**Evaluation of the efficacy of botanical insecticides in ~~controlling~~ managing tomatoball worm (Helicoverpa zea) author? and leaf ~~minor~~ miner(Lycopersicon lycopersium) authorin ~~western~~Western Tigray, Ethiopia.**


Abstract

*Aim of the study was to evaluate botanical insecticides to control tomato ~~ball~~ bollworm and leaf ~~minor~~ minerin ~~western~~ Western Tigray, Ethiopia. Field experiments was conducted during ~~2018/2020~~ 2018-2020 in the main crop growing season at Humera. A total of five treatments (Green miracle, Neembicidene, ~~Melatonin~~ Malathion,, Gm+ Neembicidene and untreated control ~~no sprayed~~) were used in the field experiment. The experiment was laid out in randomized complete block design (RCBD) with three replications.The mean yield had a significant difference among ~~treatments~~the treatments of botanical insecticides 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 untreated control (84.2) qtha$^{-1}$ respectively. The highest severity was recorded from the untreated control ~~was~~ with 85.41% ~~for~~ of leaf severity and 71.3% ~~for~~ of fruit severity. However, the lowest ~~recorded~~ severity of 18.73% for leaves and 4.55% for fruits wereregistered ~~calculated~~ from Neembicidene. The highest percent population reduction after chemical spray was recorded from Neembicidene (85.07%). Therefore, the botanical insecticide, Neembicidene ~~botanical insecticide~~is recommended ~~and promoted to verification trial to control~~ in the management of tomato bollworm and leaf ~~minor.~~miner*



***Key words:*** *Botanical insecticides, severity, yield and fruit damage*


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**Comment [G2]:** Is it a ball worm or boll worm kindly verify

**Comment [G3]:** Please add correct scientific name of leaf minor

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Introduction

Vegetables are important sources of ~~vitamin~~vitamins, 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~~ management. 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, Albizzia, etc. [3]. ~~According to [4], botanicals~~ Botanicalsare one of the groups of safe insecticides which have a broad spectrum of anti-pest activity, ~~relatively to~~ specific mode of action, and low mammalian toxicity[4].

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 [5].Pesticides**:** chemical ~~substance~~ substancesdesigned 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 a 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 [6].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~~fast-acting toxins and potent carcinogens occur naturally [7],[ 8].

Western Tigray is suitable for growing ~~one of the potential for~~ different fruit trees and vegetables ~~crops~~. This potential is due to its annually flowing rivers for irrigation purposes; like Tekeze, Ruwasa, Bahreselam, Mokozo, kaza, Kalema and Zarema. Jar jeer, Molokai, Okra and Wayka are ~~one~~ someof the medicinal and nutritional vegetable plants used in every dishin ~~western~~ WesternTigray. However, insects and diseases are the major production constraints in the area. Application of the synthetic insecticides may be hazardous and toxic for environment~~s~~, honey bee production, plants and humans 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 humans and environment.~~The~~ Thisstudy 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~~ managetomato boll worm and leaf ~~minor~~miner,

**Material and Methods**

**Description of the study area**

~~Field~~ A fieldexperiment was conducted during ~~2018/2020~~2018-2020 in main crop growing season at Humera(14° 00' 85" North latitude and 36° 34' 52" East longitude). ~~Experimental~~ The experimentalsite is characterized by hot to warm ~~temperature~~ temperaturesand high evaporation conditions (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° 00' 85" North latitude and 36° 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~~june to the middle of ~~September~~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.

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**Plant material and field Management**

A total of five treatments (Green miracle, Neembicidene, Malathion, Gm+Neembicidene and untreated 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. Melkasslsa 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~~ manufacturer'srecommended rate of each ~~chemical~~ synthetic insecticideswas diluted in 200 ~~litter~~ litersof 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.

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**Insect Data**

The percentage reduction (increase or decrease) larvae population was calculated by using the following formula [9].

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

**Data collection**

Yield components including plant height, number of ~~fruit~~ fruitsper cluster, number of fruit ~~cluster~~clusters, number of ~~fruit~~ fruitsper plant ~~yield~~and incidence and severity of ~~insect~~insects, plant height, number of ~~fruit~~ fruits per cluster, number of fruit ~~cluster~~clusters, and number of ~~fruit~~ fruits per plant were measured from five randomly selected plants in each plot. However, Fruit yieldwas measured fromeach~~plots~~ plotseparately using a sensitive balance.

