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Effect of net house and mulching on insect pest incidence of tomato in Rampur, Chitwan

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ABSTRACT

A field experiment was conducted in a single factor randomized complete block designed to evaluate the effect of net house and mulching on insect pest incidence of tomatoes in Chitwan, Nepal from October 2016 to May 2017. Five different treatments were selected with four replications, included net house with black polythene mulch, black polythene mulching only, reflective polythene mulching only and black polythene mulching with emamectin benzoate 5% SG spray and control (no mulch+ no net + no pesticide spray). The production of crops in the open fields is constrained by major pests like *Tuta absoluta* and tomato fruit borer. The result revealed that the net house totally restricts the tomato fruit borer and *Tuta absoluta* whereas black mulching with emamectin benzoate spray plot reduced tomato fruit borer and *Tuta absoluta* larvae up to 69% and 59%. Total marketable yield was found the highest inside net house 47.74% higher than that of control plot. Damage fruit percent was found the highest in the control plot (28.36%) followed by reflective polythene mulching (21.48%) and black polythene mulching only (18.41%) and the lowest inside the net house (6.04%). Net profit was found maximum inside the net house (Rs1626632.88 ha^{-1}) followed by black polythene with emamectin benzoate (Rs1141741.56 ha^{-1}) and the lowest in the control plot (Rs760277.00 ha^{-1}). Although the investment level found to be the highest in the case of the net houses in long term, higher income can be acquired as it acts as suitable means to control insect pests.

INTRODUCTION

Tomato is the third most important vegetable after cauliflower and cabbage in terms of area, and production in Nepal. It is cultivated in about 20,000 hectares (ha) producing about 0.3 million mt tomatoes annually (MoAD 2014). 'Srijana' is one of the popular varieties of tomato registered by National Seed Board with the effort of Nepal Agricultural Research Council in 2010 (NARC 2014). 'Srijana' tomato is mostly preferred by the farmers for its wider adaptability including its suitability for off season production, superior taste, as well as tolerance to bacterial wilt disease. This variety has also been identified as one of the potential crop variety for import substitution and export promotion (MoAD 2013).

Insect pests play a major role for declining tomato yields in winter and spring seasons. The crop loss due to pest is estimated to be 35-40% of the total production (PPD and FAO 2004). There are several types of insect pests such as tomato fruit borer, aphids, thrips, whitefly, tobacco caterpillar (Sri et al. 2017), tomato leaf miner (TLM) (Desneux et al. 2010) etc. that causes heavy loss in yield of tomato. The tomato fruit borer, tomato leaf miner directly damages the tomato yield whereas thrips, aphids, whitefly act as a vector for transmission of viruses. The tomato leaf miner infests the leaves and fruit of tomato plant from seedling to the fruiting stage (Desneux et al. 2010). In May of 2016, the tomato

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leaf miner, *Tuta absoluta* (Lepidoptera: Gelechiidae), was found feeding on commercial *Solanum lycopersicum* (tomato) leaves, fruits, and stems in Nepal (Bajracharya et al. 2016). Another, most important insect pest of tomato is fruit borer, *Helicoverpa armigera* (L). In spite of regular spraying of insecticides, its incidence in farmers' field varies from 10 to 20 percent and at times, this pest causes yield loss up to 40 percent (Tewari and Krishna Moorthy 1984). The average pesticides use is 396 gm a.i ha^{-1} (PPD 2015) in which more than 85 percent of imported pesticides are applying only in vegetable crops in Nepal (Sharma et al. 2015).

