# NARDF Technical Paper Series Report

## Promotion of Off-season onion production for import substitution (FPP-419)


**Abstract**

*Plastic houses are primarily used to raise temperature during winter, and to provide shade to protect crops from deleterious effects of high moisture during the summer/rainy season. The higher monetary return per unit area have been realized by the farmers growing high value crops, such as tomato, sweet pepper, cucumber, bitter gourds etc. under plastic houses. Because there is inadequate information available on the long-term use of plastic house technology on soil nutrient dynamics, and problems associated with diseases and insect pests, complaints from the farmers has been increasing.*

*This project was therefore, designed to develop practical and simple disease and insect management techniques and suggest modification in plastic house structure that small farmers can adopt and continue to take the benefit of growing high value vegetable crops in the plastic houses.*

*Insect and disease incidence monitoring in the plastic houses Palpa and Kaski (Hemja) Pokhara has shown that insects such as root knot nematodes, whiteflies, aphids and leaf miners were severe problems in several plastic houses in the study areas. Among diseases leaf spot, stem blight, leaf blight and mosaic viruses were major problems. Pheromone traps (Spodoptera, Helicoverpa, fruit flies and Leucinodes) was used to monitor the respective pests. Aphids were monitored by using water pan traps, white flies with the help of sticky traps. Direct field counts were taken from sample plants for the severity of pest outbreaks at regular interval. Diseases were monitored by taking direct field observations from sample plants. Field samples were collected and pathogen identified through laboratory examinations*

*Soil nutrient dynamics under plastic house system study showed that organic matter content was slightly higher in samples from plastic houses compared to those from outside the plastic house. Soil reactions in all the plastic houses were on the acidic side ranging from 5.1 to 6.9. Framers having soil pH less than 6.5 have been advised to apply lime in the soil and also to apply FYM to improve organic matter.*

*Wilt and nematode resistant root-stock for tomato through grafting techniques being evaluated with different root-stocks. Adoption of grafting on nematode resistant rootstocks helped to reduce nematode attack and increase the fruit yield of tomato. Grafting of tomato varieties on resistant rootstocks of other Solanum species such as eggplant accessions EG195 and EG203 and wild species of Solanum such as kantakari were also tried as root-stock. Grafting on resistant rootstock produced 50 % to 100% more yield per plant under plastic house condition. Farmer's knowledge and skill on soil nutrient management grafting of commercial varieties of tomato on resistant rootstock, training and pruning of tomato enhanced through different trainings on rootstock growing, grafting, integrated pest and nutrient management such as compost and FYM application, liming of plots and application of mustard cakes enhanced to produce more and prolonged yield of tomato. Adoption of ventilated plastic houses has helped to reduce temperature and humidity inside the plastic houses.*



**Keyword**

Root-stock, resistant, second generation problems, grafting, ventilated, scaling-up, lean-period,


**1. Introduction**

Plastic houses are primarily used to raise temperature during winter*to* protect crops from deleterious effects of rainfall during the summer/rainy season. During the cool weather in the winter, it helps to modify the environment raising temperature making it favourable for the crops that require warm temperature (such as bitter gourd and cucumber). The production and supply of these vegetables earlier than the normal season fetch high price in the market. During the rainy season, the main purpose of the plastic house is to provide shade to the crops and protect it from high soil moisture. Major crop grown in these plastic houses during the rainy season is tomato.

The higher return per unit area have been realised by the farmers growing high value crops, especially the off-season tomato in the plastic houses. Because there is inadequate information available on the long-term use of house technology on soil nutrient dynamics, and problems associated with diseases and insect pests, complaints from the farmers has been increasing. These problems must be addressed with high degree of urgency to promote the highly profitable enterprise in a sustained manner. Monitoring of soil nutrient dynamics under plastic house system through repeated analysis of soil samples to provide bases for long-term soil fertility management strategy under plastic house culture is also a priority. Identification of important diseases and insect pests, study of their population dynamics and development of management tools by using locally available resources benefit farmers to adopt plastic house cultivation of off season vegetables in a sustainable manner. The adoption of these technologies would have multi-dimensional impact on poverty alleviation, public health and import substitution. This project was designed to categorically identify the 'second generation problems' of the plastic house technology, and help develop methods to deal with these problems in a prioritised order.

To identify management practices to overcome above stated disease and insect problems and the problem of structural modification of the plastic houses are the main researchable problems and constraints the project aimed to address.

## 2. Literature Review

Work on plastic house technology in Nepal began about 20 years ago but it has become popular only in the past decade. It was estimated that plastic houses have covered more than 100 ha of land (Regmi 2005), which is rapidly increasing. Plastic house technology can be adapted from Terai to mountains to modify the environment, but the structure of plastic house should be different based on the season and altitude of the particular locations (Regmi 2005). Most of the plastic house technologies are developed for mid hill (1000 to 1400 m above sea level). Though different heights of plastic houses are recommended for lower and upper mid hill (Budhathoki 2006), very little research works has been done for their appropriateness. The protected vegetable cultivation technologies through the use of plastic house offer higher return due to increased yield, and better quality of the product extending the crop life and preventing the crops from extreme climate hazards (Regmi, 2005).