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Data analysis

Analysis of variance ~~were~~ wasdone 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 a 5% probability level. ANOVA was performed usingthe General Linear Model (GLM) GenStat version18.

**Result and Discussion**

**Yield and yield parameters**

**Fruit Yield**

The mean yield had a significant difference among treatments of botanical insecticides at ($p \leq 0.001$) ~~among the botanical insecticides described in~~ (Table1). This statement implies that ~~while~~ individual yield~~s~~ from the different treatments may ~~have~~ fluctuate~~d~~ from year to year., ~~the~~ Theaverage yield over the entire three-year period ~~reminded~~ remained 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 (q/ha or t/ha) was obtained from Neembicidene (348.8) followed by green miracle (195.8) Malathion (183), Malathion+GM (162.8), and untreated control (84.2) ~~qtha~~$^{-1}$ respectively.

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Neembicidene had recorded better yield advantage over untreated control and standard check (Malathion) as indicated in (Table2). The result was agreed with [10]who reported thatneem seed extract is the most promising insecticide for the effective management of tomato fruit worm larvaea 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,[11]reported that the yield of tomatoes inall the treatments yield of tomato was significantly different from untreated control plots.

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

| Treatments | Fruit yield | | | |
|---|---|---|---|---|
| | 2018 | 2019 | 2020 | Combined yield |
| 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 |

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Yield Parameters

In the study conducted on the effect of different botanical insecticides 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 insecticidesconcerning the date of maturity (harvesting). This implies that the different insecticideschemicals used did not have a statistically significant impact on the date of maturity or fruit harvesting time.In addition, plant height also didn't exhibit

~~wasn.t~~ any significant variation among the botanical insecticide~~s chemicals~~. However; the number of ~~fruit~~ fruitsper cluster, number of fruit ~~cluster~~ clustersper plant and number of ~~fruit~~ fruitsper plant ~~were~~ show significant difference at p<0.01 ~~value~~ among the treatments. ~~Maximum~~ The maximumamount of ~~fruit~~ fruitsper cluster (7.122), fruit ~~cluster~~ clustersper plant (31.33) and total ~~fruit~~ fruits per plant (103.3) were recorded ~~7.11, 31.33, 103.3~~from the Neembicidene~~, respectively~~. While, the minimum amount of ~~fruit~~ fruitsper cluster (3.867), fruit ~~cluster~~ clustersper plant (12.23) and total ~~fruit~~ fruitsper plant (36.3) were recorded ~~5.72, 24.33 and 84.2~~ from untreated control ~~(unsprayed), respectively~~ (Table 2). These results are in line with [12] and [11], ~~while~~ wherethe highest percent infestation was recorded in the untreated plot. Therefore, the highest percent tomato yield loss was observed in the untreated plot.

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*

Incidence and severity of insect

**Incidence and severity (%)**

It is evident that the untreated control ~~group~~ had the highest percentage mean insect incidence at 44.67%. This suggests that the untreated 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

**Comment [G13]:** 100% is given in the table. Kindly check all the values in the tables and text are similar still relatively high compared to ~~some~~ other treatments. Green miracle and the combination of Malathion with Green miracle exhibited ~~percentages o~~f 89.1~~%~~ and 87.4~~%~~ percentages, respectively, indicating their effectiveness in reducing insect incidence compared to ~~both the control~~untreated control and Malathion alone. Neembicidene recorded the lowest~~, 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~~ managinginsect ~~populations~~ populationcompared 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~~insecticides. This indicates that the effectiveness of various botanical insecticides in ~~controlling~~ managinginsect damage to fruits and leaves varied significantly. The highest severity recorded from untreated 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 was supported by shah, et al (10 2013) who reported that fruit damage in ~~was ranged from~~ Neem seed extract was (11.3%) when compared to the ~~to~~untreated control (19.65%). The result confirms with [13] who reported that variant Krisant EC 750 ml/ha + Neem Azal T/S 0.3% - 82.86% showedthe 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~~ In addition, the finding was lined with [11]who found that the percent fruit damage ~~indicates that infestation w~~as significantly affected the yield on different treatment~~ed~~ with (Tobacco extract, Volium flexci sc, Coragen, Chilli pepper, Chinaberry leaves extract and untreated ~~c~~Control)~~were~~ 16.860, 11.547,7.783, 13.093, 17.710 and 33.217 respectively.~~which were significantly different from one another.~~

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 |

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| 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*

