Why is the Red Spider Mite (*Tetranychus evansi*) a threat to Dry Season Tomato Growing in Tabora, Tanzania?

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Abstract: *Dry season tomato (Lycopersicon esculentum L.) growing is an important economic activity in semi-arid Tabora region of western Tanzania. However, red spider mite (Tetranychus evansi Baker & Prichard) has emerged as a threat to dry season tomato growing in smallholders' fields. A study was carried out in Tabora, Tanzania in order to discover factors leading to increased red spider mite infestation in tomato fields. A survey of dry season tomato growing fields was carried out in June through September in the districts of Uyui, Urambo and Tabora Municipality, for a period of three years from 2012 through 2014. Discussions with farmers and collection of pesticide containers left in the fields helped us to understand the existing gap for establishment of an effective strategy for red spider mite control. It was found that farmers lack a strong agricultural extension support to effect the integration of basic technical guidelines of integrated pest management and safe procedures of pesticide handling practiced in intensive outdoor tomato growing system. The results show that there was a high significant difference (P<0.001) in the severity of attack by red tomato spider mites among tomato fields. Red spider mites attack a wide range of alternative host plants including weeds and field crops. Profecron 720 gm/litre insecticide was used by most farmers (55.5%). Red spide mites significantly (P<0.001) attached tomato leaves than stems and dry flowers. They caused up to 100% crop loss in tomato. Use of inefective chemicals, poor field sanitation, dry climate and lack of agricultural extension support in agronomy and pesticide use were identified as factors contributing to farmers' inability to control red spider mites in the study area. Waging a war against red spider mites is urgently needed by stakeholders engaged in horticulture.*

Keywords: Dry season, *Tetranychus evansi*, tomato growing, Tanzania

INTRODUCTION

Tomato (*Lycopersicon esculentum* L) is an important vegetable crop grown in smallholders' gardens because of its high potential to address the food and income needs in Tanzania (Ngowi *et al*., 2007). Tomato is a common traded vegetable crop in Tanzania. The crop is produced by smallholder farmers under different agro-ecological zones in the country. One of the major constraints to tomato production is the high prevalence of devastating pests, particularly the red spider mites (Acari: *Tetranychus evansi* Baker & Pritchard). Spider mites are small (adult female are <0.5mm in size), cryptic

and easily transported hidden within commodities (Najavas *et al*., 2010). A single mated female has the potential to initiate a successful invasion due to its high reproductive rate (Sabelis, 1985; Moraes and McMurtry, 1987.

Bonato, 1999). *T. evansi*, possibly the native to South America, is a spider mite pest of Solanaceous crops and is currently considered to be an aggressive invasive species in the world (Boubou *et al*., 2010; Boubou *et al*., 2012). The modeling study results on the global distribution of *T. evansi* show that dryness and excessive moisture stresses limit the distribution of this pest (Migeon *et al*., 2008). The threat of invasive red spider mites is increasing in the world due to increased dryness (Navajas *et al*., 2010). The red spider mite is considered as the most difficult pest to control, causing significant crop yield losses in African countries, including Zimbabwe (Mariatou and Kwaramba, 1999; Saunyama and Knapp, 2003), Kenya (Onyambus *et al*., 2011) and Malawi (Nyoni *et al*., 2011). Studies on spider mites report increasing insensitivity of red mites to applied Imidacloprid insecticides (Szczepaniec *et al*., 2011; Raupp *et al*., 2004). In some studies successful control of red tomato mites using indigenous and synthetic pesticides has been reported (Muzemu *et al*., 2011). Mutation of red mite population has been found to increase their resistance to pyrethroids (Benjamin *et al*., 2011; Nyoni *et al*., 2011). Smallholder farmers lack appropriate equipment for spraying red mites that infest such plant cells behind the leaves (Sibanda *et al*., 2000). Vegetable growing and marketing is an expanding sector for smallholder farmers to diversify household incomes (Nyamwamu *et al*., 2012). But, spider mites cause significant economic losses of up to 90% of the crop (*Sibanda et al*., 2000). The main hosts of *T. evansi* are Solanaceae (De Moraes *et al*., 1987; Bolland *et al*., 1998; Jeppson *et al*., 1975).

