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Effect of Different Nethouses on the Incidence of Insect on Vegetable Crops

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Abstract

In this study, the effects of different types of nethouses viz., NH1, NH2, and NH3, were investigated at the research farm of the Olericulture Division, Bangladesh Agricultural Research Institute (BARI) from Sep 2021 to Mar 2022 and compared to control (open field) in terms of the incidence of white fly, aphid, leaf miners, mites, and eggplant shoot and fruit borer (ESFB). This study included six vegetables 1) Tomato, 2) Eggplant, 3) Sweet pepper, 4) Broccoli, 5) Cucumber; 6) Okra, as well as four nethouse treatments: 1) UV stabilized transparent polyethylene film with 60 mesh insect net along with green shade net (NH1); 2) UV stabilized transparent polyethylene film with 60 mesh insect net (NH2); 3) 60 mesh insect net (NH3); 4) Open field infestation of white fly, aphid, leaf miners, mites, and ESFB was observed under open field conditions followed by NH1 conditions, while the lower infestation was observed in NH2 and NH3 for all vegetables. From the study, we found the use of stabilized transparent polyethylene film with a 60 mesh insect nethouse provided a negative effect on the presence of different types of notorious insects on vegetables. So, this type of protected nethouse will provide a new dimension to producing safe and quality vegetables in Bangladesh.

Keywords

Effect Nethouse, Incidence of Insect, White Fly, Aphid, Leaf Miners, Mites, ESFB, Vegetable Crops

1. Introduction

Protected cultivation is a total concept of modifying the natural environment for optimum plant growth). It comprises the manipulation of environmental factors to some extent to control the crop's growth. It provides a partially controlled atmosphere and environment by reducing light intensity and effective heat during the daytime for crops grown under it. Hence, round the year, seasonal and off-season cultivation is possible. Protective nethouses are used in tropical and subtropical countries for effective vegetable production [1]. Vegetable production has undergone many changes in the way it is being grown in different protective nethouses, since different limiting factors, including climatic conditions, availability of water and nutrients, and quality and quantity of light, must be taken into account to provide appropriate conditions for the optimal growth and development of the crop [2]. As summarized by [3], light affects many developmental and physiological processes, including germination [4], flowering [5], and direction of growth [6].

In Israel (which receives 50 mol/m^{-2} per day of daily light integral in the summer), the recommended shading was 30% to 60% to achieve satisfactory biomass accumulation [7] and flowering [8]. Since the cladodes (shoots) are sensitive to high temperature and strong sunlight in summer, they are prone to sunburn [9] [10] [11] [12], which may reduce yield [13]. Thus, the use of shade screens in net house can help minimize sunburn [14] and maximize fruit yield and quality during the natural reproductive period. A preliminary study reported by [15] showed that the use of 32 mesh net house in Taichung, Taiwan, significantly reduced radiation and sooty mold without affecting fruit quality of *H. undatus*. However, the maximum and average air temperatures inside the net house in summer were greater than those in open field, and such environmental conditions are not favorable for the flowering of *H. undatus*. Lower mesh specifications, such as 16 mesh or 24 mesh, may be helpful to combat the heat accumulation problem and provide proper light intensity.

The protective nethouse promotes physiological responses in plant and fruit development by manipulating the spectra of radiation reaching the crops, including leaf area index, chlorophyll and carotenoid contents, tissue structure, fruit ripening, physiological disorders, nutritional quality, and so on [16]. High temperatures and high solar radiation, on the other hand, may reduce lycopene and carotene levels during tomato production, causing fruit damage, sunscald, and an increase in unmarketable fruit yield [17]. In Bangladesh, medium-sized farmers have begun flower and vegetable cultivation under various types of modular protected structures, depending on their investment capacity and market availability in their area. To date, there is not much work available on protected cultivation of quality vegetable production in Bangladesh. There is an urgent need to assess the quality of vegetable production and suitability for different vegetables under protected cultivation structures to meet the growing demand for vegetables. In order to get more information about the effect of different protective nethouses on different vegetable production for specific climatic conditions in Bangladesh, the objective of this study is to assess the incidence of different insects under different nethouse conditions.

2. Materials and Methods

1) *Experimental site*

The evaluation site was the research farm of the Olericulture Division, Bangladesh Agricultural Research Institute (BARI) from Sep 2021 to Mar 2022. The field was at 23.9920˚N Latitude and 90.4125˚E Longitudes having an elevation of 8.2 m from sea level under agro-ecological zone (AEZ) 28. The farm was situated in the sub-tropical climatic zone and was characterized by scanty rainfall during the experimental period.

