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Evaluation of Insecticides for Management of Emerging Two Spotted Spider Mite, *Tetranychus urticae* Koch (Acari: tetranychidae) on Tomato In Grusum District, Somali Regional State, Eastern Ethiopia

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ABSTRACT

Two spotted spider mite (TSSM) a world pests feed on numerous cultivated and wild plants. It is important emerging tomato infesting pest in eastern Ethiopia. There is scarce information on recommended insecticicides for the managements of TSSM on tomato. The efficacy of five insecticides viz., Radiant 120 SC, Torque 550 SC, Profit 72 EC, Agro-Thoate 40% EC and Selecron 720 EC along with control were evaluated against TSSM in Gursum district of Somali Regional State. Two round applications were made at different interval in Randomized Complete Block Design replicated three times. Mean mite at pre-spray, after four (3, 6, 9 and 14) post spray, mite percent reduction, infestation and tomato fruit yield were used for effectiveness of tested insecticides. Cost-effectiveness of insecticides determined bases on yield and control costs. The study revealed that all insecticides reduced mite population significantly than control plots. The differences between tested insecticides in percent mite reduction during both 1st and 2nd round application were not significant. Percent mite infestation found lower in all insecticides treated plants. The highest yield 335.93 qt, and highest yield gain over control 144.67 qt was obtained from profit. All insecticides sprayed plots gave the highest gross income and net income than the untreated plots. Among tested insecticides Profit 72 EC sprayed plot provided the highest gross income (839,825) and maximum net income 355,575 Ethiopian Birr (ETB). The lowest gross income 478,150 ETB obtained from untreated plots. The highest benefit cost ratio 1:84 obtained from Radiant. Based on the study four insecticides viz., Radiant 120 SC, Profit 72 EC, Agro-Thoate 40% EC and Selecron 720 EC found cost-effective and recommended for the management of the two spotted spider mite on tomato. These insecticides registered to be used in vegetable insect pest control.

Key Words: spider mite, tomato, yield, insecticides, fungicide

1. Introduction

Tomato, (*Lycoperiscon esculentum L.*) is the most important vegetable widely grown in the world. In Ethiopia, tomato is one of important and widely grown vegetable from home garden to large commercial farms (MoA, 2010). The bulk of production concentrated in the Central Rift Valleys (MoARD, 2009), due to availability of irrigation facilities and proximity to agro-processing industries (Nigatu et al., 2010). Tomato cultivated on on 7,710.16 ha area with an estimated production of 33,656 t in 2021/22 cropping season in Ethiopia. The areas and production of tomato is increasing from time to time in the country. Area and production of tomato increased by 7.62% and 21.94% in 2020/2021 (CSA, 2020). Tomato is an important cash-generating vegetable to small-scale farmers and provides employment in the production and processing industries. As it is one of the most divers use high value /cash crops vegetables, which, obviously could play a significant role to enhance income and improve the living standard of smallholder farmers and strengthen the foreign currency capacity of the country(MoARD, 2006).

Its its multiple harvests potential of year round production, which results in high profit per unit area, tomato become the most prefereable vegetable by farmers (MoANR, 2016). Large proporation accounted to 74.88 percent of produced by private peasant holdings spends for household consumption, while 24.56 percent sold for income in 2021/22 cropping season. It is among potential vegetables identified for its production improvement in the Growth and Transformation Plan (GTP) of Ethiopia. Accordingly, it is planned to increase tomato productivity from 0.87 t/ha to 13.4 t/ha with an average annual growth rate of 9 % (II, 2015). Despite of economic and dietetic importances, productivity of tomato hampered by different pest infestation, which cause significant loss in both quantity and quality of tomato fruit yield. Tomato attacked by cocktail of pests throught growing period. Among insect and mites pests the African bollworm, red spider mites, whitefly, thrips, mealy bugs and tuta absoluta are the major pests of tomato. Some of these pests occurred at early tomato growing stages such as red spider mites, tobacco whitefly and thrips, while others like African Bollworm and other tomato fruit worm occurred

