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Evaluation the Efficacy of Botanical Insecticides in Controlling Tomato Boll Worm (*Helicoverpa zea)* and Leaf Minor (*Tuta absoluta*) in WesternTigray, Ethiopia

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Authors' contributions

This work was carried out in collaboration among all authors. Authors YB, Assefa Abadi and AT design the study, perform the statistical analysis, and wrote the protocol first draft of the manuscript. Authors WN, Alem Atsbeha and MK manage analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aim of the study was to evaluate botanical insecticides to control tomato boll worm and leaf minor in western Tigray, Ethiopia. Field experiment was conducted during 2018/2020 in main crop growing season at Humera. A total of five treatments (Green miracle, Neembicidene, Melatonin, Gm+

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Neembicidene and control no sprayed) were used in the field experiment. The experiment was laid out randomized complete block design (RCBD) with three replications. The mean yield had a significant difference at (p<0.001) among the botanical insecticides. The highest mean yield was obtained from Neembicidene (348.8) followed by green miracle (195.8) Malathion (183), Malathion+GM (162.8), and control (84.2) qtha-1 respectively. The highest severity recorded from control was 85.41% for leaf severity and 71.3% for fruit severity. However, lowest recorded severity 18.73% for leaves and 4.55% for fruits were calculated from Neembicidene. The highest percent population reduction after chemical spray was recorded from Neembicidene (85.07%). Therefore, Neembicidene botanical insecticide recommended and promoted to verification trial to control tomato bollworm and leaf minor.

Keywords: Botanical- insecticide; severity; yield and fruit damage.

1. INTRODUCTION

Vegetables are important sources of vitamin, minerals and plant proteins in human diets throughout the world [1] and are rapidly becoming an important source of income for rural population [2]. Recently, studies have been intensified on the use of naturally occurring pesticides for pest control. Many investigators isolated, identified and screened chemical compounds from leaves and seeds of many botanical families for insect deterrence and growth inhibition. Some of the anti-pest plants documented included Neem, Chrysanthemum, Annona, Mahogoni, Albizziaetc [3]. According to Muhammed [4], botanicals are one of the groups of safe insecticides which have a broad spectrum of anti-pest activity, relatively to specific mode of action, low mammalian toxicity [5-7].

Botanical insecticides are one option in insect pest management and crop protection. The advantages of botanical insecticides lie in their low of persistence and bioaccumulation in the environment, selectivity towards beneficial insects and low toxicity to humans [8]. Pesticides**:** chemical substance designed to kill or retard the growth of pests that damage or interfere with the growth of crops, shrubs, trees, timber and other vegetation desired by humans. Practically all chemical pesticides, however, are poisons and pose long-term danger to the environment and humans through their persistence in nature or body tissue. Most of the pesticides are non-specific and may kill life forms that are harmless or useful [9]. Natural pesticide products are available as an alternative to synthetic chemical formulations but they are not necessarily less toxic to humans. Some of the deadliest, fast acting toxins and potent carcinogens occur naturally [10,11].

Western Tigray is one of the potential for different fruit trees and vegetables crops. This potential is due to annually flowing rivers for irrigation purposes; like Tekeze, Ruwasa, Bahreselam, Mokozo, kaza, Kalema and Zarema. Jar jeer, Molokai, Okra and Wayka are one of the medicinal and nutritional vegetable plants in every dish in western Tigray. However, insects and diseases are the major production constraints in the area. Application of the synthetic insecticides may be hazardous and toxic for environments, honey bee production, plants and human because of their toxic nature and residual effects. Therefore, testing and evaluation of different botanical insecticides are very important because they are locally available, safe for human and environment. The study was conducted to use and promote botanical insecticides in our area for organic tomato production with the aim of to evaluate and asses the efficacy of botanical insecticides to control tomato boll worm and leaf minor.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Field experiment was conducted during 2018/2020 in main crop growing season at Humera. Experimental site is characterized by hot to warm temperature and high evaporation condition (hot to warm semiarid lowland agro ecology. They differ mainly in their altitude, temperature and amount of annual rainfall. The site is located at 14^{o} 00’ 85" North latitude and 36^{o} 34’ 52" East longitude. The elevation of this station is about 600 meters above sea level. The mean annual temperature of the area is 29 ^{0}c and the rainy months extend from late June to the middle of September. The remaining 8-9 months are dry and hot. The dominant soil type is chromic black vertisol, deep clay with low organic matter content.

