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Ecofriendly Management of Two Spotted Spider Mites on Tomato (*Solanum lycopersicum)* (Mill) in Eastern Ethiopia

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A B S T R A C T

This study was initiated with the objective to evaluate the efficacy of tobacco leaf extract and potentiality of intercropping on TSSM in Eastern Ethiopia. The tomato, tomato + cabbage, tomato + common bean, tomato + onion, tomato + tobacco leaf extract and tomato + karate 5% EC were the treatments used for the trial. The overall result indicated that intercropping and tobacco leaf extract significantly reduced the population of these mite pests compared to sole tomato. The minimum population with infestation was recorded on karate (14.65, 0.79) followed by tomato – tobacco leaf extract (16.50, 0.92) and tomato onion (36.53, 1.74) from intercropping while control was the most in recording maximum population with maximum infestation (94.10, 2.88 respectively). The most population reduction with infestation was observed on tobacco leaf extract compared to untreated plot followed by tomato-onion intercropping. The highest yield (50.73tha-1) was recorded on the tomato-onion intercrops followed by karate 5%EC (43.96tha-1) and tobacco extract (43.65tha-1) while the lowest yield was recorded on head cabbage intercrops (30.10tha-1). The maximum net benefit was obtained from tomato-onion intercrops (688653.45 ETB) whereas the lowest net benefit was recorded on common bean (354176.60 ETB) intercrops. Therefore, tomato onion intercrops and tobacco leaf extract could be considered as the first options in boosting tomato production as an alternative to karate 5%EC and expected as common integrated management of TSSM on tomato.

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INTRODUCTION

The tomato (*Solanum Lycopersicum* Mill.), grown on small and large farms at the private or commercial levels using both rainfed and irrigated techniques, is one of the most widely cultivated vegetable crops in Ethiopia (Gemechis *et al*., 2012; Emana *et al*., 2014). It is widely grown by smallholder farmers in Ethiopia as a high-value horticultural crop for home consumption and processing (Hunde, 2017; Kanna, 2016).

Growing tomatoes in the tropics in an open-field setting has several obstacles due to several factors such as temperature, humidity, illnesses, and insect pests, even though there are financial benefits (Rwomushana *et al*., 2020; Tadele, 2016; Wang *et al*., 2021). Lower yields and quality are also a result of these problems in certain locations (Dube *et al*., 2020; Murúa *et al.* 2014). Arthropod pests, namely the tomato leaf miner (Tuta absoluta), tomato fruit worm (Helicoverpa armigera), whitefly (Bemisia tabaci), leafhopper (Amrasca sp), aphid, serpentine leaf miner, thrips, and mites (Tetranichus urticae), are the main causes of issues with tomato production in Ethiopia (Ayele *et al*., 2020; Dube *et al*., 2020; Tadele, 2020). A high mite infestation on tomatoes has been documented in Ethiopia (Goftishu *et al*., 2016). Known by many as the two-spotted spider mite, Tetranychus urticae (Trombidiformes: Tetranychidae) is a major global pest of agricultural crops (Migeon & Dorkeld, 2017). Worldwide, the spider mite is considered an aggressive invasive species, according to Boubou et al. (2012). Rising temperatures and increased aridity are making the world more susceptible to invasive red spider mites (Navajas et al., 2010).

Tomato is the crop most negatively affected by mite infestation, while many other crops, including sweet corn, pepper, eggplant, tomato, and cucurbits, are also affected (Meck et al. 2009). The mainstay for managing T. urticae continues to be synthetic insecticides. Red tomato mites have been effectively eradicated by using both chemical and natural pesticides, according to several studies (Muzemu *et al*., 2011). T. urticae, however, becomes extremely resistant to almost all pesticides because to its short life cycle, high fecundity, inbreeding, arrhenotokous reproduction, and high mutation rate. Moreover, synthetic pesticides could harm animals that are not their intended targets as well as the environment and public health. The development of alternative pest management techniques is currently receiving a great deal more attention due to the unfavorable side effects of synthetic pesticides. Two non-chemical alternative management options are crop diversity and plant extracts.