Pesticides use in tomato production to reduce the food loss which results from occurrence of resistant pests and diseases is inevitable (Hossain et al. 2013). In this condition, the major challenge is to control insect pests with or without using chemical insecticides. Worldwide, in Africa mobile net house (25 mesh) were effective against diamondback moth cutworm 66 to 97% (Martin et. al. 2006), in Germany net house was limited success (Mutwiwa. Tantau. 2008), nethouse and its variants have been used in some European, South American and South Asian country for producing tomato, egg plants (Kaur et al. 2004). Similarly, different color mulching has also been suggested as insect control measures in various crops (Leckie Pereira Ownley 2008). Based on this, the research has been setup with major objectives to study the effect of net house and mulching on insect pest infestation in tomato production. With the general objectives monitoring the insect, comparing the effect on the yield and analyze the benefit ratio. So by using the net house and mulching in farmers level it could be economically sound environmental sustainable or not.

MATERIALS AND METHODS

The experiment was conducted at horticultural research field of AFU, Chitwan. Srijana variety was selected. The experiment was laid out in Randomized Complete Block Design (RCBD) consisting of five treatments with four replications. Each plot size was 4.5m*2.4m (10.8$m^{2)}$ consists of 24 plants planted at a distance of 75cm row to row and 60cm plant to plant. The treatment is as net house with black polythene mulch only, Black polythene mulch only, reflective polythene mulch only, black polythene mulch with emamectin benzoate spray and control where no mulch no application of insecticides. Different parameters were recorded during the study of insect's pests in tomato as monitoring of insect using light traps, tomato leaf miner and tomato fruit borer population before and after the spray, horticulture parameters total yield, marketable yield, unmarketable yield damaged by tomato fruit borer and tomato leaf miner, Fruit diameter and fruit height, economic analysis as cost of cultivation, gross return, net return, benefit cost ratio. The collected data were compiled using the Ms-Excel program. Analysis of variance for all parameters was carried out as per the procedures given in R-STATC statistical computer package for the single factor randomized block design. Duncan's Multiple Range Test (DMRT) for mean separations was done from the reference of Gomez and Gomez (1984). Modified Abbots formula given by (Fleming and Retnakaran 1985) was used to calculate the percentage of the population reduction over control in heterogeneous or non-uniform population of insects. Statistical analysis of data was done by converting them into $\sqrt{(x+0.5)}$ as suggested by (Gomez and Gomez 1984). Yield comparison between different treatments was done by using the increase in yield over control.

RESULTS AND DISCUSSION

Monitoring insects using light traps

Light traps were installed certain distant from periphery of the plot. Large number of flying insects was trap in light trap. Major insect such as tomato leaf miner, tomato fruit borer, tobacco caterpillar was identified and monitored. In light trap, maximum number of tomato fruit borer were observed in first week of march with peak population 10 adult tomato fruit borer. Similarly, in first week of April top population of tomato leaf miner was catches up in trap with peak population of 18 tomato leaf miner as shown in Figure 1. The tobacco caterpillar also observed in light trap, peak period attained in last week of March. Similar result was observed by (Dhaliwal et al.2007). Further reported maximum temperature between 25-30°C, minimum temperature between 15-20°C, high morning relative humidity and no rainfall resulted in maximum *H. armigera* populations.

Effect on population of Tomato leaf miner *Tuta absoluta (*Meyrick*)*

Initial population of *Tuta absoluta* was observed higher in the control (1.224) comparative to the black polythene mulch only (0.958), reflective polythene mulch only (0.916), where net house totally restricts the population of tomato leaf miner.

The population reduction over control (PROC) after fourth, eighth and twelfth days of the first spray is 36.93% 59.64% and 48.38% shown in (Table 1). Similar result was observed by (Gacemi and Guenaoui 2012) evaluated the efficacy of emamectin benzoate against larvae of the tomato leaf miner in tomato greenhouse. Three foliar applications were made at 7 days interval in a tomato greenhouse with a mortality of *Tuta absoluta* reaching 87%.

Similarly, black polythene mulch with emamectin benzoate spray plot population reduction over

Table1. Effect of different treatments against tomato leaf miner (*Tuta absoluta*) on tomato after first spray at AFU, Rampur, Chitwan during 2016/2017.

