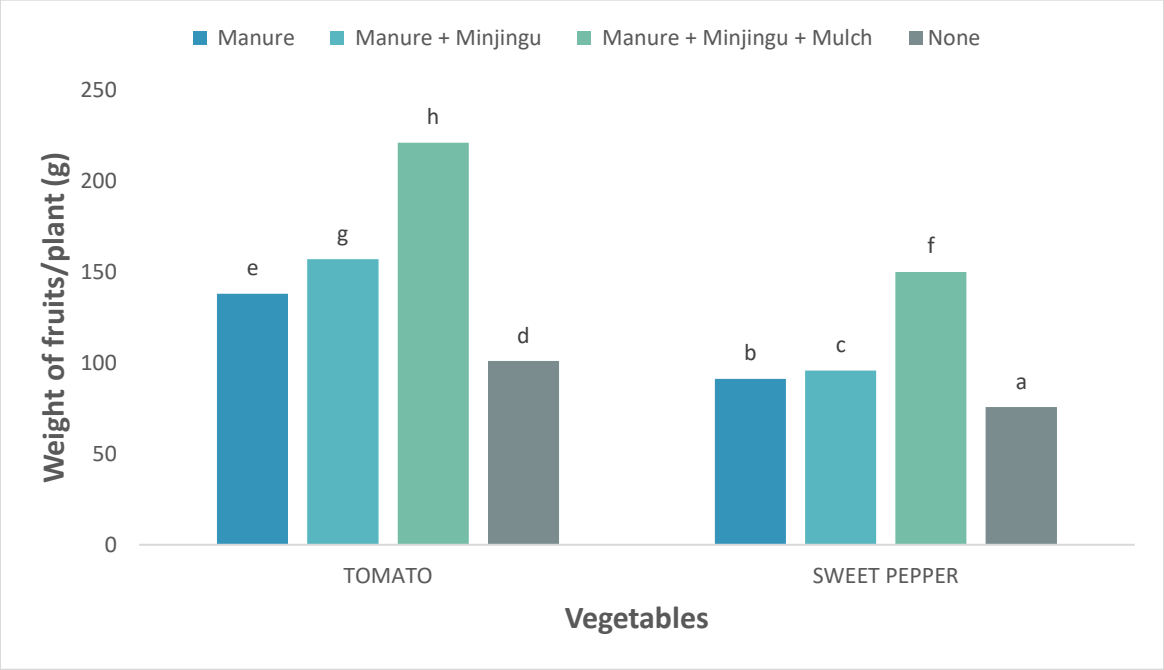

Fig 11: Effect of mulching and soil fertilization on fruit vegetable yield (Morogoro)

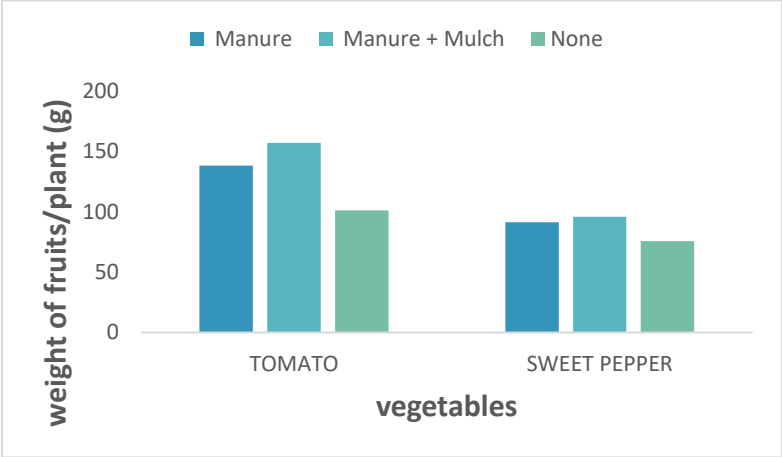

Fig 12: Effect of mulching and soil fertilization on fruit vegetables yield (Zanzibar)

For both crops, yield performance was observed to be higher in plots received a combination of mulching materials and fertilizers followed by the one received fertilizers only and crops which received none of the treatments, yield was observed to be low.