2.2 Plant Material and Field Management

A total of five treatments (Green miracle, Neembicidene, Malathion, Gm+Neembicidene and control no sprayed) were used in the field experiment (Table 1). The experiment was laid out in randomized complete block design (RCBD) with three replications. MelkassIsa tomato variety was used during the study. Seedlings were planted in a plot area of 5m x 5m with 2m between plots and 3 m between blocks keeping inter and intra row spacing of 100 cm and 30 cm, respectively. The manufacturer recommended rate of each chemical was diluted in 200 litter of water/hectare and applied at 30, 45 and 60 days after transplanting. Each experimental plot was received the same rate of inorganic fertilizer. The other management practices were applied equally and properly as per the recommendations.

2.3 Insect Data

The percentage reduction (increase or decrease) larvae population was calculated by using the following formula [12].

Percent fruit damage = (Number of damage fruit/ Total Number of fruits) x 100

2.4 Data Collection

Yield components including plant height, number of flowes per cluster, number of fruit cluster, number of fruit per plant, incidence and severity of insect were measured from five randomly selected plants in each plot. However, Fruit yield was measured from each plots separately using a sensitive balance.

2.5 Data Analysis

Analysis of variance were done for yield, yield components and incidence and severity of insect data from the field experiment, to know the main effects and their interactions using GenStat version 18 software. Least Significant Difference (LSD) values were used to separate differences among treatment means at 5% probability level. ANOVA was performed using General Linear Model (GLM) GenStat version18.

3. RESULTS AND DISCUSSION

3.1 Yield and Yield Parameters

3.1.1 Fruit yield

The mean yield had a significant difference among treatments at ($p \leq 0.001$) among the botanical insecticides described in (Table 1). This statement implies that while individual yields from the different treatment may have fluctuated from year to year, the average yield over the entire three-year period reminded relatively consistent at 194.9qtha-1. This result derived from analyzing data collected from studies where multiple treatment where applied and their respective yields were measured and recorded annually for a specified period. The highest mean yield was obtained from Neembicidene (348.8) followed by green miracle (195.8) Malathion (183), Malathion+GM (162.8), and control (84.2) $qtha^{-1}$ respectively. Neembicidene had recorded better yield advantage over control and standard check (Malathion) indicated in (Table 2). The result was agreed with Shah et al. [13] a total yield and lower toxicity to the environment as well as human being neem seed extract is the most promising insecticide for the effective management of tomato fruit worm larvae. In addition, [14] reported that all the treatments yield of tomato was significantly different from untreated plots.

3.2 Yield Parameters

In the study conducted on the effect of different botanical insecticide on the date of maturity (fruit harvesting), it was found that there was no significant variation at a p-value of less than 0.05 among the botanical insecticide concerning the date of maturity (harvesting). This implies that the different insecticide chemicals used did not have a statistically significant impact on the date of maturity or fruit harvesting time. In addition, plant height also was not significant variation among the botanical insecticide chemicals. However; number of fruit per cluster, number of fruit cluster per plant and number of fruit per plant were significant difference at $p<0.01$ value among the treatments. Maximum amount of fruit per cluster, fruit cluster per plant and total fruit per plant were recorded 7.11, 31.33, 103.3from the Neembicidene, respectively. While, minimum amount of fruit per cluster, fruit cluster per plant and total fruit per plant were recorded 5.72, 24.33 and 84.2 from control (unsprayed), respectively (Table 2). These results are in line with Sujayanand et al. [15] and [14], while the highest percent infestation was recorded in untreated plot. Therefore, highest percent tomato yield loss was observed in untreated plot.