2) *Air temperatures and relative humidity of the experimental area*

The average temperature and relative humidity for different growing conditions (NH1, NH2, NH3, NH4) during April 2021 to March 2022 were viz., 29.8˚C and 76.3%; 32.2˚C and 72.1%; 27.8˚C and 78.2%; and 31.0˚C and 76.5%, respectively. The soil of the experimental field was sandy clay loam in texture, having a pH range of around 6.0 (**Figure 1**).

3) *Treatments and plant materials*

Six vegetables: 1) Tomato; 2) Eggplant; 3) Sweet pepper; 4) Broccoli; 5) Cucumber; 6) Okra, as well as four nethouse treatments: 1) UV stabilized transparent polyethylene film with 60 mesh insect net along with green shade net (NH1); 2) UV stabilized transparent polyethylene film with 60 mesh insect net (NH2); 3) 60 mesh insect net (NH3); 4) Open condition (NH4) were included in this study. A total of 24 treatment combinations were laid out in a factorial design with three replications.

4) *Land preparation and fertilization*

The unit plot size was 3.0 × 1.00 m in a RCBD (Randomized Complete Block Design) with three replications. Row to row and plant to plant distances were maintained with standard practice. The land was fertilized with organic fertilizer-N-P-K-S-Zn-B @ 10,000-170-50-125-18-4.3-1.70 kg/ha, respectively. During final land preparation, one-third of the organic manure, half of the P, and full of S, Zn, and B, was applied. Organic manure and P and 1/3 of K were applied as basal in the pit. After land preparation, the proper sized seedlings were transplanted at the proper distance. One third of N and K were applied after 20 days of transplanting. The remaining N and K were applied in two equal installments during flowering and fruiting.

5) *Intercultural operation and plant protection*

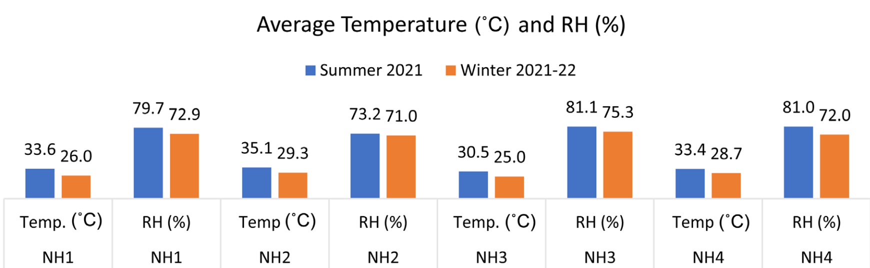

Figure 1. Air temperatures and relative humidity of different growing conditions.

Irrigation, weeding, crop management and other intercultural operations were done following standard practice and done as and when needed. No plant protection was taken during the study time to get proper pest infestation data.

6) *Data collection and statistical analysis*

Different types of growth and pest infestation data were collected from five randomly selected plants from each of the replications. The recorded data for various characters were statistically analyzed, with analysis of variance (ANOVA) and mean separation performed using R 3.6.3 statistical software.

7) *Monitoring of Insect Pests*

The presence of white fly, aphid, leaf miners, mites, and ESFB (eggplant shoot and fruit borer) was also monitored on a weekly basis during the morning hours on the different treatments. In the case of white fly and aphid, eight randomly selected leaves per block were collected in order to record the combined number of eggs, nymphs, puparium, and adult exuviae. For leaf miners, mites and ESFB, visual damage was recorded on five randomly selected plants using a 0 - 5 scale [18], with level 0 = plants not affected; level 1: number of branches with damage symptom/total branches = 10%; level 2: number of branches with damage symptom/total branches = 20%; level 3: number of branches with damage symptom/total branches = 30%; level 4: number of branches with damage symptom/total branches = 40%; and level 5: number of branches with damage symptom/total branches = 50%.

3. Results and Discussion

In this study, the effects of different types of nethouses, viz., NH1 (UV stabilized transparent polyethylene film with 60 mesh insect net along with green shade net), NH2 (UV stabilized transparent polyethylene film with 60 mesh insect net), and NH3 (60 mesh insect net) were investigated and compared to control NH4 (open field) in terms of the incidence of white fly, aphid, leaf miners, mites, and ESFB of tomato, eggplant, sweet pepper, broccoli, cucumber, and okra. A significant amount of infestation of white fly, aphids, leaf miners, mites, and ESFB was observed under different types of nethouses and control field.