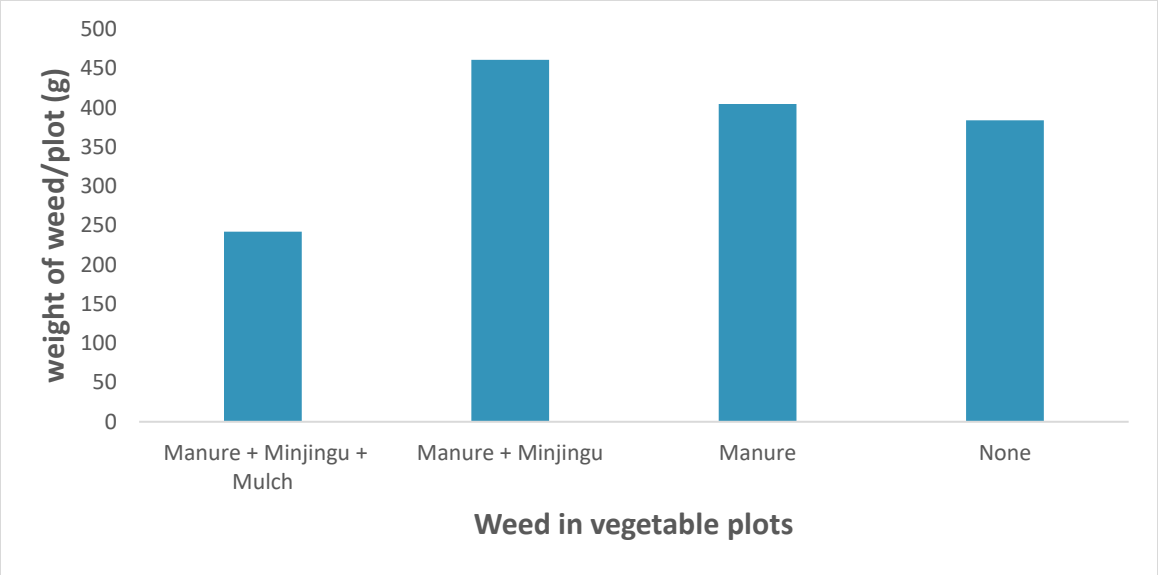

Fig 13: Weight of weed grew from vegetable plots

Mulching was observed to reduced weed emergence and growth in the field as weight of weed in mulched plots was lower than in non-mulched plots.

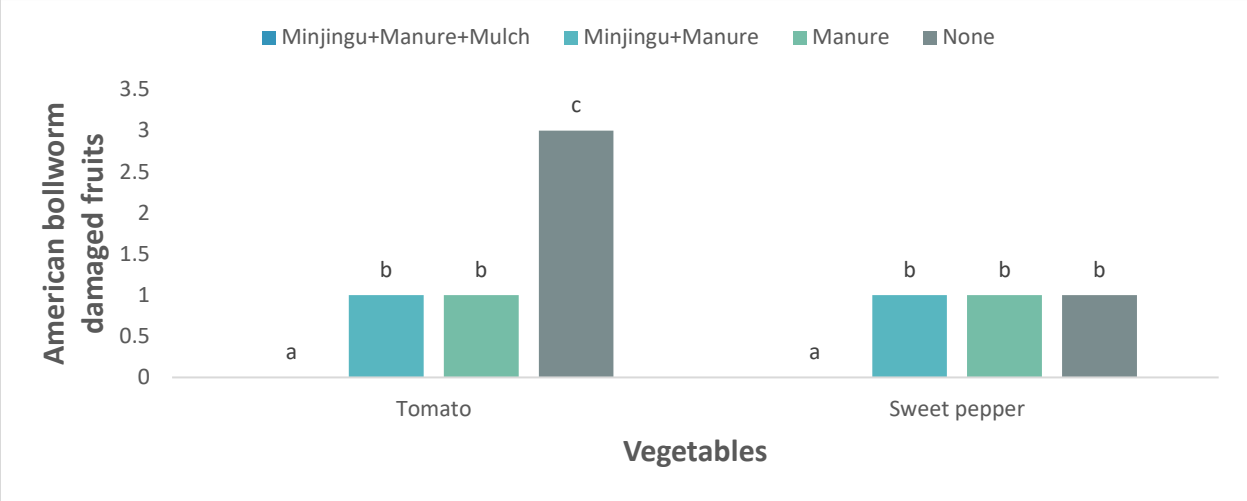

Fig 14: Ability of mulching in reducing insect pest' effect

Mulching also was observed to reduce fruits damage by insect pests. Implication is that, mulching reduces weed density as a result alternative hosts (weeds) for insect pests is also reduced. So, damage of fruits due to insect pests automatically is reduced when their hostage is low.