Treatments	Initial population (No per plant)	4 DAS	PROC	8 DAS	PROC	12 DAS	PROC
Control (no mulch + no net + no pesticide spray)	1.224^{a}±0.123 (1.310)	1.349^{a}±0.082 (1.359)		1.583^{a}±0.205 (1.437)		1.958^{a}±0.075 (1.567)	
Black polythene mulch+ Emamectin benzoate 0.625 g/lt	0.958^{a}±0.142 (1.203)	0.666^{ab}±0.096 (1.077)	36.93	0.500^{bc}±0.026 (0.998)	59.64	0.791^{bc}±0.345 (1.110)	48.38
Reflective polythene mulch only	0.916^{a}±0.173 (1.183)	1.375^{a}±0.18 (1.364)	-36.19	1.00^{ab}±0.026 (1.223)	15.58	1.375^{ab}±0.142 (1.366)	6.16
Black polythene mulch only	0.800^{a}±0.115 (1.136)	1.041^{a}±0.125 (1.238)	-18.06	1.041^{ab}±0.172 (1.235)	-0.6	1.408^{ab}±0.225 (1.373)	-10.04
Net+ Black polythene mulch	0.000^{b}±0.00 (0.707)	0.000 ^{b}±0.00 (0.707)	100	0.000^{c}±0.00 (0.707)	100	0.000^{c}±0.00 (0.707)	100
F test	***	**		**		**	
LSD 0.05	0.22	0.316		0.321		0.4076	
C.V	13.49%	18.48%		19.23%		22.30%	

DAS: Days after spraying, CV: Coefficient of variation LSD: Least significant difference, *: significant value with the same letters in a column is not significantly different at 5% by DMRT and figures after ±indicate standard error. The figures in parentheses are square root transformation.

control is 45.51%, 36.06% after 4 DAS and 8 DAS shown in (Table 2). As the efficacy of emamectin benzoate observed higher 4 to 8 days after spray. Reason behind it may be as emamectin benzoate penetrates leaf tissues by trans-laminar movement, following its treatment; larvae stop feeding within hours and die after 2-4 days (Hanafy and Sayed 2013).

Effect on population of tomato fruit borer (*Helicoverpa armigera*)

The (Table 3) revealed that initial population of *Helicoverpa armigera* was highest in control plot is 1.0416. In reflective polythene mulch and black polythene mulch only the initial population of fruit borer larva were 0.958 and 0.749. Similarly, in black polythene mulch spray with emamectin benzoate initial population of larva was 0.833. Reason behind it may be due to mulches be able to help to maintain soil moisture required for plant vigor and to promote plant tolerance to the attack of insect pests (Johnson et al. 2004). Inside net house with black polythene there was no presence of tomato fruit borer larva. Majumdar et al. (2015) reported similar type of finding that the armyworm and tomato fruit worm caterpillar numbers reduced 98-100% under net house.

After 4^{th},8^{th},12^{th}day of spray, the highest reduction of tomato fruit borer larval population over control was shown by black polythene mulch with emamectin benzoate spray 9.7%,32.67%,26.68%. Brevault et al. (2009) reported similar result on lab study of *H. armigera*, field rate of emamectin benzoate and cypermethrin caused 82.2% and 48.7% mortality in 3rd instar larvae of *H. armigera*, respectively.

The Table (4) revealed that after 4^{th} days of spray no tomato fruit borer larva was observed inside net house with black polythene mulch. Black polythene mulch with emamectin benzoate spray reduced the tomato fruit borer larval population over control (36.21%). After 8^{th} days of spray there were no sign of tomato fruit borer inside net house with black polythene mulch. Reduction in population of tomato fruit borer larva was obtained black polythene mulch with emamectin benzoate spray (31.76%) followed by black polythene mulch only (25.44%) and reflective polythene mulch (6.12%). After 12^{th} days of spray inside net house with black polythene mulch there was no presence of any tomato fruit borer larva. In black polythene mulch with emamectin benzoate spray plot highest reduction of tomato fruit borer was recorded (69.39%) followed by black polythene mulch only

Table 2. Effect of different treatments against tomato leaf miner (*Tuta absoluta*) on tomato after second spray at AFU, Rampur, Chitwan during 2016/2017.