Among the cultural alternatives to pesticide concerns are the application of intercropping systems and plant extracts (Zhou et al., 2019; Mulugeta et al., 2020). The tomato-onion (Allium cepa) combination offered the largest productivity benefits of tomatoes along with the best fruit protection against arthropods (Son et al., 2018). In order to reduce the population of two-spotted spider mites on tomatoes, Abo-shanab *et al.* (2019) found that intercropping tomatoes with coriander was the most effective treatment, resulting in a 91.2% reduction in the pest's population. Similarly, two-spotted spider mites (TSSM) in strawberry fields were decreased by up to 52% when garlic was grown as an intercrop (Fernando *et al*., 2016). In other instances, botanicals have been employed to treat pests in an environmentally responsible manner (Tadele and Emana, 2017; Hutapea et al., 2019). Furthermore, Luan et al. (2020) studied the control of leaf miners through the use of plant extracts, and they found that the extracts from tobacco and pepper leaves were more effective in reducing the larval mortality of Liriomyza species by 70%. Rana et al. (2018) conducted tests on the acaricidal and sub-lethal impacts of tobacco leaves and discovered that applying tobacco significantly reduced T. urticae fertility and inhibited its eggs. The current pest management strategies place a high priority on alternative control measures that are safe for consumers and users, affordable, adaptable, and effective. This suggests that plant extracts and intercropping systems are good examples of common-sense alternatives to insecticides in pest management. Tobacco leaf extract was frequently utilized in Ethiopia, especially in western Hararghe, to combat pest insects that feed on maize and tomatoes (Negeri et al., 2019). To combat arthropod pests on tomatoes, farmers in Eastern Hararghe do not yet use tobacco leaf extracts or information on the evaluation of tomato intercropping with other crops. Instead, they primarily focus on cereal-legume and fewer cereal-vegetable intercropping to get an extra yield by sowing in the space between the main crops. This study was conducted in order to evaluate the effect of intercropping and the efficacy of tobacco leaf extract on the management of TSSM in Eastern Ethiopia.

LITERATURE REVIEW

According to Ashok Kumar et al. (2009), a wide variety of insects attack tomatoes, which poses a serious threat to their successful production and yield. Compared to other vegetable crops, tomatoes are more susceptible to insect assaults due to their sensitivity and suppleness. Within the Trombiformes family (Tetranychus urticae, Tetranychidae), the two-spotted spider mite is a major pest of agricultural crops found all over the world. According to Miegen and Dorkeld (2017), T. urticae is known to target over 1200 different plant species, including a wide variety of weeds, field crops, decorative and house plants, vegetables, fodder crops, small fruits, and tree fruits. Boubou et al. (2012) state that the spider mite is regarded as an aggressive invasive species globally. The environment is becoming increasingly vulnerable to invasive red spiders due to rising temperatures and greater aridity.

Synthetic pesticides remain the cornerstone for controlling T. urticae. Several studies have shown that red tomato mites can be successfully eliminated with chemical and natural pesticides (Muzemu et al., 2011). However, T. urticae's short life cycle, high fecundity, inbreeding, arrhenotokous reproduction, and high mutation rate lead it to become exceedingly resistant to practically all pesticides. Furthermore, synthetic pesticides have the potential to damage the environment, public health, and animals that are not their intended targets. Boubou et al. (2012) state that as the usage of biological control agents is growing, techniques that do not harm predatory mites are preferable for application in agriculture.

One non-chemical control method for biological control agents is plant extracts. Among these, tobacco was used as an insecticide for the first time in France in 1690. In America, tobacco was first applied as an insecticide in 1814. Many commercial tobacco products have become available recently, including 10% Nicotine AS (Beijing Kingbo Biotech Co., Ltd., China) and Nico Dust or Nico Neem (Nico Orgo Manures, India) (Pavela, 2016). Numerous studies have been conducted to examine how plant extracts affect plant parasitic mites.The effects of aqueous extracts of N. tabacum on T. urticae eggs and adults were studied by Almansour and Akbar (2013). They discovered that at the maximum dose, the mortality rates of eggs and adults were 90% and 82.3%, respectively. The highest mortality was discovered in Skorupska's (2013) investigation into the death of T. urticae on kidney beans following treatment with aqueous extracts from N. tabacum. Plant extracts' acaricidal properties are known to be correlated with their molecular makeup (Singh et al. 2001). Numerous alkaloid compounds found in tobacco leaves frequently have a built-in pharmacologic defense against insects, microbes, and vertebrates. Among alkaloids, nicotine is the most prevalent (Harris et al., 2015), with leaves containing up to 60% of the total amount of nicotine. Therefore, the nicotine level of the tobacco may be the cause of its toxicity. Applying tobacco at the studied dose significantly reduced T. urticae fecundity, according to Rana et al. (2018), who based their findings on the nicotine and other components of tobacco.