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at latter stage and damage fruits (Sardana et al., 2017). In survey made in four districts namely Grusum, Gode, Berano and Kelafo, five insect and mites (red spider mites, whitefly, thrips, mealy bug and fruit worms were found attacking tomato with different level of infestation across the districts. Apart coomon pests, recently introduced pests cause great challenges in tomato production in Ethiopia. The red spider mite and leaf miner are among emerging injuries pests of tomato. Tomato growers rely on pesticides control of pest on tomato. The red spider mite become one the major pest of tomato in low land irrigated tomato production of Somali region. Sinces newly emerging tomato pests there is no available information on effective chemical that use by vegetable growers in eastern Ethiopia against spider mite which initatite haphazard chemical application on base of availability. Therefore, this research initated to evaluate and identify cost effective insecticides for management of red spider mite on tomato that can be use by vegetable growers.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in Grusum district of Fafen zonal administration of Somali region. Bombas is the district's capital, located about 48 km from the regional capital city Jigjiga. Babille borders it on the south; on the west by the Oromia Region, on the north by Ajersagora, on the east by Jigjiga, and on the southeast by Kebri Beyah. According population projection for 2017, district population projected to be 35, 578, out of which 31,584 (88.77 %) is rural habitants (CSA, 2013). The district comprises 13 rural and 2 urban Kebeles.

The district receives three rainy seasons rather than two. The main rainy season extends from April to May (gu rains), that from June to July (Hagaa rains) and that from August to September (Karan rains). The 'Karan' rains are unique to the northern zones of Fafen and allow the cultivation of long-maturing rain-fed crops, which is not feasible in other parts of the region. The mean annual rainfall of in the district is 660 mm. The mean minimum and the mean maximum temperature in this area are 20 °C and 35 °C, respectively . Farming system characterized by rain fed mixed-farming systems. Maize and sorghum is indispensably cultivated by all farmers mostly intercropped with haricot bean. Tomato, onion and pepper are important cash crops grown by farmers under supplementary irrigation along Fafen River. At the Fafen zonal level, onion cultivated on about 293.83 hectares of land by 4,296 farmers and produced 15,975.13 qt in 2014/15(, CSA).

2.2. Experimental Materials

The efficacy of five insecticides viz., Radiant 120 SC (Spinetoram), Torque 550 SC (Fenbutatin), Profit 72 EC (Profenofos), Agro-Thoate 40% EC (Dimethoate 40% EC) and Selecron 720 EC (Profenofos "Q" 720 gL-l) on red spider mites were evaluated on Gelilema (Oval red) tomato variety. Gelilema tomato is determinate growth habit with 500 qt/ ha released in 2015 by MARC/EIAR. All insecticides are registered by Ministry of Agriculture for pest control in Ethiopia. The seeds of tomato variety and insecticides were purchased for local market. The detail on insecticides presented in (Table 1)

Table 1: Name, active ingredient and application rate of insecticides

Trade Name	Active ingredient	Rate/ha
Radiant 120 SC	Spinetoram	130 ml
Torque 550 SC	Fenbutatin	1 lt
Profit 72 EC	Profenofos	1 lt
Dimethoate 40%	Agro-Thoate 40% EC	1.5 lt
Selecron 720 EC	Profenofos "Q" 720 gL^{-1}	1 lt

2.3. Seeding and Field Establishment

The experiment was undertaken under irrigation using natural mite populations. The seeds of Gelilema tomato was sowed at rate of 10 g/ 5 m2 (350 kg/ha) on standard bed size 1 m x 5 m (5 m2) lightly covered with soil and mulched with grasses. The mulch was moved after the seed fully germinated. DAP at sowing and Urea at 5 cm height of seedling stage was applied at the rate of 100 g/bed of 5 m2. Agronomic practices like, watering (using watering can), cultivation and weeding were maintained as per recommended for tomato seedling. The seedlings were transplanted to experimental plots thirty five days after sowing.