The present recommended plastic house structure is suitable to an area ranging between 1000 to 1400 meters from sea level. Adoption of this technology beyond this range has led to the problem of temperature regulation within the plastic houses (Problems Reported from Madan Pokhara of Palpa in June 2003). The rise in temperature in the summer months could cause heat stress to the crops grown within. This problem may be solved by structural modification of the plastic houses.

Tomato, cucumber, squash, sweet pepper and bitter gourd are among the most profitable vegetables that can be grown in plastic houses (Budhathoki 2006). Because of the repeated cultivation of crops of similar nutritional requirements and their susceptibility to similar spectrum of disease causing pathogens and insect pests, it is likely that the productivity (and eventually the profitability) of the plastic house cultivation diminish over time. Because the plastic house is a semi permanent structure it is unlikely that the farmers rotate these plastic house (the labour requirement and the monetary involvement is usually prohibitive for such rotation). Budhathoki (2006). Regmi (2005) have provided list of major diseases and insect pest problems of important crops grown in plastic houses, which includes root knot nematode, wilts, leaf blights, whitefly, aphids, fruit flies and tomato fruit borer. However, information on their seasonal distribution and severity is lacking. It is therefore important to prepare inventory of pests and their natural enemies associated with the plastic house crops, which enables us to prioritise further research and development activities. Some works have been done on the survey of natural enemies of tomato fruit worm (Pandey et al 1996), white grub control (GC et al. 2005). Organic amendments have been reported to suppress root knot nematodes in vegetables (Chaube and Singh 2004).

## 3. Materials and methods (conceptual framework, data, model, methodology)1 ?

The project activities have been divided into action research activities and extension/development activities. The action research activities have been undertaken in first and second year whereas developmental activities have been undertaken in second and third year.

The action research activities included monitoring of biotic and abiotic (soil related) factors affecting crop production. To monitor insects various trap (sticky, pheromones etc.) and direct field observations have been used. Aphids were monitored by using water pan traps, white flies with the help of sticky traps. Direct field counts were taken from sample plants for the severity of pest outbreaks at regular interval. Data were presented through appropriate graphical or tabular formats.

Diseases were monitored through direct observations on the sampled plants at different growth stages of crop. Field samples were collected and pathogen identified through laboratory examinations.

Soil samples were collected from plastic houses and compared with soil from outside plastic houses Soil samples were collected from same plastic houses in the second and third year and a trend of major crop nutrient (NPK) and organic matter dynamics were determined. The samples were analysed at soil science laboratory (NARC and DOA). Comparison of the nutrient contents were presented through numerical data as appropriate.

Based on the findings of above studies and other available techniques of pest management, efforts have been made to manage the identified problems through the adoption of environmentally friendly techniques such as modification of cultural practices, use of bio-rational tools including attractants, traps and biological control agents. The results and lessons learnt during the project implementation have been documented in the form of various reports and disseminated through field days, exposure visits, workshops and publication distributions Different agronomic and horticultural practices and plant protection and soil management with safety measures were applied in the demonstration plastic houses with the help of Field Technicians and lead farmers.

Field days have been conducted in both the districts where farmers had the opportunity to directly observe the improved techniques of growing tomato under plastic houses and interact with the co-operator farmers. Reports on second generation problems associated with plastic house culture of commercial vegetables identified through field studies and outcomes of management studies prepared in Nepali language and published in the form of leaflets. These publications have been made available to the field workers and farmers for wider application of the specific techniques.

A short video film that highlights the findings of the project have been made available to electronic media dissemination to TV and radio people.

District and field workshops and meetings have been conducted where the representatives from government and non-governmental agencies participated.

1 for social science studies

## 4. Results

***Result 1:*** **Plastic house second generation problems identified.**

Insect and disease incidence monitoring in the plastic houses Palpa and Kaski (Hemja) Pokhara has shown that insects such as Root knot nematodes, whiteflies, aphids and leaf miners were severe problems in several plastic houses in the study areas. Among them, aphids' root-knot nematodes and white flies were the major problems and prioritized for study and control. Among diseases leaf spot, stem blight, leaf blight and mosaic viruses are major problems. Pheromone traps (Spodoptera, Helicoverpa, fruit flies and Leucinodes) was used to monitor the respective pests. Aphids were monitored by using water pan traps, white flies with the help of sticky traps. Direct field counts were taken from sample plants for the severity of pest outbreaks at regular interval. Diseases were monitored by taking direct field observations from sample plants. Field samples were collected and pathogen identified through laboratory examinations

Whiteflies on the lower part of the leaf.