Treatments	Initial population	4DAS	PROC	8DAS	PROC	12DAS	PROC
Control (no mulch + no net + no pesticide spray)	1.958 ±0.075 (1.567)	2.458^{a}±0.041 (1.71)		2.416^{a}±0.22 (1.70)		2.987^{a}±0.1685 (1.865)	
Black polythene mulch+ Emamectin benzoate 0.625 g/lt	0.791±0.345 (1.110)	0.541^{bc}±0.151 (1.01)	45.51	0.624^{bc}±0.125 (1.055)	36.06	1.25^{bc}±0.144 (1.4286)	-3.58
Reflective polythene mulch only	1.375 ±0.142 (1.366)	1.833^{ab}±0.18 (1.52)	-6.51	2.208^{a}±0.205 (1.64)	-30.14	2.50^{ab}±0.065 (1.731)	-19.18
Black polythene mulch only	1.408 ±0.225 (1.373)	2.291^{a}±0.075 (1.67)	-29.58	1.916^{ab}±0.255 (1.547)	-10.25	2.437^{ab}±0.17 (1.171)	-13.43
Net + Black polythene mulch+ no spray	0.000 ±0.00 (0.707)	0.000^{c} ±0.00 (0.707)	100	0.000^{c} ±0.00 (0.707)	100	0.000^{c} ±0.00 (0.707)	100
F test		*		*		**	
LSD 0.05		0.57		0.549		0.894	
C.V		29.16%		27.67%		24.32%	

DAS: Days after spraying, CV: Coefficient of variation LSD: Least significant difference, *: significant value with the same letters in a column is not significantly different at 5% by DMRT and figures after ±indicate standard error. The figures in parentheses are square root transformation.

Table 3. Effect of different treatments against tomato fruit borer (*Helicoverpa armigera*) on tomato after first spray at AFU, Rampur, Chitwan during 2016/2017.

Treatments	Initial population (No per plant)	4DAS	PROC	8DAS	PROC	12DAS	PROC
Control (no mulch + no net + no pesticide spray)	1.041^{a}±0.1717 (1.23)	0.750^{a}±0.048 (1.117)		1.083^{a}±0.173 (1.252)		1.208^{a}±0.184 (1.301)	
Black polythene mulch + Emamectin benzoate 0.625 g/lt	0.833^{a}±0.065 (1.154)	0.541^{a}±0.0754 (1.018)	9.7	0.583^{ab}±0.107 (1.036)	32.67	0.708^{ab}±0.041 (1.098)	26.68
Reflective polythene mulch only	0.958^{a}±0.184 (1.200)	0.875^{a}±0.0754 (1.17)	-26.80	1.041^{a}±0.142 (1.237)	-4.5	1.25^{a}±0.048 (1.322)	-12.47
Black polythene mulch only	0.749^{a}±0.088 (1.116)	0.792^{a}±0.1044 (1.133)	-46.76	1.083^{a}±0.088 (1.257)	-38.89	1.25^{a}±0.22 (1.315)	-43.72
Net + Black polythene mulch	0.000^{b}±0.00 (0.707)	0.000^{b}±0.00 (0.707)	100	0.000^{b}±0.00 (0.707)	100	0.000^{b}±0.00 (0.707)	100
F test	***	*		*		*	
LSD 0.05	0.484	0.464		0.657		0.755	
C.V	14.30%	15.47%		19.02%		19.83%	

DAS: Days after spraying, CV: Coefficient of variation, LSD: Least significant difference, *: significant value with the same letters in a column is not significantly different at 5% by DMRT and figures after ±indicate standard error. The figures in parentheses are square root transformation.