2.4. Design and Treatments

The experiment was laid in Randomized Complete Block Design (RCBD) with three replications. Plot size of 3 m width x 1.8 m length was used with space of 70 cm and 30 cm between rows and plants, respectively. There were 4 rows in each with 6 plants. Half (0.5) m and 1 m distances were kept between each plot and blocks, respectively. Five pesticides and control were used as treatments. The treatments (T) were: Radiant 120 SC (T1); Torque 550 SC (T2); Profit 72 EC (T3); Agro-Thoate 40% EC (T4); Selecron 720 EC(T5) and untreated control (T6). The plant were fertilized with DAP at the rate of 200 kg/ha, while Urea at 150 kg/ha. DAP all and Urea 50% applied at transplanting and the rest 50% Urea applied half months after transplanting (EARO, 2004). The plant were protected from fungal diseases by spraying Mancozeb (Penncozeb 80% WP) fungicide at the rate of 3 kg/ha. Agronomic practices like, watering (using watering can), cultivation and weeding were maintained as per recommended for tomato.

2.5. Monitoring and Insecticides Applications

The plants were regularly monitored for mite occurrence. Insecticides were applied when mite observed on the experimental plants. Insecticides were applied using manually operated knapsack sprayer with 15 liter capacity. The sprayer was thoroughly cleaned before using for other insecticides. During insecticides application plot was shielded with 1 m high polyethylene sheets on all sides to avoid insecticides drifts on to other plots. Two insecticides application were made in 30 days interval throughout experimental period.

2.6. Data Collection

The data on mite density, infestation percentage and fruit yield data were recorded on experimental plants. The mite density and infestation percentage data was recorded at different times during experimental period, while fruit yield data were recorded at maturity of the tomato. The details in data recording procedure presented as follows;

2.6.1. Mites and Plant Damage

Mites were counted on 5 randomly selected plants before insecticides spray and post spray at 3, 6, 9 and 14 days after spray (DAS). The motile mites were counted on underside of three leaves (top, middle and bottom) of sampled plants using a 10 x hand lens (Reddy et al., 2013). The mite was considered dead if not move when lightly touch with fine brush (Reddy et al., 2014). The mite infestation was recorded using damage scale ranges from 0-3: 0: no damage; like slight damage 1-25%; moderate damage 26-65% and severe damage >65. Other arthropod other than red spider mite found on plant was recorded. The mean number of mites in treated and untreated leaves was calculated to assess the efficacy of different treatments.

2.6.2. Fruit Yield

The fruits were collected when the fruit fully colored from central two rows. The collected fruits from each plot was weighed and rated as marketable or unmarketable fruit. The unmarketable fruit due to mechanical, disease, or insect injury discarded. Mean fruit weight per sampled plant and percent of infested fruit recorded for each treatment. The total fruit yield was calculated by summing fruit weight of harvesting times. The fruit yield in kg per plot was converted to yield in quintal per hectare. Changes in leave color due to probable phytotoxicity of tested insecticides were recorded.

2.6.3. Statistical Analysis

All collected data were subjected to analysis of variance (ANOVA) using SAS (SAS, 2009). Means were separated by Fisher's protected Least Significant Difference (LSD) test to determine significant differences among the tested treatments. The data was checked for normality and some count data were square root transformed before analyses of variance (ANOVA). The percentage efficacy of insecticides was estimated based on pre-spray motile mite count and post spray motile mites counts (Shiberu, 2021).

$$Yieldgain = \frac{(Yieldintreatement - Yieldoncontrol)}{Yieldintreatement} * 100 \qquad (2)$$

Cost benefit analysis was done for each insecticides for red spider management option as per described by (Shabozoi et al.,2011).The value fruit harvested kg /plot and cost of mite insecticides control were used for cost benefit analysis. The prices of 1 kg of tomato fruit was obtained from nearby market at Fafen. During study period the selling prices of 1 kg marketable fruit was 25 Ethiopian Birr (ETB). The total fruit values were obtained by multiplying yield from each insecticide with market prices of 1 kg of fruit. The cost of red spider insecticides controls; cost of insecticides purchase and labor cost for insecticides application was considered for cost benefit analysis. Two litters were considered for each insecticide for hector with two times spray. The purchasing prices for 1 L of Profit 72 EC was 1, 800 ETB and 1,650 ETB/litter for the rest insecticides. Labor payment for pesticides spray is not same payment for other activities such as weeding and cultivation etc. As a results four hundred (400) ETB paid for one time insecticides spray and 800 ETB for two sprays. Three sprayers were considered for hector with two times spray which costs 6 x 400=2,600 ETB. The total control costs (insecticides + labor cost) were calculated for each insecticide.

