Far Western Review
A Multidisciplinary, Peer Reviewed Journal
ISSN: 3021-9019
Published by Far Western University
Mahendranagar, Nepal

Economic Assessment of *Tuta Absoluta* Effect on Tomato Production in East Nawalparasi

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Abstract

Tuta absoluta is an invasive and highly destructive pest of tomato plants, originated in South America, specifically Peru. It has the capability to infest and cause extensive damage to large areas of cultivated tomato fields, as well as other plants in the solanaceous family. This study aims to assess the economic analysis of effect of Tuta absoluta on tomato production. The study was carried out in Kawasoti municipality, Madhyabindu municipality, and Hupsekot rural municipality of East Nawalparasi district of Nepal. They were selected purposively as research sites as the problem of Tuta was more prominent in these localities. Ninety households that were involved in tomato cultivation were selected through the simple random sampling method for the survey. The primary data were collected through individual respondents through pre-tested questionnaires, face-to-face questionnaire surveys, key informant interviews, and focus group discussions. Descriptive statistics, scaling & indexing were used to analyze the data. Most of the farmers cultivated tomatoes in open fields (68.8%) only whereas 26.6% of farmers cultivated in plastic tunnels. The insect pest problem was ranked as the first major problem of farmers. The study revealed that all of the farmers had problems with

Tuta in their tomato fields. The minimum yield loss due to Tuta absoluta was 10% and the maximum loss was 80%. The total variable cost (T.V.C) for tomato production in one kathha is NRs. 11210. Average production of tomato per kathha was 550 kg. Gross return and gross margin from tomato cultivation in 1 kathhaare NRs. 16500 with Benefit Cost Ratio (BCR) of 1.64. The average loss of tomatoes per kathha was 72 kg. Only 20 % of the farmers had knowledge regarding the life cycle Tuta absoluta. The most affected stage by Tuta was the flowering stage. This study suggests that effective management of Tuta absoluta can substantially improve tomato production.

Keywords: BC ratio, gross return, pest management, production, varieties

Introduction

Tomatoes, scientifically known as *Lycopersicum esculentum*, are a significant commercial horticultural crop cultivated in Nepal (Kimura & Sinha, 2008). According to MoAD (2022), the total production of tomato was 4,22,703 mt within the area of 2, 2911ha.with productivity of 18.45 mt/ha. Tomato is a flowering plant belonging to the solanaceae family, is widely grown for its edible fruits. It originated in the Andes mountains of South America, initially used as a food source in Mexico, and later spread worldwide following the Spanish colonization of the Americas (Medina Saavedra et al., 2017). Tomato is ranked first in consumption than other vegetables because of it's excellent flavour, and medicinal value (Dessalegne, 2002). In 2021, Nepal exported "Tomatoes, fresh or chilled" worth a total of $15,000 and Imported worth a total of $4.22 million (Annual International Trade Statistics by Country (HS), 2022).

Tuta absoluta is one of the most important and serious pests of tomatoes (Chang et al., 2021). The moth species *Tuta absoluta*, part of the Gelechiidae family, is commonly known by several names, including South American tomato pinworm, tomato leaf miner, tomato pinworm, and South American tomato moth. Tomato leaf miner larvae feed on the leaves, buds, stems, and fruit of tomato plants, initially targeting the leaves. As they advance, they infest other parts of the plant. Fruit rot results from secondary pathogens invading the fruits that have been bored by the insect (Rijal et al., 2018). It is widely recognized as a major pest of tomato crops in Europe, southern Africa, western Asia, and South and Central America (Chideg et al., 2016). The tomato leaf miner *(Tuta absoluta*) was first recorded in Nepal's Kathmandu Valley in May 2016 (Bajracharya et al., 2010).

Tuta absoluta infestation can decrease yield and fruit production by up to 80%, negatively impacting food security and the livelihoods of farmers engaged in tomato farming (Desneux et al., 2010). The impact of *Tuta absoluta* attacks can vary based on the severity of the infestation, the crop's growth stage, and the management practices used (Shiberu & Getu, 2017). In Nepal, the potential annual losses due to this pest could

amount to 550 million (Poudel, 2017). Moreover, many farmers lack knowledge of its life cycle, control measures, and management strategies. This has resulted in significant reductions in tomato yields in their fields. Effective management and control of this pest are crucial to minimize its impact on the environment and human health. Fear of crop loss due to this pest has discouraged tomato farmers in East Nawalparasi, as it has severely affected tomato production and increased reliance on insecticides. However, frequent pesticide use raises concerns about hazardous residues, sustainability, human health risks, and higher production costs (Buragohain, 2021). There is an urgent need for immediate action and practical solutions to control and manage this pest. The study document the tomato leaf miner's effect on tomato production and household economy and also estimate the potential losses by *Tuta absoluta* in the yield of tomatoes and also determine the benefit-cost ratio, gross return and gross margin.