The destruction of red mites on crops is exacerbated by increased temperature and dryness (Nyiira, 1980). Lack of adequate cultural practices for red mite control have been cited as the factors that increase their negative impact on crop destruction (Inoue, 1995). However, cultural practices are important in pest control in tomato production (Kumar and Sigh, 2000). Tomato growers in Tanzania intensively use insecticides to control various insect pests including red tomato spider mites (Ngowi *et al*., 2007) and fungal diseases (Lyimo *et al*., 1998). The problem of red mites on tomato has been reported to be increasing because red tomato spider mites are insensitive to common insect pesticides. Lack of water to effect appropriate irrigation has been noted as factor increasing red mite infestation in dry season agriculture in semi-arid areas of western Tanzania. It is important to study drivers of *T. evansi* infestation at field level with farmers' participation. The detailed analysis of cultural practices at farm level underscores the possibility of developing field management based interventions. This study was conducted on smallholders' tomato growing fields to identify cultural practices, and management gaps leading to increased red tomato spider mite populations.

MATERIALS AND METHODS

Study area

The study was carried at Tumbi, Tabora, in Tanzania (E 032° 41´46.7´´ S 05°04´55.4´´ with an elevation of 1155m a.s.l.). The study was conducted for three years - 2011-2014. Tomato growing is a dominant occupation of smallholder farmers during the dry season in the months of June through September. Tomato plants are irrigated using underground water collected from hand-dug shallow open wells. Different soils are used for tomato growing, including Gleyic Arenosols, Eutric Cambisols, and Fluvisols in valley bottoms (Mitchell, 1984).

Seasonal rainfall distribution and wind speed in Tabora region

Red spider mites increase in population during the dry season between the months of June through September. The period of dryness is also characterized by increased wind speed that influences red spider mites' dispersal over long distances. The red spider mite attack on plants is influenced by dryness as observed in previous studies pest (Migeon *et al.,* 2008).The long dry season and the associated increased wind speed in Tabora region support breeding of red spider mites. Red spider mites move under the aid of wind which increases from the month of June through September (Figure 1).

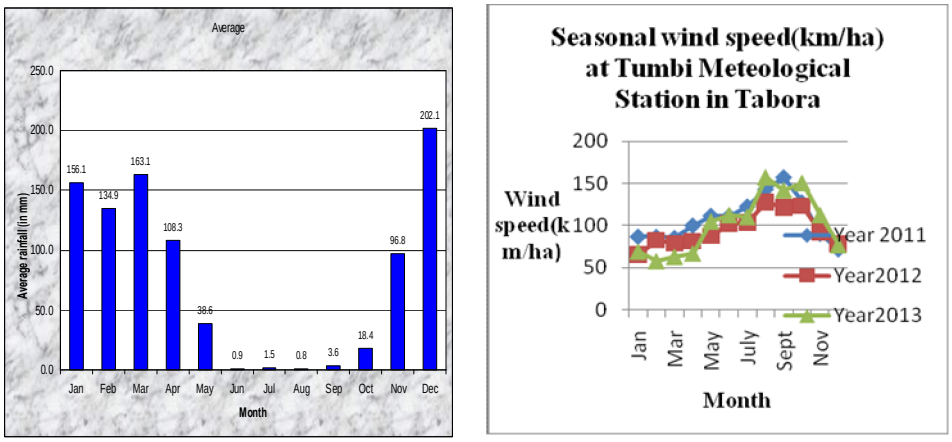

Figure 1: Seasonal rainfall distribution(Left) and Wind speed (Right) characteristics of Tabora region,Tanzania(Tumbi Agrometeological Station)

Assessment of red spider mite severity in tomato fields

Field sampling of 20 tomato plants was done and the level of mite damage of tomato leaves was assigned a leaf damage score of 1-5 (1= few yellow spots, 5= dried leaves, plant with webbings). Field observations were carried out to study the post-harvest infestation of harvested tomato plants by red tomato mites. The score on leaf damage of 1-5 was assigned to different harvested tomato fields. The data was organized and statistically analyzed using ANOVA procedures, and software tools - the GenStat Discovery Edition 4 and VSN International Ltd.