3. Results and Discussion

3.1. Effects Insecticides on Mites Population and Infestation

3.1.1. Effects Insecticides on Mites Population

The effects of different insecticides on mite population at after 1st, 2nd spray and after four (3, 6, 9 and 14) post spray presented in (Table 2)and (Table 3), respectively. There were significant ($P<0.05$) difference between the plots in mean mite density in pre-spray count. The highest mean mites were recorded on plot designated for profit insecticide treatment. The lowest mean mite per plot was recorded on plot designated for Radiant insecticide treatment. The mite population reduced almost in half in all insecticides applied plants three days after first insecticide application. The highest percent reduction obtained from Profenofos insecticide treated plots. The lowest percent reduction was from Dimethoate treated plots. However, there were no significant differences between insecticides in percent reductions after three days of insecticides application. Six days after insecticides application, the highest percent mite reduction obtained from profit insecticide treated plots, while the lowest reduction percentage from Dimethoate insecticide. However, the different was statistically not significant. At nine and frothy days of post insecticides application more than 90% of mites were reduced in all treated plants. In contrary, mite population increasing on plant in untreated plots.

Percent mite reduction increased with increasing post application from 3 days to 14 days. At 14 days post application all insecticides reduced over 90 perecent of mite on plants.

The second round insecticides applications stayed long until mite recover and build their population on experimental plants. It has been done after month of the first round insecticides application (Table 3). The experimental field are under good management like irrigation, weeding in and around the plots. This delays fast occurrences and invasion of mites from adjacent field. The mean mite density per plants during pre-spray count was significantly different between

Table 2: Mean motile mite population before spray and percent reduction after 3,6,9 &14 days 1st insecticides application

Treatments	Pre-spray	Percent reduction in mite Days after first spray			
	1	3	6	9	14
Profit	12.57a	59.31a	83.82a	96.95a	99.95a
Profenofos	10.77ab	59.92a	82.16a	82.15a	94.90a
Dimethoate	9.53ab	50.14a	79.53a	99.05a	99.19a
Radiant	7.93b	50.93a	81.08a	94.55a	98.65a
Torque	9.93ab	52.06a	80.34a	86.86a	99.41a
Control	10.10ab	-10.20b	-29.40b	-38.86b	-49.74b
LSD5%	1.6720	0.4941	13.156	14.836	14.172
CV	20.20	13.64	12.38	25.26	23.28

*Means followed by the same letters in a column are not significantly (P<0.05), LSD=Least significant difference, CV=Coefficient of variation

Table 3: Mean motile mite population before spray and percent reduction after 3,6,9 &14 days 2nd insecticides application

Treatments	Pre- spray	Percent reduction in mite Days after 2nd spray			
	1	3	6	9	14
Profit	3.77b	61.59a	85.63a	97.04a	100.00a
Profenofos	3.71bc	64.45a	84.84a	92.76ab	99.92a
Dimethoate	3.31d	56.04a	75.73a	98.95a	99.74a
Radiant	3.6bc	65.96a	80.47a	95.19ab	99.85a
Torque	3.47cd	60.04a	75.89a	88.61b	99.49a
Control	5.17a	-3.54b	-4.55b	-42.07c	-30.20b
LSD5%	0.1733	5.1242	14.489	3.4742	2.1817
CV	3.62	12.37	26.75	11.96	9.43

*Means followed by the same letters in a column are not significantly (P<0.05), LSD=Least significant difference, CV=Coefficient of variation

the plots. The highest mean mite density at pre-spray count was recorded on plant in untreated plots. The lowest mean mite density at pre-spray count was recorded on plant treated with Dimethoate. In the second round insecticides spray all insecticides significantly reduced mite on plants in compared to control. High reduction percentage recorded on plant treated with Radiant three days after application. Previous study indicates that Radiant 120 SC caused the highest mortality of 96.7% 48 h after treatment application and 100% mortality 72 h after treatment application on fall armyworm (Birhanu et al., 2019). However, the differences in percent mite reduction among insecticides were not significant. In same fashion all insecticides reduced mite density on plant 6, 9 and 14 days after application. But the differences between insecticides in percent mite reduction were not significant.