Research Methodology

The sites used for the study were Kawasoti municipality, Madhyabindu municipality, and Hupsekot rural municipality in East Nawalparasi District. These were purposefully selected since these municipalities are areas of the vegetable zone under PMAMP and were more prone to *Tuta* infestation. 30 households from each municipality, were selected making a total of 90 samples from the sampling frame. The study employed a simple random sampling technique to select a sample from the population. Farmers who cultivate tomatoes and implement control measures for *Tuta absoluta* were chosen as the sampling units for this research. The study was carried out in wards no. 4, 9, 12, and 13 of Kawasoti municipality; wards no. 1, 2, 3, and 6 of Madhyabindu municipality; and wards no. 1, 2, 3, and 4 of Hupsekot rural municipality. The interview schedule was pre-tested by administering it to ten households in the study area. After considering the feedback from the pre-testing phase, the final interview schedule was prepared. Subsequently, a field survey was conducted using structured and semi-structured questionnaires. Qualitative data was gathered through focus group discussions, direct observations, and key informant interviews. Secondary information was obtained from relevant sources such as journals, research articles, books, newspapers, reports from organizations like the Vegetable Zone, PIU (Project Implementation Unit), East Nawalparasi, Agriculture Knowledge Center (AKC), NGOs, and INGOs. The data collected from the field was initially coded and entered into a database. Descriptive statistics including mean, standard deviation, percentages, and frequencies were employed to analyze socio-economic and farm characteristics. Data entry and analysis were conducted using computer software packages such as SPSS and Microsoft Excel. The following analysis was performed.

Gross Return

It is the total amount of the revenue after the total quantity of tomato production is

sold.

Gross return = Quantity (kg) *price per unit (NRs.)

Gross Margin

It is the difference between the gross revenue earned and the variable cost incurred.

Gross margin= Gross return-Total variable cost

Benefit-cost Analysis

The gross return of production of tomatoes and the total cost for production are used to analyze the B/C ratio. The formula used for calculating the B/C ratio is

B/C ratio = Gross return (Rs.)/Total cost (Rs.)

Where Gross return was calculated from the income of tomato products (NRs.)

Index of Tomato Production Problems

The scaling technique provides the direction and attitude of the respondents towards propositions. Farmer's perception of the production problems can be presented by a five-point scale comprising most serious, serious, moderate, a little bit, and the least serious. The scale value of 1, 0.8, 0.6, 0.4, and 0.2 was used for the most serious, serious, moderate, a little bit, and the least serious problem, respectively.

Mathematically, $I_{imp} = \Sigma (S_i f_i/N)$

Where,

I_{imp} = index of importance, $\sum$ = summation, S_i = I^{th} scale value, N = total number of respondents

F_i = frequency of i^{th} importance given by the respondents

Results and Discussion

Socio-demographic Characteristics of the Respondents in the Study Area

The results of the study showed that 78% of the respondents were male and 22 % of the respondents were female. Various ethnic groups were found in the study area, the majority of the respondents were found to be Janjati (45.6%) followed by Brahmins (34.4%), Chhetri (10%), and Dalit (10%). The result showed that the minimum age of farmers involved in tomato cultivation was 26 years and the maximum age was 67 years, with a mean age of 53.02. The study revealed that the majority of the respondents in the study area were between the ages of group 32-52 years (64%) followed by >54 years (24%) and <32 years (10%). The occupation pattern of the study area showed that 88% of the respondents were employed in agriculture, 7% in service, and 5% in business. The study revealed that 47 percent of the respondents in the study area had a primary level of education followed by respondents having a secondary level of education i.e. 31 percent. Similarly, 4 percent had higher education and 18 percent of the respondents were

illiterate.

Table 1

Socio-demographic characteristics of the respondents in the study area

Variable	Frequency
Sex	
Male	70 (78)
Female	20 (22)
Ethnicity	
Brahmin	31 (34.4)
Chhetri	9 (10)
Janjati	41 (45.6)
Dalit	9 (10
Age category	
<32	9 (10)
32-54	58 (64)
> 54	24 (26)
Main occupation	
Agriculture	79 (88)
Service	6 (7)
Business	5 (5)
Education level	
Illiterate	16 (18)
Primary	42 (47)
Secondary	28 (31)
Higher education	4 (4)

Source: Field Survey, 2023

Note: Figure in the parenthesis indicate percentage

Total Land Holding of Farmers

Survey research revealed that the total land of farmers ranges from 8 to 46 kattha with a mean land holding of the area of 21.42 kattha. Mean land under tomato cultivation was found to be 12.93 kattha indicating that commercial production in this area. The maximum land for tomato cultivation was 32 kathha and the minimum of 1 kattha.