Crop diversification is one of the numerous non-chemical management methods offered by TSSM. According to reports, intercropping aromatic plants reduces insect populations and plant damage (Hata et al., 2018; Zhou et al., 2013). In field studies, Bemisia tabaci Genn. was found to be repelled by basil (Ocimum basilicum L.), citronella (Cymbopogon sp.) (Poaceae), and coriander (Coriandrum sativum L.) when interplanted with tomato (Carvalho et al., 2017). Intercropped plants ought to be an unfavorable host for the pest in order to prevent pest populations from growing in the field. When it comes to TSSM hosts, tomato leaf discs are preferred over onion (Allium cepa L.), leek (Allium porrum L.), or parsley (Petroselinum crispum Mill.). This is because the fertility of females fed on these plants was shown to be lower than that of strawberries (Hata et al., 2016; 2017). According to research by Abo-shanab et al. (2019), intercropping tomatoes with coriander was the most effective way to reduce the number of two-spotted spider mites on tomatoes. By using this technique, the pest's population was 91.2% lower. Growing garlic as an intercrop decreased two-spotted spider mites (TSSM) in strawberry fields by as much as 52%, according to Hata et al. (2016). Besides a reduction in TSSM populations and infestations, an increase of beneficial insects because of attraction effects of the aromatic crops was the main importance in the study (Karuppaiah *et al*., 2018).

METHODOLOGY

The experiment was conducted at Haramaya University research station in 2021 using irrigation. The main crop in the experiment was tomato (Geli-lema variety), which was transplanted at 40 days and interplanted with onion (Nafis red variety) transplanted after 40 days, beans (Babile 1), cabbage (Copenhagen market variety) transplanted after 40 days, beans, and sole tomato. All of these crops except beans and cabbage were obtained from the Melkassa Agricultural Research Center (EIAR). In addition, a treatment consisting of tobacco crude leaf extract and karate 5% EC at 320 ml/ha (Standard check) was applied. Generally, six treatments, tomato sole, tomato +cabbage, tomato + common bean, tomato + onion, tomato + tobacco leaf extract and tomato + karate were used in the experiment. Tobacco leaf extracts were made with freshly harvested leaf materials, which were ground with a mortar and pestle. As per the work of Hussain *et al*. (2017) for the stock solution, the resultant leaf juice was filtered through muslin cloth and modified to have an extract to be sprayed on tomato crop at a rate of 1 kg leaves per one liter of water. The solution was sprayed onto the target plot after being diluted with one (1) liter of water. The experiment was set up using a Randomized Complete Block Design (RCBD) with four replications.

Field Management

Six rows of a plot, which had a length of 3.6 meters, a width of 2.4 meters, and a plot area of 8.64 m^2. The blocks and plots were separated by 1.5m and 1m, respectively. The intra and inter spaces were 40cm and 60cm, respectively. As an additional plant population, the vegetables beans, cabbage, and onions were sown in between the tomato rows. When tomato seedlings reached three to four genuine leaves (40 days after seeding), they were transplanted to the main experimental field. In the main field, beans were directly sown in the designated rows. Every suggested management strategies were used. Using a Nap-sack sprayer, tobacco leaf extract and Karate 5%EC were applied eight times weekly and six times every ten days, respectively beginning on day twenty-one (21) after transplanting and ending with the first fruit harvesting (Tadele, 2016).