Leaf blight in tomato in plastic house

Leaf blight in tomato in plastic house

Aphid monitoring

Diseases monitoring in Palpa and Kaski showed that tomato diseases like leaf spot, leaf blight, stem blight and powdery mildew were the major problems associated with tomato crop. Tomato planted in the plastic house is continued to harvest for quite long time (up to nine months) and then the field is usually kept fallow for until next season.

Insect monitoring in the same plastic houses were observed as aphids, white flies, nematode, fruit flies and leaf miner were the major insects. The intensity of all the pests observed were very low in Palpa when alarmingly high infestation of whitefly and root knot nematode were observed from sites such as Hemja (Kaski) where the plastic house technologies are commercialised. A single male lure trap put in the plastic house prevented any damage to tomato fruits by the fruit flies. Whiteflies were observed in small number at the end of the season. The findings are summarized in Table 1 and

Table 2 and figure 1 and figure 2

Disease monitoring summary

Crop: Tomato

Table 1: Percentage of diseases incident at different dates

| Diseases | 1-Aug | 15-Aug | 30-Aug | 15-Sep | 30-Sep | 15-Oct |
|---|---|---|---|---|---|---|
| Average leaf spot infected percent in population | 2 | 8 | 12 | 15 | 12 | 6 |
| Average leaf blight infected percent in population | 1 | 8 | 15 | 14 | 10 | 7 |
| Average stem blight infected percent in population | 1 | 1 | 6 | 8 | 7 | 2 |
| Average powdery mildew infection percent in population | 1 | 15 | 18 | 17 | 9 | 4 |

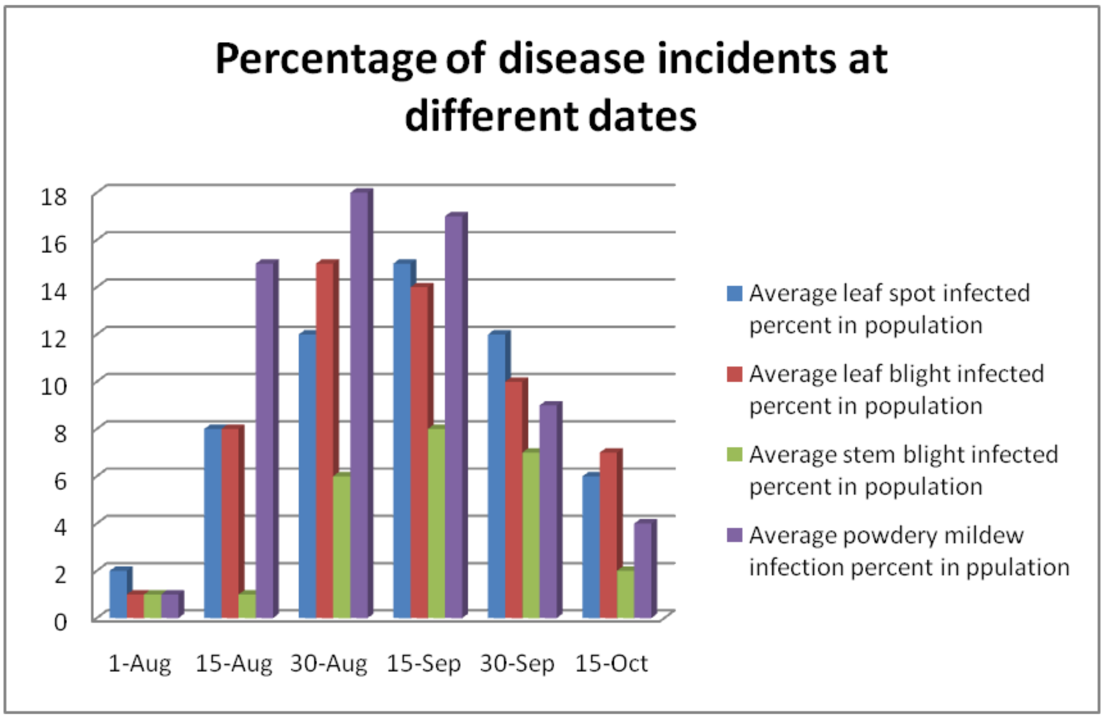


Figure 1: Percentage of disease incidents in tomato under plastic house at different dates

The main off-season of tomato harvesting is August to October when tomato supply is lean period and fetches higher prices. For this season tomato planting starts from May/June and fruiting starts from July and tomato starts maturing from August and continues up to November. During early stage the plants are healthy and diseases attack is less. When rainy season and high humidity prevail from August onward the diseases attack also increases. Disease incidence is highest during August and September. From October onward temperature starts falling down and rain is over and diseases also are reduced. During rainy season precautions must be taken to manage the diseases. It is evident from Table 1 and figure 1 also.