**Incidence of tomato leaf miner**

The larvae population after spray was observed to vary significantly between the untreated control ~~unsprayed~~ and those treated with botanical insecticides. The highest larvae population was recorded in the untreated 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~~ 0,89 on leaves, ~~4.31~~ 1.31 on fruits, 1.61 on flowers, and 3.81 in total per plant. This result indicates that Neembicidene appears to be effective in ~~controlling~~ managing thelarvae infestation based on the significant reduction in larvae population~~ observed after its application~~. Overall, ~~The~~ the lower counts of larvae on leaves, fruits, flowers, ~~and overall~~ per plantindicate that Neembicidene could be a promising solution for managing larvae infestations in agricultural settings. The ~~curent~~ currentresult was supported by [14] who stated that the minimum number of larvae was recorded from neem extract. Whereas the maximum amount of larvae was counted from untreated control~~ (untreated)~~. ~~Inaddition~~ In addition[13] reported that neem (botanical) product showed ~~agood~~ a goodbiological activity against to insect pest management ~~of~~ intomato production.



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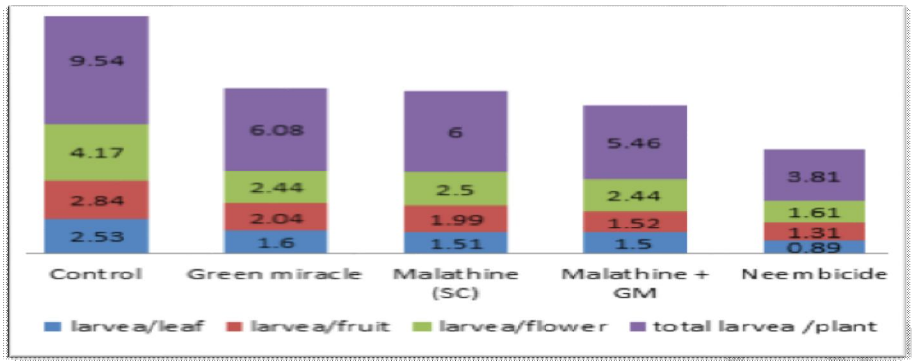


Fig1. *Larvae population per different plant parts*

**Severity (%) (Leaf and fruit damage)**

**Botanical efficacy**

The study on larvae count was conducted two times, once before and after the ~~chemical spray~~ insecticide application on the different plant parts, including the ~~leaf, fruit, and flower~~leaves, fruits and flowers. The highest percent ~~population reduction/~~efficacy/ after ~~chemical~~ insecticide spray was recorded from Neembicidene (85.07%) followed by green miracle (~~68.84~~61.32%), Malathion+GM (~~65.35~~68.84%), Malathion (~~61.32~~65.35%), and untreated Control (0%) respectively as indicated in table 4. The result was lined with [13]who reported that the organic product Neem Azal T/S 0.3% has both insecticidal and acaricidal activities ~~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 of Krisant EC 750 ml/ha + Neem Azal T/S 0.3% have very good effectiveness against tomato insect ~~pest~~pests. Our results confirm the data established by [15] for a wide range of action against various pests of products from the botanical insecticides group.

Table 4. Efficacy of botanical insecticides on the ~~control~~ managementof tomato ~~ball~~ bollworm and leaf miner.

| 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*

**Conclusion**

There was ~~significance~~ significantdifference among treatments across three years in yield, severity, incidence, flower damage, leaf damage, fruit damage/plant, number of larvae/leaf, number of larvae/plant, number of larvae/fruit. Two ~~botanical~~ botanicals(Neembicidene and Green miracle) and one synthetic (Malathion)~~ as standard check)~~ insecticides as standard checkincluding untreated control were evaluated for three years at Humera for their efficacy to ~~control~~ managetomato bollworm and leaf minor. The highest insect incidence (44%),~~and~~ (leaf severity (85.41%) and fruit severity (71.3%) ~~was~~ wererecorded from untreated control while the lowest incidence (19.89%)~~,and severity (~~leaf severity (18.73) and fruit severity (4.55%) were recorded from Neembicidene. The highest mean yield (348.4qt/ha) was recorded from Neembicidene and the lowest (84.2qt/ha) was obtained from untreated 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~~ untreated respectively. Therefore, Neembicidene, a botanical insecticide shall be recommended ~~and promoted to verification trial~~ to ~~control~~ manage tomato bollworm and leaf ~~minor~~ miner.

**Comment [G15]:** q/ha or t/ha

**Comment [G16]:** q/ha or t/ha



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