Data Collection

Six (6) plants were chosen and tagged from the middle four rows of tomatoes in each plot prior to data collection. Every week, three leaves from each plant were evaluated to examine the abundance of insects. Following Tadele's (2016) research, data were gathered on the quantity of insects per leaf, per plant, and the number of infested or damaged leaves weekly for eight (8) times. After two weeks of transplantation, population counts of two spotted spider mites using hand lenses with ten times magnification started. Early in the morning, observations were taken on the abaxial surface of the chosen plant leaves (Fernando *et al.,* 2016). Levels of infestation or damages noted according to Mackenzie *et al*. (1993). The amount of damage or infestation level was determined by counting the number of areas that were yellowing, crumbling, and bronzing caused by mites. The areas were then scored on a scale of 1 to 5, with 0 representing no damage, 2 representing little damage, 3 representing (25–50%), 4 representing serious damage (50–75%), and 5 representing extremely severe damage (>75%). The percentage of decrease of insect pests was computed as follows in order to assess the effectiveness of the tested materials: %PR =

$\frac{C-T}{C} X 100$ Where c, control; t, treatment; and %PR, percent population reduction (Henderson & Tilton, 1955)

Data analysis

All the collected data were analyzed using SAS software version 9.4 (SAS, 2013) and analysis of Variance (ANOVA) on the obtained parameters was carried out in accordance with the procedures outlined by Gomez and Gomez (1984). Tukey's Studentized range test was used to test treatment mean differences at 5% significance level. The percent population reduction (%PR) was calculated following Henderson & Tilton (1955).

RESEARCH RESULT AND DISCUSSIONS

Seasonal Abundance of Two-Spotted Spider Mite, Tetranychus urticae

The result revealed that botanical extract and intercrops showed highly significant difference on the populations ($F_{a, b}$ = 91.22, 3.31; *df* = 15; $p < 0.0001$) and infestation ($F_{a, b}$ = 73.06, 3.31; *df* =15; $p < 0.0001$) of TSSM. The tomato sole had the highest mite population and infestation (94.10 and 2.88, respectively) (table 1) (figure 1), followed by the common bean (80.06 and 2.22, respectively). The tomato treated with karate had the lowest population number and infestation (14.65 and 0.79) followed by tobacco crude leaf extracts (16.5 and 0.92). Tomato onion intercropping significantly reduced mite population and infestation (36.53 and 1.74) on tomato. Furthermore, all treatments dramatically reduced the mite population compare by control (table 1). Tobacco leaf extracts showed the maximum population reduction in comparable to karate 5%, with onion intercrops showing effective population reduction from intercrops. The intercrops of tomato common beans showed the lowest reduction at 14.92% (figure 2). Accordingly, Christine and Hoeschle (2011) reported the application of soap, ash, and tobacco extract greatly decreased the number of TSSM on tomatoes, which is consistent with this finding. Tests on the acaricidal and sub-lethal effects of soft soap, garlic bulbs, and tobacco leaves were done by Rana *et al*. (2018) who found that applying tobacco at the tested dose considerably decreased T. urticae fecundity. The same author also discovered that extracts from garlic bulbs and tobacco leaves may be utilized to suppress T. urticae eggs. Mulatu and Gebissa (2018) conducted similar research on the fatal effects of botanical extracts on potato TSSM under laboratory circumstances. They found that Amitraz 20 EC and A. indica seed oil were equally effective in managing TSSM. This result suggests that tobacco leaf extracts can be used as an alternate control strategy to Karate 5% EC, which is persistently producing ecological problems on people and other beneficial organisms. Tobacco leaf extracts have demonstrated a satisfactory acaricidal action in a population reduction and infestation of TSSM in this study.

Table.1: Effect of Intercropping and tobacco leaf extract on population abundance and infestation of two spotted spider mites.

Treatments	No mites/plant	Infestation
Control (Tomato sole)	94.10[a]	2.88[a]
Tomato + cabbage	77.27[b]	2.19[b]
Tomato + common bean	80.06[b]	2.22[b]
Tomato + onion	36.53[c]	1.74[c]
Tomato + tobacco extract	16.50[d]	0. 92[d]
Tomato + karate	14.65[d]	0. 79[d]
LSD(0.05)	8.74	0.23
CV (%)	10.90	8.43

Means assigned with the same letter are not significance difference at 5% level of significance.