Table 2

Total land holding and under tomato cultivation in the study area (N=90)

Land (in kattha)	Minimum	Maximum	Mean
Total land holding	8	46	21.42
Land under tomato cultivation	1	32	12.93

Tomato Cultivation

Tomato Cultivation System

Most of the farmers cultivated tomatoes in open fields (68.8%), whereas 26.6% of farmers cultivated in plastic tunnels. Out of them, only 4.6% of the farmers grew tomatoes in both open fields and plastic houses.

Table 3

Tomato cultivation system

Method	Frequency
Open field	62 (68.8)
Plastic tunnel	24 (26.6)
Both	4 (4.6)

Source: Field Survey, 2023

Note: Figure in the parenthesis indicate percentage

Tomato Crops per Year

The study result showed that 76 % of total farmers grow tomato crops in one seasons of the year while 24 % of the farmers grow in two seasons in a year.

Table 4

Number of tomato crops per year

Tomato crop per year	Frequency
One season	68 (76.6)
Two season	22 (24.4)
Total	90 (100)

Source: Field Survey, 2023

Note: Figure in the parenthesis indicate percentage

Varieties of Tomato Cultivated

Most of the tomato farmers had more preference for the variety Surya III followed by Srijana and Manisha. A total of 40 of the respondents cultivated the Surya III variety and the Srijana variety was cultivated by 17 only. Likewise, out of the total respondents, Manisha, Aayush, and Samjhana were cultivated in 13, 10, and 10 of the respondents

respectively.

Table 5

Varieties of tomato cultivated

Variety	Frequency
Srijana	17 (18.4)
Manisha	13 (14.4)
Aayush	10 (11.1)
Surya	40 (44.4)
Samjhana	10 (10)
Total	90

Source: Field Survey, 2023

Note: Figure in the parenthesis indicate percentage

Involvement of Tomato Gowers in Cooperative/Farmers Group

Table 6 shows that about 85 percent of the tomato growers were involved in the cooperatives or farmers group whereas 15 percent were not involved in any cooperatives or farmers group.

Table 6

Involvement of the tomato growers in cooperative/farmers group

Involvement	Frequency
Yes	77 (85)
No	13 (15)
Total	90 (100)

Source: Field Survey, 2023

Note: Figure in the parenthesis indicate percentage

Problem Seen in Tomato Cultivation

Major problems seen in tomato cultivation in the study area were insects and diseases, unavailability of input, lack of technical knowledge, labor shortage, and lack of irrigation. As given in the table 7, insect insects were ranked as a major problem for farmers with index value 0.956 followed by disease, unavailability of input, lack of knowledge, labor shortage, and lack of irrigation respectively. These findings were consistent with the findings of Rijal et al. (2018) and Gauli et al. (2020).

Table 7

Problem seen in tomato cultivation

Problems	Index	Rank
Unavailability of input	0.636	III
Lack of technical knowledge	0.512	IV
Insect	0.956	I
Disease	0.812	II
Labor shortage	0.45	V
Lack of irrigation	0.339	VI

Source: Field Survey, 2023

Knowledge Level on the Life Cycle of Tuta Absoluta

Out of 90 respondents, only 20% farmers revealed that they had knowledge regarding the life cycle of *Tuta absoluta*. Almost 80% of the farmers were ignorant about the pest life cycle.*Tuta absoluta* has been the major problem in tomato cultivation in this area. Almost all of the farmers field was infested with *Tuta absoluta* which was similar to the findings of Rijal et al. (2018) .

Table 8

Knowledge regarding the lifecycle of Tuta absoluta

Response of farmers	Frequency
Yes	18 (20)
No	72 (80)
Total	90 (100)

Source: Field Survey, 2023

Note: Figure in the parenthesis indicate percentage

Stage of Plant Mostly Affected

The pest affects all the stages of the plant. According to the survey result, 52 farmers responded that the flowering stage was the most affected while 29 and 9 respondents reported that the fruiting and seedling stages respectively were the most infested stage. Similar result was obtained by Rijal et al. (2018) in Nuwakot district.