Alternative host plants species of red spider mites in Tabora region in Tanzania

Field observations and farmer experiences were used to identify plant spicies host of red spider mites. Identification of plants in local language was given by farmers. Botanical names were assigned to identified plant spicies using respective literature in Botany (Akobundu and Agyakwa, 1987; Ruffo *et al*., 2002).

RESULTS AND DISCUSSIONS

Red spider mites feed mostly on tomato leaves, but as the leave dries up they move to the reproductive parts of the plant that are considered to be mineral nutrient sink for the plant. Tomato leaves are most preferred for feeding, breeding and hiding places for red mites on tomato plants (Table 1).The progressive death of tomato leaves, cause red spider mites to move to different parts of the tomato plant. Fresh tomato stalks and dried tomato floral parts are used by red spider mites for feeding when the leaves dry. This emphasizes the importance of post-harvest sanitation of infested tomato fields to reduce red spider mites' populations and subsequent infestation of non-infested fields.

Table 1: Mean Red Spider Mites Attack Severity on Dried Tomato Flowers, Stalks and Leaves

Part of Tomato plant	Red spide mite severity (RSMS)
Tomato flowers (n = 30)	12.00
Tomato stalks (n = 30)	13.00
Tomato leaves (n = 120)	49.00
F-test	F = 18.26 , p<.0001
CV	127.9
LSD0.05	29.64

There was a high significant difference ($p<0.001$) of red spider mites infestation in tomato fields indicating that the control of red spider mites in tomato fields was variable among farmers who had different knowledge and resources for controlling this pest (Table,2).

Table 2: Analysis of Variance of the Severity of Red Spider Mites in Post-harvested Tomato Fields

Source of variation	Df	SS	MS	Vr	Fpr
Tomato plants	19	10.6250	0.5592	0.82	
Tomato fields	5	178.1417	35.6283	52.05	<.001
Residual	95	65.0250	0.6845		
Total	119	253.7917			

Methods used by farmers to control red spider mites in fields

Farmers used different brands of insecticides for control of red spider mites (Table 3). The common insecticides used by farmers were Profecron 720gm/litre which constitute 55.5% of all the insecticides used by farmers in insect pest control in tomato plants. According to

farmers' observations, broad spectrum insecticides were ineffective against the red spider mites. Similar observations are documented in other studies including, Szczepaniec *et al.* (2011) and Raupp *et al*. (2004). Broad spectrum insecticides were found to kill the natural enemies of the red spider mites thus promoting their population increase (ICIPE, 2003). Sibanda *et al*. (2000) observed that, smallholders in Zimbabwe lack appropriate chemical spray equipment for effective control of red spider mites which feed on the underside of the leaf. Farmers lack knowledge of using appropriate and effective pesticide for control of red spider mites. Use of ineffective chemicals for red spider mites control has been documented in different studies (Szczepaniec *et al*., 2011; Raupp *et al*., 2004). In this study different 92 ineffective chemicals are used by farmers to control red spider mites in Tabora, Tanzania (Table, 3).