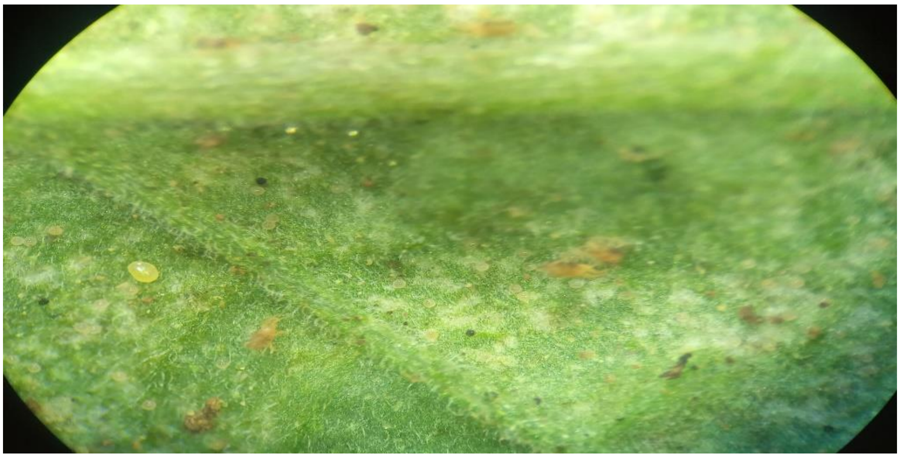
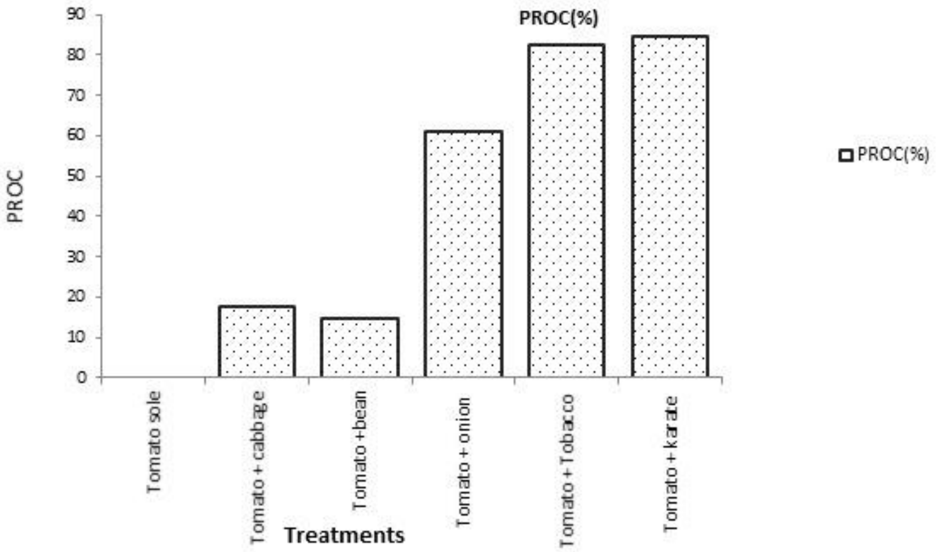


Figure 1: Picture of Two-Spotted Spider Mites assessed during January to May in 2021



Where, PROC= Population reduction over control

Figure 2: Population reduction of TSSM assessed during January to May in 2021

In terms of intercropping, aromatic plants have the ability to keep pests away from their host due to the volatile compounds that are naturally present in them and give off a strong scent. This outcome was consistent with the research conducted by Abo-shanab *et al.* (2019), who discovered that the most successful treatment for reducing two-spotted spider mites on tomatoes was to intercrop tomatoes with coriander. This method reduced the pest's population by 91.2%. In a similar vein, Hata *et al.* (2016) found that growing garlic as an intercrop reduced two-spotted spider mites (TSSM) in field of strawberries by up to 52%. In a laboratory and greenhouse setting, Hata *et al.* (2020) investigated the effects of aromatic plants on T. urticae on strawberry leaves. They found that the mite's biological parameters were impacted by the aromatic plants. For example, Chinese chives decreased the number of eggs by 34.79%, whereas garlic decreased the number of eggs by 25.65%. Furthermore, intercropping onions with tomatoes decreased the TSSM infestation on tomatoes, according to Christine and Hoeschle (2011). Generally, Aromatic plants in intercropping are reported as reducing pest populations or injuries to plants (Hata *et al.*, 2018). Besides a reduction in TSSM populations and infestations, an increase of beneficial insects because of attraction effects of the aromatic crops was the main importance in the study (Karuppaiah *et al.*, 2018).