(18.52%) and reflective plastic mulch (5.8%). This finding was supported by (Katrojuet al. 2014) that the effectiveness on first spray of emamectin benzoate was 29.29% and second spray 54.95%.

Yield attributing characters

Maximum marketable yield was obtained from the net house with black polythene mulch (100.91 mt ha^{-1}) than that of control plot (68.31 mt ha^{-1}) (Table 5). As the insect pest activity was lower inside the net house results (6.04%) affected fruit whereas, 28.36% fruit were damage by borer and miner in the control plot which was reason for the maximum yield inside net house. 47.73% of increased marketable yield was obtained in net house with black polythene plot compare to the control (no net + no spray+ no mulching) shown in Figure 2. These find on the agreements to (Palada and Ali 2007) and (Majumdar and Powell 2011) the net shade greatly reduced insect population by 80% and marketable yields were 1.5 to 2 times greater under than in the open field. In black mulching with emamectin benzoate spray plot only 11.75% fruit damage by the tomato leaf miner and tomato fruit borer and marketable yield (84.973 mt ha^{-1}) was recorded. (Muruguraj et al. 2006) also reported similar results emamectin benzoate was highly effective in reduction borer population results lower fruit damage and higher marketable yield.

Table 4. Effect of different treatments against tomato fruit borer (*Helicoverpa armigera*) on tomato after second spray at AFU, Rampur, Chitwan during 2016/2017.

Treatments	Initial population (No per plant)	4DAS	PROC	8DAS	PROC	12DAS	PROC
Control(no mulch + no net + no pesticide spray)	1.208 ±0.184 (1.301)	1.208^{ab}±0.075 (1.305)		1.458^{a}±0.184 (1.394)		1.625^{a}±0.104 (1.456)	
Black polythene mulch + Emamectin benzoate 0.625 g/lt	0.708 ±0.041 (1.098)	0.374^{bc}±0.041 (0.934)	36.21	0.583^{bc}±0.088 (1.038)	31.76	0.291^{b}±0.041 (0.888)	69.39
Reflective polythene mulch only	1.25 ±0.048 (1.322)	1.000^{ab}±0.155 (1.219)	20	1.416^{a}±0.048 (1.384)	6.12	1.583^{a}±0.1075 (1.441)	5.8
Black polythene mulch only	1.25 ±0.22 (1.315)	1.333^{a}±0.253 (1.341)	-6.64	1.125^{ab}±0.155 (1.269)	25.44	1.37 ^{a}±0.142 (1.366)	18.52
Net + Black polythene mulch	0.000±0.00 (0.707)	0.000^{c}±0.00 (0.707)	100	0.000^{c}±0.00 (0.707)	100	0.000^{b}±0.00 (0.707)	100
F test		*		*		.	
LSD 0.05		0.875		0.785		1.032	
C.V		23.47%		20.44%		26.23%	

DAS: Days after spraying, CV: Coefficient of variation, LSD: Least significant difference, *: significant value with the same letters in a column is not significantly different at 5% by DMRT and figures after ±indicate standard error. The figures in parentheses are square root transformation.

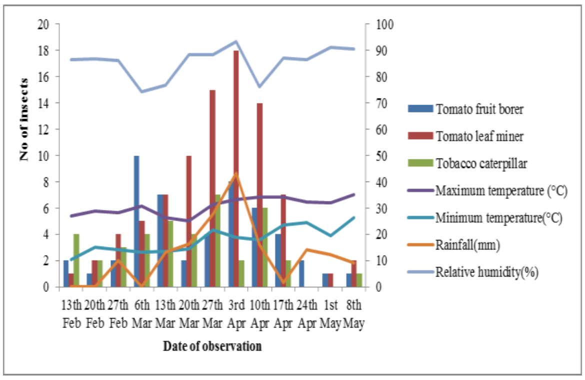

Figure1. Graphical diagram showing number of insects population capture in light trap in different dates of monitoring.