Table 3: Insecticide Brands Used for Control of Insect Pest Among Tomato Growers in Tabora Region

SN	Trade name	Action	Active ingredient	Manufacturing company	Frequency
1	AmeCron 720 EC	Non-systemic fungicide and acaricide with contact and stomach action	Profenofos 720 g/L	Ametech International GmbH,Germany	1
2	ABANIL 18 EC	Insecticide for control of spidermites on fruits	Abamectin 18g/L	Farmbase LTD, Dar es Salaam,Tanzania	2
3	Amekan C344 SE	Systemic insecticide with contact stomach action	Cypermethrin 144g/L+Imidacloprid 200 g/L	Ametech Chemicals Ltd, GmbH, Germany	6
4	ASCOMEC 1.8 EC	Broad spectrum insecticide	Abamectin,18 g/L	Sharda Worldwide Exports, Ltd,India	6
5	ATTAKAN C244 SE	A broad spectrum insecticide	Cypermethrin, 144g/L+ Imidacloprid 200g/L		1
6	BAMETRIN 2.5 EC	A broad spectrum pyrethroid insecticide	Deltamethrin 25g/L EC	Avestar Industrial Ltd	1
7	BANOFOS 720 EC	A foliar insecticide and acaricide with contact action	Profenofos 720 g/L	Bajuta International(T) Ltd	1
8	Confidor	A systemic insecticide used as a foliar and soil application	Imidacloprid 200g/L	Bayer Crop Science,GmbH,Germany	4
9	DICHLORVOS 100% EC	Insecticide	Dichlorvos 100% EC	Agrochemical Ltd Kampala	1
10	DUDU-ALL 450EC	A broad spectrum insecticide	Cypermethrin 10%+ Chlorpyrifos 35%	Hanghou Agrochemicals Ltd, China	3
11	Dume 40 EC	Insecticide with contact action	Dimethoate 400g/L	Nanjing Limin Chemical Ltd,China	2
12	FARMGURD 344 EC	A systemic insecticide for control of aphids, bollworm and sucking insects	Cypermethrin 144g/L+ Imidacloprid 200/L SE	Farmbase LTD,Dar es Salaam,Tanzania	3
13	FARMRIFOS 48EC (DURSBAN 48%)	Insecticide	Chlopyrifos 480g/L	NANJING LIMIN CHEMICAL(CO) Ltd China LTD.	1
14	KUNG FU 5 EC	Insecticide	Lambda cyhalotrin 50 g/L	Sulphur Mills Chemical Company Ltd,India	7
15	METAKAN SUPER 350 EC	A broad spectrum systemic insecticide with contact and stomach action	Cypermethrin g/ L+ Imidacloprid /L SE		1
16	LAMBDASCOPE	Abroad spectrum	50g/L	Cropstar(UK) Chemical	2

	5EC	contact and stomach acting pyrethroid insecticide	Lambdacyhalothrin	Industry Limited	
17	Profecron 720 EC	Broad spectrum insecticide	Profenofos 720 g/L litre	Nagarjuna Agrichem Ltd,India	35
18	Profit 720 EC	Foliar insecticide	Profenofos 720 g/L	DVA Agro GmbH,Germany	1
19	SUBA CHLO 55 EC +INSECTICIDE	Insecticide with contact action	Chloropyrifos 50% +Cypermethrin 5.0% +Inert materials 52.0%	Sulphur Mills Ltd, India	5
20	SUPERCRON (Profenofos 500EC)	Broad spectrum non-systemic, contact,ovicidal and stomach acting insecticide	Profenofos 50%/L	Eximco Agro-Limited Hong Kong,China	8
21	Zetabestox™ 10%EC	Insecticide/Acaricide	Zeta-Cypemetrin 10%	Not indicated	1
	Total				**92**

Use of non-effective insecticides in the control of red spider mites (Table 3) was a big constraint to dry season tomato production. Most farmers used broad spectrum insecticides (Table 3) to control red spider mites of which Profecron 720 gm/litre active ingredient containing insecticides were common constituting of 55.5% of total number of insecticides used in tomato growing. Broad spectrum insecticides are less effective against red spider mites (Szczepaniec *et al*., 2011; Raupp *et al*., 2004). In this study Abamectin 18g/litre active ingredient containing insecticides were reported by farmers to be effective against red spider mites. However, these insecticides constitute only 9.5% of the insecticides used by farmers**.**