White fly

A significant number of whiteflies infestations were observed under the protected cultivation treatments during the 20 weeks of total crop cultivation period. However, from the start of the plant developmental stage, an increased infestation of whiteflies was observed from the NH1 and NH4 (control) in all of the six crops viz., tomato, eggplant, sweet pepper, broccoli, cucumber, okra, with white fly infestation was 8.25%, 7.5%, 8.75%, 1.2%, 4.75%, 2.25% in NH1, respectively and 11.0%, 8.5%, 9.75%, 1.5%, 7.75%, 6.25% in NH4, respectively (**Figure 2**).

The NH1 was made of UV stabilized transparent polyethylene film, a 60 mesh insect net, and a green shade net, which encourages high temperatures and relative humidity percentages. The shading effect provided by the green colored net appears to have provided the right conditions for the rapid multiplication of

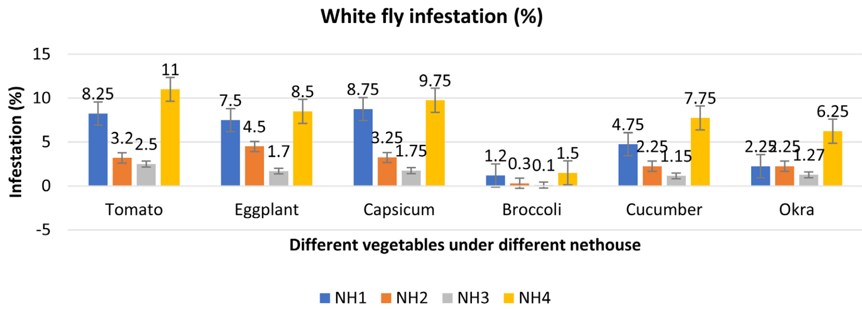

Figure 2. White fly infestation (%) of tomato, eggplant, sweet pepper, broccoli, cucumber and okra under different type of nethouse.

white fly population under this specific protected structure [2] (Sotelo-Cardona *et al.*, 2021). The control treatment NH4 condition encourages more infestation of white fly due to its open condition. That is why the white fly infestation was higher in NH1 and NH4 compared to NH2 and NH3. The NH2 is made of UV stabilized transparent polyethylene film with a 60 mesh insect net, and the NH3 is made of only a 60 mesh insect net, which ensures a higher temperature and a lower relative humidity percentage, resulting in a lower infestation in these NH2, NH3.

Aphid

A significant amount of aphid infestation was observed under the protected cultivation treatments during the entire crop cultivation period. Aphid infestation increased from NH1 and NH_4 (control) in all six crops, namely tomato, eggplant, sweet pepper, broccoli, cucumber, and okra, with an aphid infestation of 7.25%, 8.75%, 9.5%, 1.0%, 4.5, 3.7% in NH1 and 12.0%, 9.5%, 10.75%, 1.25%, 6.75%, 9.25% in NH4 (**Figure 3**).

The NH1 was made of UV stabilized transparent polyethylene film, a 60 mesh insect net, and a green shade net, which encourages high temperatures and relative humidity percentages. The shading effect provided by the green colored net appears to have provided the right conditions for the rapid multiplication of aphid population under this specific protected structure [2]. The control treatment NH4 condition encourages more infestation of aphids due to its open condition. That is why the aphid infestation was higher in NH1 and NH4 compared to NH2 and NH3. The NH2 is made of UV stabilized transparent polyethylene film with a 60 mesh insect net, and the NH3 is made of only a 60 mesh insect net, which ensures a higher temperature and a lower relative humidity percentage, resulting in a lower infestation in these NH2, NH3.

Mite

A significant amount of mite infestation was observed under the protected cultivation treatments during the entire crop cultivation period. An increased infestation of mites was observed in two vegetables, viz., eggplant and sweet pepper from the NH4 (9.25% and 12.5%, respectively), followed by NH1 (4.3% and 7.5%, respectively), NH2 (2.8% and 2.55%, respectively) and the lowest infestation was in NH3 (2.0% and 2.05%, respectively) (**Figure 4**).