Impact of tobacco extract and intercropping on tomato yields

The marketable yield (Fa, b = 38.07, 3.31, df = 15, $p < 0.0001$), non-marketable yield (Fa, b = 21.75, 3.31; df = 15; p = <.0001) and total yield (Fa, b = 29.46, 3.31; df = 15; p = <.0001) were also significant among the treatments (Table 2). Maximum marketable yield (39.37 tha^{-1}) and total yield (50.73 tha^{-1}) were obtained from the tomato-onion intercrops followed by tobacco leaf extracts (marketable yield = (33.65 tha^{-1} and total yield = 43.65 tha^{-1}) in comparison to sole tomato (19.58 tha^{-1} and 38.96 tha^{-1}) (Table 2). In parallel to this result, Rahman *et al*. (2014) had obtained the highest yield from neem and tobacco leaf extract sprayed plots. The present result also agrees with Nehal *et al*. (2015) who reported that garlic extract and eucalyptus oil increased the total yield of tomatoes compared to the control. Muhammad *et al*. (2018) found that neem and turmeric extracts showed a positive impact on the growth and yield of Okra crops. The higher gross and yield by these extracts can be attributed to the low incidence of pest attacks as revealed by Hossain *et al*. (2013). Similarly, Son *et al*. (2018) evaluated the intercropping of tomatoes with aromatic plants yielded twice the tomato yield in aromatic intercrops than tomato without association. The secret of the increment of the yield of the crop associated with aromatic crops may be the emitting of chemicals that have a potential direct effect on the pests, such as repellent, toxic, masking host plant odors, and masking visual orientation, or indirect effect, such as stimulating natural enemies and inducing resistance in host plant as stated by Zhou *et al*. (2013). According to this study, common bean intercrops also increased the yield of tomatoes compared to the sole cropping following the fact that Legume tomato intercropping is the compatible cropping practice in which the legumes fix nitrogen found in the air thereby increasing soil fertility and reducing moisture stress upon its broad leaves or canopy. Similar to this result, Alemayew *et al*. (2016) found maize legume intercropping was productive and gave 18% of yield increase over sole crops of maize. In the same studies, Khonde *et al*. (2018) reported that maize intercropped with all legumes produced a higher yield advantage compared to sole maize. The yield of tomato in head cabbage intercrops may be reduced due to head cabbage competition for more space and its canopy and competing for abiotic resources such as sunlight, nutrients, and water as stated by Carvalho *et al*. (2012) who studied tomato peppermint and fennel intercropping. Contradicting to this result, cabbage tomato intercropping was compatible in yield and pest infestation reduction as reported by Asare-Bediako *et al*. (2010) in which tomatoes can substitute chlorpyrifos spray for Diamondback Moth (*Plutella xylostella*), causing better production results when compared to cabbage monocrop. Even though the economic aspects head cabbage brings to tomatoes are not supported by any scholars, head cabbage productivity increased where ever tomato intercropped (Leonardo *et al*., 2020). However, all intercrops allowed for an increment in the use of land, increasing the combined yield obtained per unit area. Besides of a reduction in TSSM populations, the possibility that the aromatic plants increase the grower's production/ income without increasing the production area (Zito *et al*., 2019).

Table 2: impact of intercropping and tobacco leaf extract on tomato yields in 2021 (January to May)

Treatments	MYtha^{-1}	NMYtha^{-1}	TYtha^{-1}	%Yield increase
control	19.58d	19.38a	38.96c	
Tomato + cabbage	17.19d	12.92c	30.10d	-12.21
Tomato + bean	25.52c	17.19b	42.71b	30.34
Tomato + onion	39.37a	11.35cd	50.73a	103.15
Tomato + Tobacco	33.65b	10.00d	43.65b	71.86
Tomato + karate	33.85b	10.01d	43.96b	72.88

LSD(0.05)	3.46	2.05	3.16
CV (%)	8.14	10.09	5.02

The means with the same letters assigned have no significance difference at 5% level of significance,