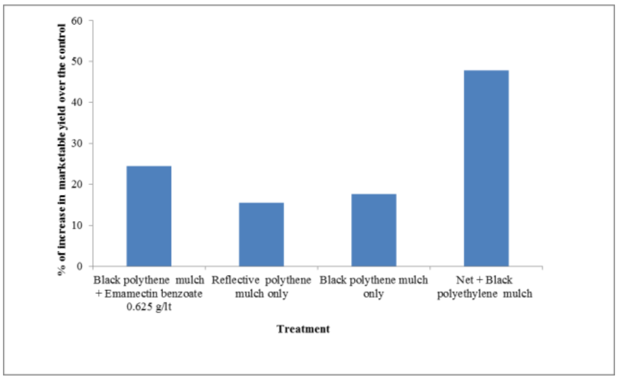

Figure 2. Increase in marketable yield of tomato over the control with different treatments plot in AFU, Rampur at 2016/017.

Table 5. Yield and yield attributing characters of tomato as affected by net and mulching at AFU, Rampur, Chitwan

Treatments	Total yield (mt ha^{-1})	Marketable yield (mt ha^{-1})	Borer and miner affected fruit (%)
Control ((no mulch + no net + no pesticide spray)	95.36^{b}	68.312^{c}	28.36%
Black polythene mulch + Emamectin benzoate 0.625 g/lt	96.29^{b}	84.973^{b}	11.75%
Reflective polythene mulch only	100.451^{ab}	78.871^{bc}	21.48%
Black polythene mulch only	98.45^{ab}	80.318^{bc}	18.41%
Net + Black polythene mulch +no spray	107.40^{a}	100.918^{a}	6.04%
F test	*	***	
S.E	2.98	2.73	
LSD0.05	9.38	13.2999	
C.V	6.322%	10.782%	

S.E: Standard error CV: Coefficient of variation, LSD: Least significant difference, *: significant value with the same letters in a column is not significantly different at 5% by DMRT.

Table 6. Economic analysis of tomato among different treatment at Rampur, Chitwan

Treatments	Total cost of cultivation (Rs ha^{-1})	Total fruit yield (mt ha^{-1})	Market price (Rs kg^{-1})	Gross income (Rs kg^{-1})	Net profit (Rs ha^{-1})	B:C Ratio
Control (no mulch + no net + no pesticide spray)	605970.00	68.31236	20	1366247.00	760277.00	2.25:1
Black polythene mulch + Emamectin benzoate 0.625 g/lt	557734.44	84.97381	20	1699476.00	1141741.56	3.04:1
Reflective polythene mulch only	552912.22	78.87161	20	1577432.00	1024519.67	2.85:1
Black polythene mulch only	546334.34	80.31837	20	1606367.00	1060032.66	2.94:1
Net + Black polythene mulch	896334.62	100.9187	25	2522967.50	1626632.88	2.81:1

Economic analysis

The net profit was exerted maximum inside the net house with black polythene mulch (Rs.16,26,632.88) followed by black mulching with emamectin benzoate spray plot (Rs.11,41,741.56) and lower in control plot (Rs.7,60,277.00). The highest benefit cost ratio was obtained from black polythene mulch with emamectin benzoate spray plot (3.04:1) and lower in control plot (2.25:1) (Table 6).

CONCLUSIONS

Tomato crop suffered from various insect pests during its development period. The maximum infestation by *Tuta absoluta* and *Helicoverpa armigera* were observed in control plots where net house totally restricted the *Helicoverpa armigera* but *Tuta absoluta* adults were in lower level. The marketable yield was obtained highest inside the net house followed by the black polythene mulch with emamectin benzoate spray plot. The initial investment inside net house was comparative higher to that of other treatment. In chitwan, condition, from economic point of view black mulching with chemical pesticides seems suitable for tomato production but on contradictory to the health and environment net house serves best followed by black polythene mulch. This finding clearly showed the impact of net house, black polythene mulch research on such will be valuable for the farmers in different agro-climatic locations of the country for validation.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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