Table 2: Insect monitoring summary

| Average insect count per five plant | | | | | | | |
|---|---|---|---|---|---|---|---|
| Insects | 1-Aug | 15-Aug | 30-Aug | 1-Sep | 15-Sep | 30-Sep | 15-Oct |
| Aphid per five mid leaves | 0 | 13 | 15 | 20 | 25 | 18 | 15 |
| White fly per five mid leaves | 0 | 50 | 65 | 75 | 50 | 40 | 15 |
| Fruit fly collected in trap inside plastic house | 0 | 1 | 2 | 4 | 5 | 3 | 1 |
| Leaf minor infected leaves per plant | 0 | 0 | 0 | 3 | 3 | 2 | 1 |

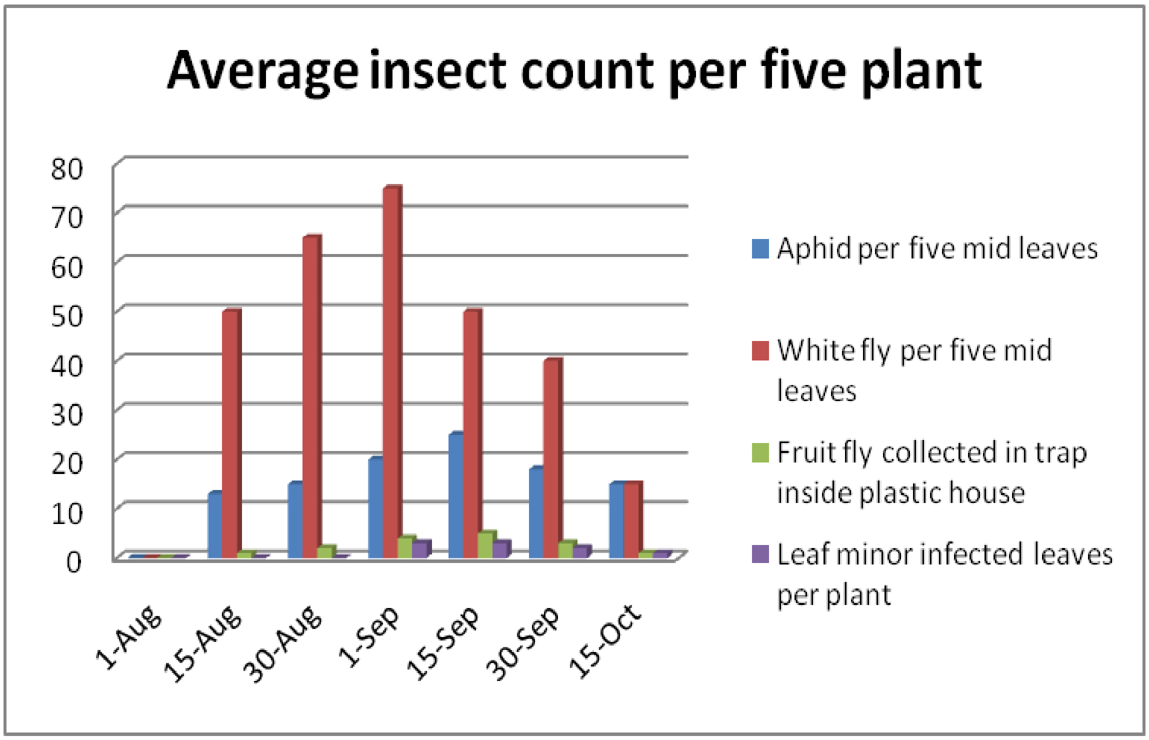


Figure 2: Average insect count per five plant inside plastic house in tomato at different dates

Insect and disease incidence monitoring in the plastic houses Palpa and Kaski (Hemja) Pokhara has shown that insects such as Root knot nematodes, whiteflies, aphids and leaf miners were severe problems in several plastic houses in the study areas. Among them root-knot nematodes and white flies were the major problems and prioritized for study and control. Among diseases stem blight, leaf blight and powdery mildews and leaf miners are major problems.

The severity of insect attack also associated with temperature and humidity. During high temperature and high humidity during August the insect count was found high (Table 2 and Figure 2). With the unset of rain and lowering of temperature the insect population decreases.

During a field visit, farmer reported that the whitefly problem has decreased with the onset of rain. They also indicated that application of insecticide has worsened the situation in the previous year. However, a close observation in the field has indicated the presence of a new potential predatory insect suspected as *Macrolophus* spp. (Hemiptera: Miridae). This insect was more prevalent in the fields that did not receive chemical insecticide application. There appeared a negative correlation between this bug and whitefly populations.

Similarly, during the second visit, few whitefly adults were found dead in the tomato leaves where some fungal growth was also seen. This is suspected as a potential pathogen against whitefly. Project expert Dr. Raju Pandey discussed it with the Regional Plant Protection Laboratory at Hariharbhawan to isolate and multiply this fungus. Further work will depend on the progress with these biological control agents.