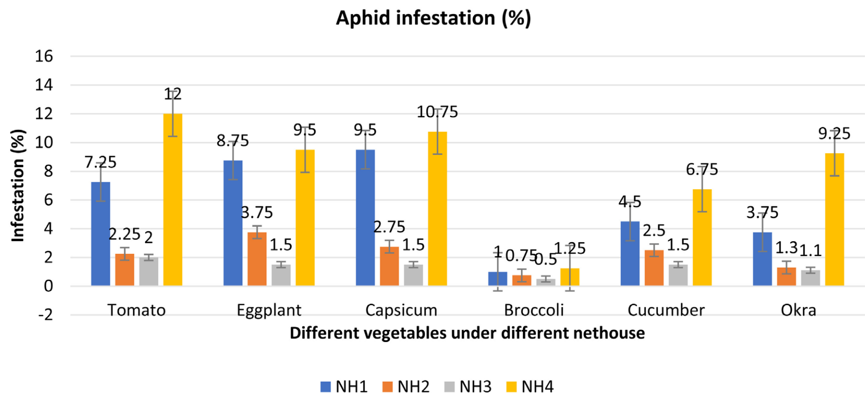

Figure 3. Aphid infestation (%) of tomato, eggplant, sweet pepper, broccoli, cucumber and okraunder different type of nethouse.

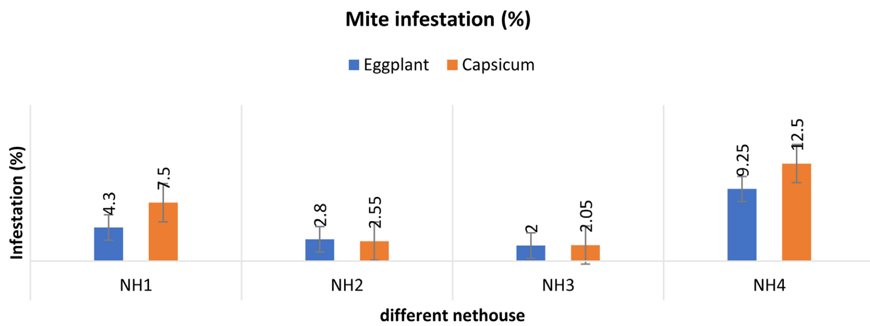

Figure 4. Mite infestation (%) of eggplant and sweet pepper under different type of nethouse.

The NH1 was made of UV stabilized transparent polyethylene film, a 60 mesh insect net, and a green shade net, which encourages the high temperature and relative humidity percentage. The shading effect provided by the green colored net appears to have provided the right conditions for the rapid multiplication of mite population under this specific protected structure [2]. The control treatment NH4 condition encourages more infestation of mites due to its open condition. That is why the mite infestation was higher in NH1 and NH4 compared to NH2 and NH3. The NH2 is made of UV stabilized transparent polyethylene film with a 60 mesh insect net, and the NH3 is made of only a 60 mesh insect net, which ensures a higher temperature and a lower relative humidity percentage, resulting in a lower infestation in these NH2, NH3.

Leaf miners

Maximum leaf miner infestation (15.3%) in tomato was observed in NH4 due to its open condition, which provides free mite movement to the crops (**Figure 5**). In contrast, the high temperature and low relative humidity recorded under protected conditions seemed to deter the presence of leaf miners, as damage levels were very low, whereas the second highest damage levels (7.2%) were observed under more mild temperature and higher relative humidity conditions offered by NH1 in our study. Infestation was lower in NH2 (3.4%) and NH3

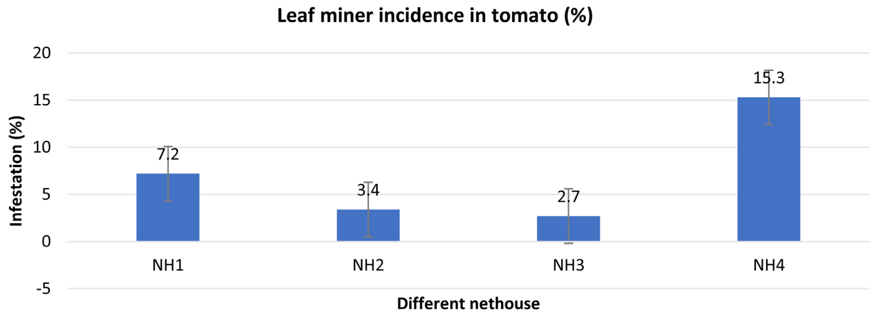

Figure 5. Leaf miner infestation (%) of tomato under different type of nethouse.