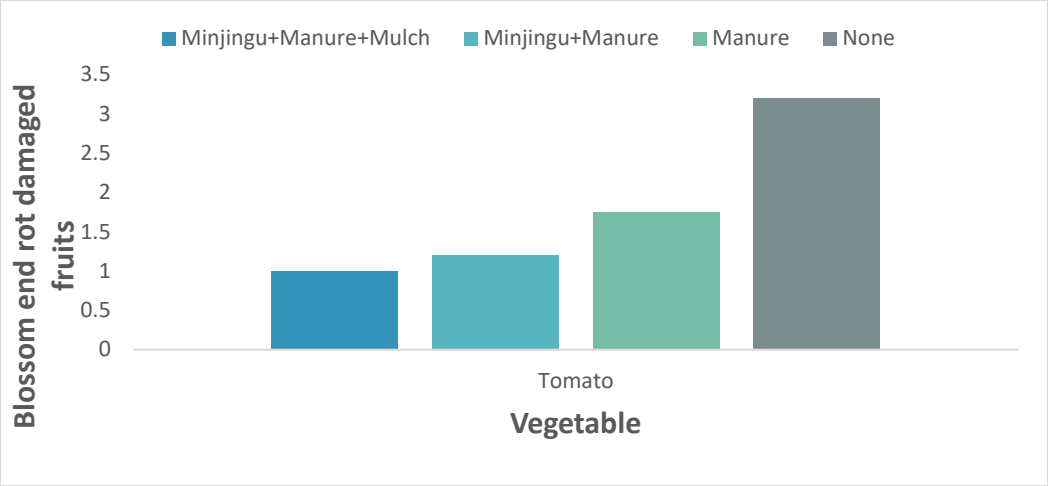

Fig 15: Ability of mulches in reducing fruit rot

It was observed that, incidence of blossom end rot was reduced. Although blossom end rot is mainly caused by calcium insufficiency and irregular irrigation, mulching appeared to prevent direct contact between fruits and soil which could lead to fruit rot. This is because, soil contain a number of microorganisms which are responsible for rotting/deterioration of fruits when in direct contact.

4.0 CONCLUSION AND RECOMMENDATION

In Morogoro, fruit vegetables are highly grown by organic farming farmers. Although poor soil fertility, pests and diseases are major limitations in achieving high crop productivity. Farmers have been trying their best to find solutions for those challenges, but highly effective solutions are needed. Different studies came up with several technologies to be used in order to improve crop productivity. But also, validation study conducted on the recommended technologies adheres with the research's recommendations, since results were similar to those from research studies. In order to improve fruit vegetables productivity, farmers need to adapt seed treatment practices which ensure a good start up of crops, but also adoption of soil fertility and conservation technologies. Validation findings recommend application of A. vera and C. arabica (singly or in combination) for seed treatment, application of organic mulches (rice husks and dry grasses) for soil conservation and weed management, but also application of organic fertilizers (poultry/cattle manures and Minjingu nafaka fertilizers) for improvement of soil fertility. Also, one more validation work is recommended in order to see the effect of season variability on effectiveness of the recommended technologies.

5.0 COMPARISON BETWEEN RESEARCH FINDINGS AND VALIDATION FINDINGS

5.1 Seed treatment

A study by Mbega et al. (2012) indicated that plant extracts from A. *vera*, C. *arabica* and Y. *schidigera* are potential candidates for seed treatment against seed-borne xanthomonads of tomato in Tanzania. Validation study also shown that a combination of A. *vera* + C. *arabica*, A. *vera* and C. *arabica* have good efficacy against BLS causing pathogen.

5.2 Fertilizers application

A study by Rwiza and Kisetu (2014) shown Minjingu mazao fertilizer to have a positive impact on crop productivity. Also, a study by Kisetu and Heri (2014) reported poultry manure to have positive effects on crop productivity. From validation study, application of Minjingu fertilizers and poultry manures increased crop productivity.

5.3 Mulching

Studies by Mtui et al. (2015) and Mwakyusa (2016) recommended the use of organic mulches in order to improve crop productivity, reduce insect pests' problem and reduce blossom end rot problems in tomato. Results from validation study also found the recommended technologies to be of positive impacts in improving crop productivity, reducing reduce insect pests' problem and reduce blossom end rot problems.

Generally, the validation' results correlate with the recommendations from research findings although another validation study might be needed to clear out the doubt of seasonal variations.

REFERENCES

Kisetu. E and Heri. P. (2014). Effect of poultry manure and N: P: K (32:10:5) Fertilizer on Tomato variety Tanya grown in selected soils of Morogoro Region, Tanzania. *Asian Journal of Crop Science,* 6(2):165-175.

Mbega, E. R., Mortensen, C. N., Mabagala, R. B. and Wulff, E. G. (2012). The effect of plant extracts as seed treatments to control bacterial leaf spot of tomato in Tanzania. *Journal of General Plant Pathology*, *78*(4), 277-286.

Mondelaers, K., Aertsens, J. and Van Huylenbroeck, G. (2009). A meta-analysis of the differences in environmental impacts between organic and conventional farming. *British food journal*.

Mtui, H. D., Maerere, A. P., Bennett, M. A. and Sibuga, K. P. (2015). Effect of mulch and different fungicide spray regimes on yield of tomato (Solanum Lycopersicum L.) in Tanzania. *African Journal of Food, Agriculture, Nutrition and Development*, *15*(1), 9607-9619.

Mwakyusa, J. P. (2016). Effect of mulching materials on growth of Okra (*Abelmoschus esculentus* L.) cultivars in Morogoro.

Rwiza, A. A. and Kisetu, E. (2014). Effect of NPK and Minjingu mazao fertilizers on the performance of Sweetpepper in Morogoro, Tanzania. *Direct Research Journal of Agriculture and Food Science (DRJAFS)*, *2*(11), 179-183.

Seufert, V., Ramankutty, N. and Mayerhofer, T. (2017). What is this thing called organic? How organic farming is codified in regulations. *Food Policy*, *68*, 10-20.