Importance of post-harvest field sanitation for effective control of red spider mites breeding sites

Cultural control methods such as field sanitation for destroying breeding sites have been neglected among tomato growers (Table 4). There was a significant difference of red spider mites' infestation in tomato fields and on post-harvested tomato fields indicating the farmers' negligence of conducting field sanitation on living post-harvested crops host to red spider mites (Table 4). Farmers in Tabora region, lack organization and training on tomato production and integrated pest management and handling of pesticides as documented in northern Tanzania (Musebe *et al*., 2014). The tomato production scale is small and in some cases it has the subsistence character as opposed to intensive commercial tomato production under adequate water supply (Musebe *et al*., 2014).

Table 4: Analysis of Variance of the Severity of Red Spider Mites in Post-harvested Tomato Fields

Source of variation	Df	SS	MS	Vr	Fpr
Tomato plants	19	10.6250	0.5592	0.82	
Tomato fields	5	178.1417	35.6283	52.05	<.001
Residual	95	65.0250	0.6845		
Total	**119**	**253.7917**			

Figure 2: Severe red spider mite attacked of tomato plants at Tumbi, Tabora in Tanzania

Tomato yield loss caused by red spider mites range from 20 to 100%. Late infestation of the crop has cause low yield loss as compared to early tomato plant growth infestation in absence of effective chemical control method and water scarcity to cause effective watering of tomato plants during the peak of the dry season in the month of July through September (Figure 2).

The spectrum of red spider mites alternative host species in Tabora, Tanzania

Plant species in the Solanaceae family have been reported to be most preferred by red spider mites in different studies (De Moraes *et al*., 1987; Bolland *et al*., 1998; Jeppson *et al*., 1975). In this study plant species outside the family Solanaceae were found to host red spider mites. Plants in the families of Asteraceae, Fabaceae, Cucurbitaceae, Lamiaceae, Malvaceae and Poaceae were found to host red spider mites simultaneously with those plants in the family Sonaceae.

Table 2: Alternative Host Plant Spicies to Red Spider Mites in Tabora,

Botanical name	Family	Nature of plant
Nicandra physaloides (L.) Gaertn	Solanaceae	Common weed
Nicotiana tabacum (L).	Solanaceae	Field cash crop
Phaseolus vulgaris (L.)	Fabaceae	Field food crop

Cucurbita maxima Duchesne	Cucurbitaceae	Field food crop
Sida acuta Burm.f.	Malvaceae	Common weed
Acanthospermum hispidum DC.	Asteraceae	Common weed
Solunum incanum L	Solanaceae	Common weed
Solunum torvum Sw	Solanaceae	Common weed
Solanaceous aethiopicum (L)	Solanaceae	Field food crop
Hyptis lancoelata Poir	Lamiaceae	Common weed
Hyparrhenia rufa	Poaceae	Common weed

CONCLUSIONS

The problem of red spider mites infestation in dry season tomato growing is growing and is considered by farmers as a menace. Red spider mites pose a threat to dry season tomato growing. Farmers have little knowledge on the effective use of insecticides for red spider control. The use of broad spectrum insecticides is less effective for control of red spider mites. Abamectin 18 gm/litre active ingredient have significant control of these pests. However, the price of Abamectin containing insecticides is reported to be higher compared to other insecticides.

This study has showed that there are alternative plant species host to *T.evansi* outside the Solanaceae family such as Asteraceae, Cucurbitaceae, Fabaceae, Malvaceae, Lamiaceae and Poaceae. Integrated approach for red spider mites control is needed. This should include; the use of acaricides and other effective chemicals, chemical adjutants to improve the effectiveness of applied chemicals, water use efficient methods and increased agricultural extension support for dry season tomato growing farmers.

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