(2.7%). The NH2 is made of UV stabilized transparent polyethylene film with 60 mesh insect net, while the NH3 is made of only 60 mesh insect net, which ensures a higher temperature and lower relative humidity percentage, resulting in a lower infestation of tomato leaf miner.

Eggplant shoot and fruit borer

Generally, eggplant shoot and fruit borer infestations are seen in the shoot and fruit. The shoot infestation starts earlier than fruit. In this study, a significant variation of infestation was seen among the shoot and fruit. Maximum infestation for both fruit and shoot was calculated in NH4 due to open condition cultivation, though fruit infestation (22.0%) was higher compared to shoot (15.0%). The second highest infestation was calculated in NH1, which consists of UV stabilized transparent polyethylene film with a 60 mesh insect net along with a green shade net, which favors the high temperature with a high relative humidity percentage. But in this case, the fruit infestation (4.3%) was lower compared to the shoot (7.3%) (**Figure 6**). Lower fruit infestation and shoot infestation were counted in NH2 (3.3% and 2.3%, respectively) and NH3 (2.2% and 1.2%, respectively). The lower infestation was due to the NH2 being made of UV stabilized transparent polyethylene film with a 60 mesh insect net and the NH3 being made of only a 60 mesh insect net, which ensures a higher temperature and a lower relative humidity percentage, resulting in a lower infestation of eggplant shoots and fruit borer in eggplant.

Furthermore, in this study, the nethouses of NH1, NH2, and NH3 were prepared using 60 mesh size insect net, but still the tiny pests, viz., white fly, aphid, leaf miners, mites, and ESFB, were noticed and plants were infested in those nethouses. The insect-proof screens provided partial shade and reduced the amount of radiant heat entering the houses, they also may decrease air flow and lower the warm air removal rate, leading to significant greenhouse effect [14]. 24 mesh screens blocked invasion by scarab beetles, stink bugs, and melon flies and reduced damage caused by these pests [19]. So, the size of the insects is another important aspect to consider, as it has been previously shown that these tiny pests can easily enter through the nets, even if they are 50 - 60 mesh size [20]. In addition, several studies have also indicated the need to optimize the mesh size to reduce adverse climatic conditions by allowing better ventilation, and reducing heat while offering effective protection against insect pests [21] [22].

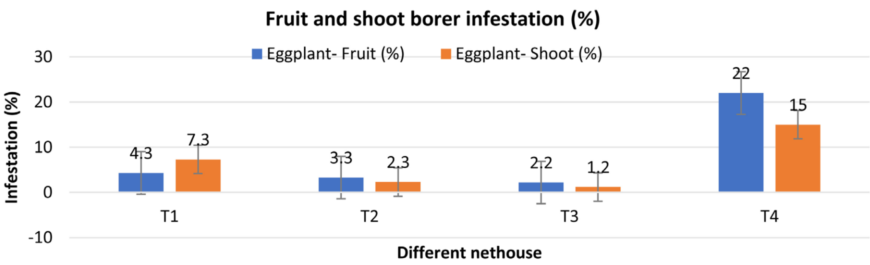

Figure 6. Eggplant shoot and fruit borer infestation (%) of eggplant fruit and eggplant shoot under different type of nethouse.

4. Conclusion

In our study, the effects of different types of protected nethouses, viz., NH1, NH2, and NH3, were investigated and compared to control (open field) in terms of the incidence of white fly, aphid, leaf miners, mites, and ESFB of tomato, eggplant, sweet pepper, broccoli, cucumber, and okra. Under open field and NH1 conditions, a significant amount of white fly, aphid, leaf miners, mites, and ESFB infestation was observed, whereas NH2 and NH3 conditions had a lower infestation. The use of NH2, *i.e.* UV stabilized transparent polyethylene film with a 60 mesh insect net, continues to be a good strategy to allow better utilization of the sunlight due to the manipulation of the light spectrum, which in turn promotes desired physiological plant responses. From the study, we found the use of stabilized transparent polyethylene film with a 60 mesh insect nethouse provided a negative effect on the presence of different types of notorious insects on vegetables. So, this type of protected nethouse will provide a new dimension to producing safe and quality vegetables in Bangladesh.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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