***Result 2:*** **Soil nutrient dynamics under plastic house system explored**

The main objective of soil nutrient analysis was to define and describe the nutrient change pattern under plastic house crop production system

Soil samples from plastic house and outside plastic house from Madanpokhara and Chirtungdhara Palpa and Hemja and Batulechaur of kaski collected. Soil samples also have been collected from the same plastic houses in the second and third year and a trend of major crop nutrient (NPK) and organic matter dynamics have been determined. Collected Soil samples submitted to laboratories for general analysis such as PH, organic matter content, Nitrogen, Phosphorus and Potash content and micro-nutrient analysis mainly for boron and calcium. The samples were analysed at soil science laboratory (NARC Bhairahawa, Pokhara and Soil Management Directorate Department of Agriculture, Harihar Bhawan. Soil sample analysis is completed and report from laboratory available. Soil samples collected during first year second trimester to third year first trimester is completed for major and micronutrient analysis. Soil nutrient dynamics under plastic house system has been explored. Organic matter content was slightly higher in samples from inside plastic houses compared to those from outside the plastic house. Over all the organic matter content was medium whereas Phosphorus and Potash were high in all the samples. Soil reaction in all the plastic houses were acidic ranging from 5.1 to 6.9. Framers having soil pH less than 6.5 have been advised to apply lime in the soil. Farmers trained on adding organic manure and lime at recommended dose are made as regular practice. Micro-nutrients such as boron have been found decreasing in soil which leads to fruit end blight in tomato. The details of soil analysis are presented in Annex 1.

**Result 3: Biotic constraints (insect and disease) overcoming tool developed**

**3.1 Screening and identification of possible rootstocks against soil borne diseases:**

The objective of this screening was to identify resistant rootstock to nematode and soil borne diseases of tomato. There were three main objectives a) Study graft suitability in terms of success rate of grafting b) study impact of root stock on tomato yields of commercial variety c) Disseminate the results of study for commercialization.

Grafting of tomato varieties on resistant rootstocks of other Solanum species including egg plant, is commonly practiced to control wilt diseases in other countries such as Japan, Taiwan, Thailand, Vietnam, Bangladesh etc. AVRDC recommends eggplant accessions EG195 and EG203. They are resistant to damage caused by flooding, bacterial wilt, root-knot nematode (caused by Meloidogyne incognita), and tomato *Fusarium* wilt (caused by *Fusarium oxysporum f.sp. lycopersici*). Similarly, some of the soil borne diseases of cucumber also can be controlled by grafting the cucumber scion on other cucurbit crops varieties such as bottle gourd. This method however, has not been practiced in Nepal. Possibility of using such techniques on suppressing soil borne disease of cucumber should be assessed in future

Seeds of resistant rootstocks for tomato acquired from AVRDC and planted for seed multiplication during first season. During second season grafting techniques were evaluated with different root-stocks in Hemja and Batulechaur of kaski. Effect of rootstock on scion yield studied in Hemja and Batulechaur of Kaski

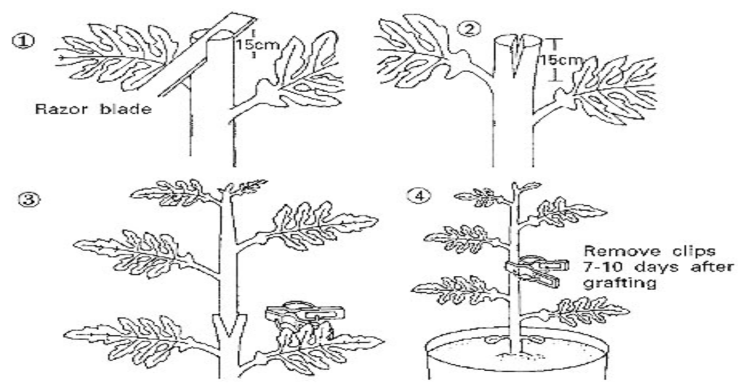


Figure 3: Grafting techniques of tomato

Figure 4: Grafting of tomato on nematode and bacterial disease resistant root stock

Grafting techniques has been evaluated with different root-stocks. Grafting of tomato varieties on resistant rootstocks of other *Solanum* species such as eggplant accessions EG195 and EG203 were also tried. Wild species of Solanum such as kantakari also tried as root-stock. The study showed that tomato seedling has good compatibility with *Solanum torvum*, *S. xanthocarpum*, *Solanum cicimrifolium* and *S. melongena including tomato line received from AVRDC*. Tomato seedling grafted on *Solanum torvum*, and *Solanum. xanthocarpum*, gave better scion yield compared to grafted on *Solanum melongena* and AVRDC tomato line. Study confirmed that both root stocks gave better yield than planted without grafting. The success rate of grafting and tomato yield per grafted plant are presented in Table 3