3.3 Incidence and Severity of Insect

3.3.1 Incidence and severity (%)

It is evident that the control group had the highest percentage mean insect incidence at 44.67%. This suggests that the control treatment was less effective in reducing insect incidence compared to the other treatments mentioned. Malathion, a common insecticide, showed a mean insect incidence of 95.2%, which was lower than that of the control (100%), but still relatively high compared to some other treatments. Green miracle and the combination of Malathion with Green miracle exhibited percentages of 89.1% and 87.4%, respectively, indicating their effectiveness in reducing insect incidence compared to both the control and Malathion alone. Neembicidene, with a mean insect incidence of 62.4%, demonstrated the lowest percentage among all treatments listed. This suggests that Neembicidene was relatively more effective in controlling insect populations compared to the other treatments mentioned.

It is mentioned that there was a significant difference in the severity of fruit and leaf damage among different botanical insecticide. This indicates that the effectiveness of various botanical insecticides in controlling insect damage to fruits and leaves varied significantly. The highest severity recorded from control was 85.41% for leaf severity and 71.3% for fruit severity. Whereas, Neembicidene is a substance that has been studied for its impact on plants, particularly on leaves and fruits; the severity of its effects was measured, with the lowest recorded severity percentages being 18.73% for leaves and 4.55% for fruits (Table 3). The result supported by Shah et al. [13] who reported that fruit damage was ranged from Neem seed extract (11.3%) to control (19.65%). The result confirms with Mineva et al. [16] the best effectiveness against the larvae of the cotton bollworm (*Helicoverpa armigera* Hübner, 1808) is the variant Krisant EC 750 ml/ha + Neem Azal T/S 0.3% - 82.86%, followed by Neem Azal T/S 0.3% -78.57% and Krisant EC 750 ml/ha - 62.73%. in addition, the finding lined with Zohair et al. [14] the percent fruit damage indicates that infestation was significantly affected the yield on different treated with (Tobacco extract, Volium flexci sc, Coragen, Chilli pepper, Chinaberry leaves extract and Control were 16.860, 11.547,7.783, 13.093, 17.710 and 33.217 respectively which were significantly different from one another.

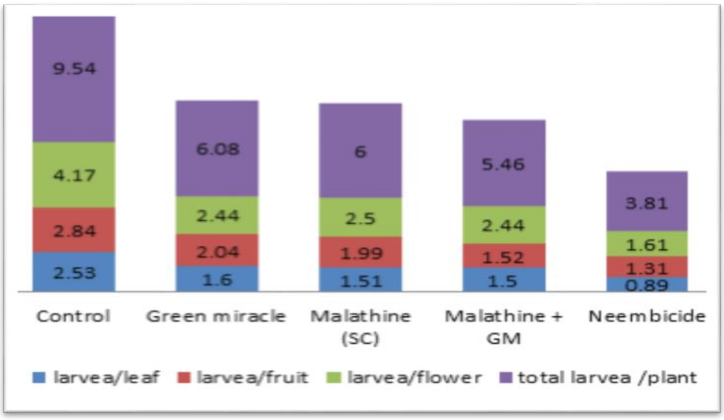

Fig. 1. Larvae population per different plant parts

Table 1. Mean yield of tomato fruit across three years (2018-2020)

Treatments	Fruit yield			Combined yield
	2018	2019	2020	
Control	86.7	81.7	84.3	84.2a
Green miracle	134.8	224.3	190	195.8b
Malathion	134.3	193.3	160.7	183.1b
Malathion+GM	140.7	235	211.7	162.8b
Neembicidene	231.3	463.3	351.7	348.8c
Mean				194.8
Lsd (5%)				62.43
CV (%)				19

Table 2. Yield components of tomato combine in once across three years

Treatments	DM	NF/C	NFC/P	NF/P	PH
Neembicidene	113.1	7.122a	31.33a	103.3a	57.8
Malathion	112.7	6.267b	24.2c	67d	58.9
Green miracle	112.4	5.733c	26.53b	76c	58.8
Malathion+GM	112.4	5.722c	24.33c	84.2b	51.8
Control	112.2	3.867d	12.23d	36.3e	56.6
Grand mean	112.58	5.742	23.73	73.37	57.41
Lsd (5%)	3.074	0.495	1.89	4.652	6.035
CV (%)	2.9	9	8.40	6.6	11