In both 1st and 2nd post application mite counts, all evaluated insecticides significantly reduced the two spotted spider mite in compared to the control. Efficacy of Profenofos and Profenofos"Q"720 g/l was evaluated in green house on egg and adult stage of mite. It was found that the Profenofos"Q"720 g/l reduced 78.57% and 93.53% on egg and motile stages, respectively. Similarly, Profenofos cause 79.07 and 96.45 percent reduction on egg and motile stages, respectively (Yassin et al., 2019). Recent study indicated that spinetoram sprayed plots found fewer numbers of thrips and higher bulb yields (Belete et al., 2020). Dimethoate is systemic and contact insecticide for the control of aphids, psylla, red scale, fruit fly, Bryobia mite, woolly aphid, mealy bug and black moth on crops. Agro-Thoate 40% EC, Selecron 720% EC, Radiant 120 SC, Profit 72% EC are among the most common products vegetable growers used in Ethiopia (Mengistie et al., 2016).

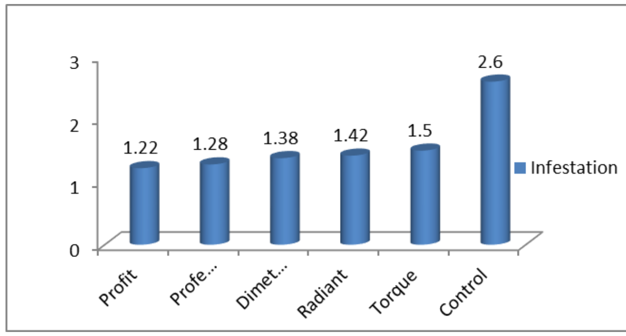

Figure 1: Mite infestation in different insecticides and control

3.1.2. Effects Insecticides On Mite Plant Infestation

The mite infestation was recorded using damage scale ranges from 0-3: 0: no damage; 1: slight damage 1-25%; 2: moderate damage 26-65% and 3: severe damage >65. Mite infestation recorded on experimental tomato after different insecticides post application presented in (Figure 1). The percent infestation on plant treated with different insecticide found significantly lower than plants in control plots. The highest percent infestations (2.6%) were recorded on plants in control plots. The lowest percent infestations (1.22) were recorded on plants treated with profit. However, the percent infestations were not in same trend of mite population reduction due to insecticide treatment. This mainly because of plant injury is not only due to the mite feeding but also due to other insect feeding on experimental tomato. Effort has been made to record on mite feeding injury but difficult in some case. Instance, spider mite, thrips and white fly are sucking pests that cause similar feeding injury symptom on plant.

3.2. Tomato Fruit Yield

Tomato fruit yield as affected in different insecticides application against mites presented in (Table 5). There was significant difference in mean fruit yield between insecticides and untreated control. All insecticides yielded higher mean fruit yield than the control. The highest yield obtained from profit and the lowest from Torque treated plants but statistically not significant difference between insecticides treatment. Insecticides application resulted high yield gain ranging from 109.51-144.67 qt over untreated control (Table 4). However, the yield difference between insecticides and untreated plot was not only due to the mite, but also other insect pests. On insecticide applied plot other insect pests also affected by insecticides sprayed against mite.

During the course of experimental period insects other than the target mites were recorded on plants. Thrips, leaf miners, white fly, and fruit worm were recorded on tomato. These insect pests are among tomato injuring pests in other areas of the region where tomato cultivate under irrigation.