NMYtha^{-1}= Non marketable yield in tone per hectare
MYtha^{-1}= Marketable yield in tone per hectare
TYtha^{-1} = Total yield in tone per hectare

Financial Advantages of Intercrops and Tobacco Leaf Extract

For every treatment, the economics of production were computed. The total revenue from intercrops and tomatoes is known as the net gross. The entire cost of the study comprised the labor and fertilizer costs that were expended for each treatment. Additionally, the cost of seed varied among the treatments, with the exception of the major crop in tobacco extracts and karate. Based on local market pricing at Bate and Haramaya town, the costs and profits were calculated. Table 3 displayed the net gross generated from each treatment, the costs associated with each treatment, and the benefit-cost ratios. There were variations in net returns amongst the treatments (Table 3). The tomato plots intercropped with onion crops had the highest net return and B: C ratio (12520.97 and 7.191, respectively), making it the most profitable. Tobacco extracts (7926.91 and 6.340) and tomato plots treated with karate 5% (7981.09 and 6.381) were the next most lucrative. Tomato cultivation as a solitary crop without treatment was the least profitable since it produced the lowest net returns and B: C ratio (4290.4 and 4.088, respectively). The study by Son *et al*. (2018), which found that the tomato-onion association recorded highest net advantages compared to solitary tomatoes and the acquired benefit was five times that of tomato without association, served as an example of the current result. According to Sharma *et al*. (2018), when coriander was interplanted with okra, the benefit-cost ratio increased to 3.00. According to Sarker *et al*. (2007), mustard intercropped with onion and garlic produced the best cost-benefit ratios when compared to sole crops and other spice intercrops. Tobacco leaf extracts seemed to be a promising botanical extract to reduce TSSM on tomato as an alternative to karate 5%EC at the study area. Consequently, tomato onion intercropping is the first option in boosting tomato production to produce a tomato with less infested fruits and get high net benefits.

Table 3: Yield, economic benefits and cost analysis of treatments in 2021 cropping Season

Treatments	**yields (kg/ha)**	**NG ($)**	**TC ($)**	**NB($)**	**B : C ratio**
Sole	19580.00	5340.00	1049.6	4290.4	4.088
Cabbage	73486.29	12876.73	2016.8	10859.93	5.385
Cbean	27603.33	7717.57	1278.0	6439.57	5.039
Onion	47124.63	14262.1	1741.13	12520.97	7.191
Tobacco	33650.00	9177.27	1250.36	7926.91	6.340
Karate	33850.00	9231.82	1250.73	7981.09	6.381

NG ($), net gross in American dollar	B: C ratio, Benefit to cost ratio
TC ($), Total cost in American dollar	NB (ETB), Net benefits in American dollar
Sole, Tomato sole	Onion, Tomato + onion
Cabbage, Tomato + cabbage	Tobacco, Tomato + tobacco extract
Cbean, Tomato + common bean	Karate, Tomato + karate 5%EC

CONCLUSIONS AND RECOMMENDATIONS

In the world, tomatoes are the most widely consumed nutritious vegetable. Tomatoes are the horticultural crop most severely harmed by arthropod pests in the study area. Red spider mites are the main sucking pests that consume tomatoes. This study found that tomato-onion intercropping and tobacco leaves extract reduced the population of twospotted spider mites (TSSM) and reduced tomato infestation. Consequently, when compared to other treatments and the untreated control, the yields of the tomato-onion intercropping and tobacco leaf extract treatment were maximized. Intercropping tomatoes and onions also yielded the maximum production advantage and the largest net benefit. In general, crop diversification and botanical extract had a negative impact on the population expansion of two spotted spider mites in the study area. Among the environmentally friendly management alternatives to using karate 5% EC for the control of twospotted spider mites in the study area and the same agro ecologies are tobacco leaf extract and tomato-onion intercropping. Tobacco leaf extract and tomato onion intercropping, thus, are the two most promising management approaches for the integrated control of two-spotted spider mites on tomatoes.

ADVANCED RESEARCH

Every research certainly has limitations. Limitations in the sense of research limitations that affect the researcher's ability to explore the data being studied, limitations of available data, or external factors of research such as limited time and resources. So further research is needed for the perfection of this research.

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