Note: GM= Green miracle*, DM=days to maturity, NF/C= number of flowers /cluster, NFC/P=number of fruit clusters/plant, NF/P= number of fruits /plant, PH=plant height*

Table 3. Combined mean yield, incidence and severity across three years

Treatments	Incidence%	%Leaf severity	%Fruit severity
Control	100	85.41	71.3
Green miracle	89.1	44.59	8.28
Malathion (SC)	95.2	46.26	15.19
Malathion+ GM	87.4	43.79	12.9
Neembicidene	62.4	18.73	4.55
Mean	86.82	47.8	22.45
LSD (5%)	12.29	19.5	20.7
CV (%)	24.70	8.9	4.4

Note: GM=Green miracle, SC=standard check

Table 4. Efficacy of botanical insecticides on the control of tomato boll worm and leaf mine

Treatments	Efficacy Botanical
Control	0d
Green miracle	61.32c
Malathion (SC)	65.35bc
Malathion+ GM	68.84b
Neembicidene	85.07a
Mean	56.1
LSD (5%)	6.81
CV (%)	12.7

Note: GM=Green miracle, SC=standard check

3.4 Incidence of Tomato Leaf Miner

The larvae population after spray was observed to vary significantly between the control unsprayed and those treated with botanical insecticides. The highest larvae population was recorded in the control group, with counts of 2.53 on leaves, 2.84 on fruits, 4.17 on flowers, and 9.54 in total per plant. On the other hand, the lowest larvae population was found in the Neembicidene-treated plants, with counts of 0.81 on leaves, 4.31 on fruits, 1.61 on flowers, and 3.81 in total per plant. This result indicates that Neembicidene appears to be effective in controlling larvae infestation based on the significant reduction in larvae population observed after its application. The lower counts of larvae on leaves, fruits, flowers, and overall per plant indicate that Neembicidene could be a promising solution for managing larvae infestations in agricultural settings. The curent result was supported by Jawad et al. [17] who stated that minimum number of larvae recorded from neem extract. Whereas maximum amount of larvae counted from control (untreated). Inaddition [16] reported that neem (botanical) product showed agood biological activity against to insect pest management of tomato production.

3.5 Severity (%) (Leaf and Fruit Damage)

3.5.1 Botanical efficacy

The study on larvae count was conducted two times, once before and after the chemical spray application on the different plant parts, including the leaf, fruit, and flower. The highest percent population reduction/efficacy/ after chemical spray was recorded from Neembicidene (85.07%) followed by green miracle (68.84%), Malathion+GM (65.35%), Malathion (61.32%), and Control (0%) respectively indicated in Table 4. The result lined with Mineva et al. [16] who reported that the organic product Neem Azal T/S 0.3% has not only good insecticidal action, but is also a good acaricide. The botanical products Krisant EC 750 ml/ha, Neem Azal T/S 0.3% and the combination Krisant EC 750 ml/ha + Neem Azal T/S 0.3% have very good effectiveness against tomato insect pest. Our results confirm the data established by Dively et al. [18] for a wide range of action against various pests of products from the botanical insecticides group.

4. CONCLUSION

There was significance difference among treatments across three years in yield, severity, incidence, flower damage, leaf damage, fruit damage/plant, number of larvae/leafs, number of larvae/plant,number of larvae/fruit. Two botanical (Neembicidene and Green miracle) and one synthetic (Malathion) as standard check) insecticides including control were evaluated for three years at Humera for their efficacy to control tomato bollworm and leaf minor. The highest insect incidence (44%) and (leaf severity 85.41% and fruit severity71.3%) was recorded from control while the lowest incidence (19.89%) and severity (leaf severity18.73 and fruit severity 4.55%) recorded from Neembicidene. The highest mean yield (348.4qt/ha) was recorded from Neembicidene and the lowest (84.2qt/ha) obtained from control. Botanical insecticides will be important for organic production in the area. Neembicidene had recorded 25% and 19% yield advantage over Malathion (SC) and control respectively. Therefore, Neembicidene botanical insecticide recommended and promoted to verification trial to control tomato bollworm and leaf minor.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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