Table 9

Most affected stage by Tuta absoluta

Infested stage	Frequency

Seedling	9 (10)
Flowering	52 (57.7)
Fruiting	29 (32.2)
Total	90 (100)

Source: Field Survey, 2023

Note: Figure in the parenthesis indicate percentage

Level of Infestation/Yield Loss by Tuta Absoluta

Out of the total population, 42 percent reported a high level (20-40%) of infestation, 24 percent reported a very high level (40-60%) of infestation, 19 percent reported a medium level (10-20%) of infestation, 11 percent reported low level (0-10%) of infestation and 3 percent reported extreme level (60% above) of infestation. Sah (2017) also reported the pest can cause 80-100% tomato yield loss.

Table 10

Level of infestation/crop damage by Tuta absoluta

Level of infestation /crop damage percent	**Frequency**
Low (0-10%)	14 (15)
Medium (10-20%)	23 (26)
High (20-40%)	32 (36)
Very high (40-60%)	18 (20)
Extreme (60% above)	3 (3)
Total	90

Source: Field Survey, 2023

Note: Figure in the parenthesis indicate percentage

Economic Analysis

Cost of Production

The average cost of the production which was the summation of variable costs like the cost of seeds, fertilizers, pesticides, land preparation, management cost, maintenance and repair cost etc was calculated for 1 kattha of land. The total variable cost (T.V.C) for tomato production in one kathha is NRs 11,210.

Table 11

Average cost of production for the cultivation of tomato for one kathha of land

	Particulars	**Units**	**Quantity**	**Rate (Rs.)**	**Total cost (Rs.)**
A	Variable cost				
	Labor expenses				

1	Seed bed preparation	Man-days	2	500	1000
2	Seedling raising	Man-days	1	500	500
3	Land preparation	Man-days	2	400	800
4	Training pruning and weeding	Man-days	3	330	990
5	Manuring and pesticide application	Man-days	2	500	1000
6	Harvesting and storage	Man-days	5	500	2500
	SUB TOTAL				6,790
	Particulars	**Amount**	**Unit**	**Rate/unit**	**Total cost**
B	Material expenses				
1	Seed	10	gm		750
2	Farmyard manure	2	kg	400	800
3	Chemical fertilizer				
a	Urea	7	kg	50	350
b	DAP	4	kg	50	200
c	Potash	3	kg	40	120
4	Pesticides and insecticides				1000
5	Traps	5	piece	200	1000
6	Zinc borax and other micro nutrients				200
SUB TOTAL					5,670
TOTAL					11,210

Return from Tomato

Table 12

Average production and gross return from tomato production

Average production per kathha (kg)	Average loss per katha (kg)	Average selling price (NRs/kg)	Gross Return or Revenue (NRs/kathha)
550	72	30	16500

Source: Field Survey, 2023

The average production of tomato per kathha is calculated 550 kg. The average loss of tomatoes per kathha is calculated to be 72 kg. The average selling price of tomato per kg is NRs 30.

Gross Return = total amount of products * respective average market price

=550 * 30

= NRs 16,500

So the Total Revenue or Gross return (G.R) from tomato cultivation in 1 kathha is NRs 16,500.

Gross margin = Gross return-Total variable cost

= 16,500-11210

= NRs 5290

So the Gross margin (G.R) from tomato cultivation in 1 kathha is NRs 5,290.

Benefit Cost Ratio

Benefit cost ratio is the ratio of gross revenue to total cost. It was interpreted as the return received on the costs of one rupee.

Mathematically, Benefit Cost Ratio (BCR) = Gross Revenue/Total Cost

=16500/11210

=1.64

From the above calculation, it was found that the total average variable cost of production was Rs.11,210 and the total average revenue was 16500. This indicates that the benefit-cost ratio is 1.64 for 1 kattha of cultivated land which is similar to the findings of Subedi et al. (2020) and Kafle and Shrestha (2017).

Conclusion

Almost all of the farmers had problems of *Tuta absoluta* in their tomato fields which had caused a significant reduction in yield up to eighty percent in East Nawalparasi. Most of the farmers cultivated tomatoes in open fields and few farmers cultivated in plastic tunnels. Surya III was the popular hybrid variety cultivated by the farmers followed by Srijana and Manisha. Insect and disease problem was ranked as the first and second major problem of farmers followed by unavailability of input lack of technical knowledge, lack of technical knowledge and labor shortage in tomato cultivation. Tomato production seems beneficial in the study site with B:C ratio more than one. Effective management practices of *Tuta* would obviously reduce the cost of production in tomato cultivation and enhance productivity and profitability. Further study can be done on management practices applied by the farmers for the control of *Tuta absoluta.*

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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