**Table 3: Success rate of graft and yield per grafted plants**

| Sites of grafting | Root stocks used | Scions used | Graft success rate% | Yield per graft plant kg |
|---|---|---|---|---|
| NHPC plastic house Khumaltar | *Solanum torvum* | Thims -16 | 60 | 4 |
| | | Sirjana | 57 | 4.6 |
| | S. xanthocarpum | Thims -16 | 49 | 3.2 |
| | | Sirjana | 65 | 3.4 |
| | S. cicimbrifolium | Thims -16 | 76 | 7 |
| | | Sirjana | 70 | 9 |
| | S. melongena EG 195 | Thims -16 | 54 | 3.5 |
| | *S. melongena EG 203.* | Thims -16 | 51 | 4.0 |
| Chitranath Paudel Hemja Kaski | *Solanum torvum* | Thims -16 | 36 | 5.2 |
| | | Sirjana | 26 | 4.3 |
| | S. cicimbrifolium | Thims -16 | 60 | 8.8 |
| | | Sirjana | 40 | 6.0 |
| Lok Bahadur Thapa, Batule chaur Kaski | *Solanum torvum* | Thims -16 | 60 | 6.5 |
| | S. cicimbrifolium | Thims -16 | 70 | 9.0 |

Grafting of tomato varieties on resistant rootstocks of other *Solanum* species such as eggplant accessions EG195 and EG203, *Solanum cicimrifolium* wild species of Solanum such as kantakari also tried as root-stock. Grafting on resistant rootstock produced 50 % to double yield of tomato per plant (average 4kg per plant in non grafted plant while it was 6-9 kg per plant in grafted plant) under plastic house condition. Efforts have been made to demonstrate and transfer simple technique for the grafting of commercial tomato variety on these rootstocks. These technologies have been transferred to farmers through trainings and demonstration.

### 3.2 Development of biological control agents:

Biological control agents play crucial role in the insect pest management. While monitoring the important pests, their prevalent natural enemies also have been monitored. Important insect pest such as *Helicoverpa armigera* is attacked by egg parasitoids of Trichogramma. Many predators including green lacewings prey upon aphids and whiteflies. Trichogramma and Chrysoperla are being reared at NARC Centres. These parasites were received from NARC, Entomology Division and were multiplied in larger scale at NHPC laboratory. The effectiveness of the biological control agents have been evaluated by augmentative releases of the agents under plastic house conditions. This practice could help up to October. After October *Trichograma* and *Chrysoperla* rearing in the laboratory has decreased due to severe cold in the winter coupled with the long hours (14-16 hours) of load shedding. Three major steps were identified for biological control of major insects of plastic house *Helicoverpa* and white flies.

1. Survey of biological control agents associated with white flies
2. Multiplication of identified biological control agents
3. Management of white flies through application of biological control agents

**Production of biological control agents**

Tiny egg parasitoid belonging to the genera *Trichogramma (Hymenoptera: Trichogrammatidae)* is the most commonly used biological control agent world wide. This wasp usually attacks the eggs of moths and butterflies. Indigenous species of Trichogramma was surveyed and reported from the western mountains area (Tanahu, Kaski and Syanjgja districts) and reared successfully at Lumle agricultural center. Since then, a small culture of this insect is being maintained at entomology laboratories at Lumle agriculture research station and Central division of Entomology, Khumaltar using the eggs of *Corcyra cephalonica* (Lepidoptera: Pyralidae).

*Corcyra cephalonica* is commonly known as Indian meal moth. It is common pest of stored food grain. At the same time, it has been most widely used as laboratory host for several biological control agents. Eggs of Corcyra can be used to rear Trichogramma egg parasitoids and green lacewings, a common predatory insect.

Eggs of this moth can be easily produced in the laboratory using corn meal. *Corcyra* production was initiated after receiving eggs from Entomology Division, NARC, Khumaltar in March 2008 in boxes. Adults were aspirated using a modified vacuum pump and transferred to egging cage made from plastic bucket fitted with window screen.

About 0.5 ml of Corcyra eggs were added to the insect rearing cage containing about 5 kg of corn, yeast meal (1 ml = 16000 – 18000 eggs). Room temperature was maintained at 20-25 degree Celcius. Adult moth began to emerge after about three weeks which was aspirated using a modified vaccum pump and transferred to an egging bucket. Eggs were collected and volumetrically measured. Parts of the eggs were used to produce more moths while others were used to produce *Trichogramma* wasps.

*Corcyra cephalonica* received from NARC. Adults were set in the laboratory for mass production during March 2008 in boxes. Total adults and eggs produced were recorded from April to December. The total adults production and egg productions are presented in Table 4 and Table 5 and figure 5 and figure 6 below;

**Table 4: Corcyra cephalonica adults' production in the laboratory during different months**

| Months | Total adults/month | Average adults/day |
|---|---|---|
| April | 3868 | 148.77 |
| May | 5162 | 215.08 |
| June | 5858 | 266.27 |
| July | 5423 | 335.35 |
| August | 4988 | 300.66 |
| September | 3257 | 204.78 |
| October | 2183 | 236.6 |
| November | 1129 | 125.44 |
| December | 918 | 92.55 |