Table 4: Mean yield and yield gain over control

Treatments	Fruit yield/ha	YoC-qt	Percent
Profit	335.93a	144.67	43.07
Profenofos	332.58a	141.32	42.49
Dimethoate	314.66a	123.4	39.22
Radiant	304.95a	113.69	37.28
Torque	300.77a	109.51	36.41
Control	191.26b		
LSD5%	37.022		
CV	15.28		

*Means followed by the same letters in a column are not significantly ($P<0.05$), LSD=Least significant difference, CV=Coefficient of variation

Table 5: Profitability of different insecticides application rate against mite

Treatments	Yield qt/ha	GI($)	BC($)	CC($)	NI($)	CBR
Profit	335.93	839,825	361,675	6,100	355,575	59
Profenofos	332.58	831,450	353,300	5,700	347,600	62
Dimethoate	314.66	786,650	308,500	5,700	302,800	54
Radiant	304.95	762,375	284,225	3,258	278,525	84
Torque	300.77	751,925	273,775	5,700	270,517	50
Control	191.26	478,150		0	0	0

GI=Gross income ($), BC=Benefit over control, CC=Cost of control, NI=Net income ($),CBR=Cost: Benefit ratio, Gross income ($)=Yield x Price, BC= GI-CC, NI=BC-CC, CBR= BC / CC

The leaf miner and two spotted spider mite are an emerging pests, particularly, the leaf miner recently introduced and takes major pest status in tomato. During this study beyond the presence of these pests the effects of tested insecticides are not considered. However, most of the tested insecticides are registered for the managements of major insect pests particularly the two fruit boring insects viz., tomato leaf miner, Tuta absoluta and Helicoverma armigera. As results the tested insecticides against the mites have impacts on these insects also. The effectiveness of the tested insecticides against the spider mite found opportunity for tomato growers in controlling both pests in single spray. The thrips and white fly are injuries insect pests of several cultivated plants. They cause economic damage on plant both by direct feeding as well as by vectoring major plant pathogens such as fungi, bacteria and virus. The major viral diseases of tomato transmitted by thrips and white fly.

3.3. Economic Analysis

All insecticides sprayed plots gave the highest Gross Income (GI) and Net Income (NI) than the untreated plots (Table 5). Among tested insecticides Profit sprayed plot provided the highest gross income (GI) 839,825 Ethiopian Birr (ETB) and the lowest gross income 478,150 ETB obtained from untreated plots. The maximum net income 355,575 ETB obtained from plot treated with profit and the lowest net income 270,517 ETB obtained from Torque treated plots. The maximum highest benefit cost ratio 1:84 obtained from Radiant treated plots. The minimum benefit cost ratio 1:50 obtained from Torque treated plots.

4. Conclusion and Recommendations

The study revealed that all insecticides reduced mite population significantly than control plots. The differences between tested insecticides in percent mite reduction during both 1st and 2nd round application were not significant. Percent mite infestation found lower in all insecticides treated plants. All insecticides sprayed plots gave the highest gross income and net income than the untreated plots. Among tested insecticides Profit 72 EC sprayed plot provided the highest gross income (839,825) and maximum net income 355,575 Ethiopian Birr (ETB). The lowest gross income 478,150 ETB obtained from untreated plots. The highest benefit cost ratio 1:84 obtained from Radiant. Based on the study four insecticides viz., Radiant 120 SC, Profit 72 EC, Agro-Thoate 40% EC and Selecron 720 EC found cost-effective and recommended for the management of the two spotted spider mite on tomato. However, these are only for urgency solution for short term. In long term several insecticides in combination with non-synthetic plant originated pesticides need to be screened for the control of two spotted spider mites. This is because frequent application of few synthetic insecticides and insecticide dependency of mite control cause resistances development. It is well known that the two spotted spider mite are among the top 12 species that have developed resistance to multiple pesticide active ingredients spanning several chemical classes ("Arthropod Pesticide Resistance Database"). www.pesticideresistance.com. Therefore, for sustainable managements of emerging two spotted spider mite on tomato, several insecticides that will use in rotation and non-synthetic plant originated pesticides need to be screened for future.

Conflict of Interest

The author declares that there is no conflict of interests involve in publishing this research paper.

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