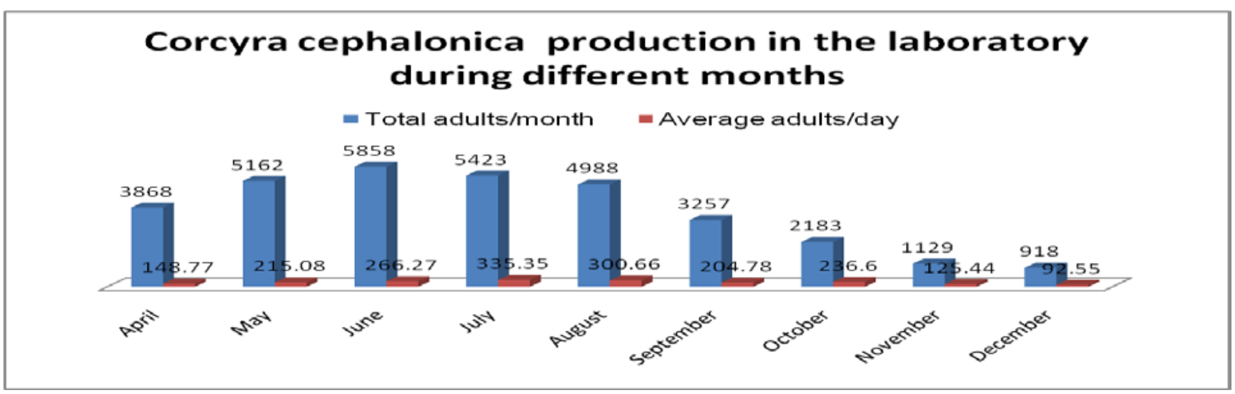


**Figure 5: Corcyra cephalonica production in the laboratory during different months**

**Table 5:** ***Corcyra cephalonica*** **eggs' production in the laboratory during different months**

| Months | Total Eggs ml/month | Average eggs ml/day |
|---|---|---|
| April | 12.49 | 0.48 |
| May | 41.4 | 1.73 |
| June | 41.7 | 1.9 |
| July | 67.8 | 2.61 |
| August | 57.9 | 1.96 |
| September | 37.98 | 1.45 |
| October | 21.83 | 0.96 |
| November | 9.98 | 0.34 |
| December | 4.9 | 0.15 |

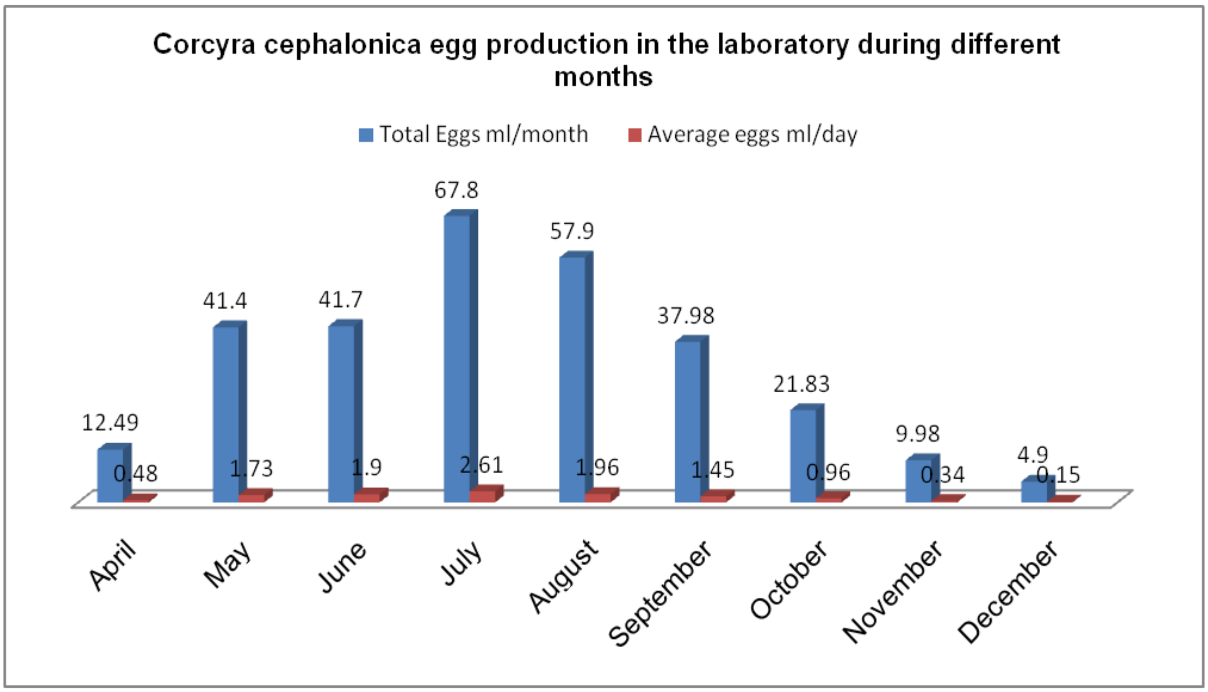


**Figure 6: Corcyra cephalonica egg production in the laboratory during different months**

## Rearing of host insect *Corcyra cephalonica*

Rearing has started from March 2008 and continued till December. Laboratory rearing of *Corcyra cephalonica* adults about 2 g (~30,000) *Corcyra* eggs produced daily.

## Trichogramma production:

Trichogramma cards (Tricho-cards) were made by gluing the eggs onto card-board paper. The eggs were then sterilized by exposing the tricho-cards to UV light for 30 minutes. Such cards were inoculated with live adult Trichogramma. Parasitized eggs turn black (as the Trichogramma turn into pupa stage within the corcyra eggs) in about 5-7 days and adult emergence occurred between 8-10 days. As much as 80% eggs were parasitized by *Trichogramma*. Trichogramma can be field released by hanging the tricho-cards on the plants in the field once they turn black (pupa stage).

Release of about 5000 trichogramma per ropani provides satisfactory control of pests such as fruit worm, *Helicoverpa armigera* in tomato.

**Production of Chrysoperla**

Green lace wing is a generalist predator widely used for the control of soft bodied insects such as aphids, whitefly, mealy bug, thrips etc. This insect lays eggs on stalked plant surface infested with prey insect. Upon hatching, the larva feeds voraciously on the prey. Larva pupates in a silken cocoon from which the adult lacewings emerge.

In the laboratory, production of this insect is tricky, as the late instars larvae are cannibalistic (feeding on their own species). Individual larvae were transferred into small plastic tubes which were provided with fresh Corcyra eggs daily. Adults were held on a larger cage and eggs laid within the cage were collected by brushing.

Production of host insect Corcyra and the biological control agents were seriously affected by long hours of load shedding, especially during the winter and early spring.

Parasitoid *Trichogramma* and predator *Chrysoperla* production continued for year 2 also. . A new potential predatory insect suspected as *Macrolophus* spp. (Hemiptera: Miridae) identified. Biological control agents play crucial role in the insect pest management. While monitoring the important pests, their prevalent natural enemies have also been monitored. Important insect pest such as *Helicoverpa armigera* is attacked by egg parasitoids such as *Trichogramma*. Many predators including green lacewings prey upon aphids and whiteflies. *Trichogramma* and *Chrysoperla* reared at NARC Centres were received and were multiplied in larger scale at NHPC laboratory. The effectiveness of the biological control agents were evaluated by augmentative releases of the agents under plastic house conditions. Parasite and predator rearing procedures have been shared with the farmers of Madanpokhara and Chirtungdhara, Palpa and Hemja and Batulechaur of kaski.

**Rearing of parasite/BCA production in Khumaltar**



A scene of parasite rearing in laboratory at NHPC Khumaltar



Trichogramma pupa turning black and ready for field release

**3.3: Demonstration of integrated pest management:**

The main objective of the demonstration was to transfer the technology and skill of off-season tomato production through applying appropriate technology of using biological and cultural practices to manage insect pests in the plastic houses.

**Methodology of integrated pest management**:

Based on the findings of above studies and other available techniques of pest management, integrated approach have been demonstrated to suppress the diseases and insect pests by using the biological control agents, resistant varieties and bio-rational pesticides (such as Neem, and other botanicals). Final work plans were developed after discussion with the farmers. Three most important pests: whitefly, fruit fly and root knot nematode were the target of this demonstration. The IPM technology included para-pheromone trap and *augmentoria* (fruit fly), promotion of natural enemy of whitefly and use of resistant root stock (root knot nematode). This activity has been conducted in Kaski and Palpa. Application of mustard cake and bio-slurry also controlled nematode in plastic houses.

Meetings and field days with farmers were organized in Madanpokhara chirtungdhara, Palpa and Hemja and Batulechaur Kaski to discuss the IPM strategy and study plans. Farmers have been shared with basic principles of grafting and IPM strategies. Extension material such as integrated pest management prepared and distributed to the farmers. Workshops were organized to disseminate the findings and learning from the study.

**Result 4: The project output disseminated to wider range of clients through workshops, field days and extension materials such as and leaflets**

Farmer's knowledge and skill on soil nutrient management, grafting of commercial varieties of tomato on resistant rootstock, training and pruning of tomato have been enhanced through different trainings such as rootstock growing, grafting, integrated pest and nutrient management such as compost and FYM application, liming of plots and application of mustard cakes enhanced to produce more and prolonged yield of tomato. Field days and intensive coaching on grafting have been organized in successful demonstration plots to widen the understanding of farmers based on the principles of **"Seeing is believing and learning by doing"** The specific activities conducted for output dissemination are as follows:

1. Four disease and insect management plots demonstrated through integrated approach in Madam Pokhara Palpa and Hemja and Batulechaur Kaski.
2. The success of program was publicised through various leaflets and exhibition. .
3. Farmers meeting, field days, field visits successfully organized which provided forum for discussion/interaction among farmers and technicians. It has helped to develop awareness about the management techniques.
4. Field level dissemination workshops on plastic house management organized in Hemja Kaski and Madam Pokhara Palpa were participated by field technicians and farmers from the respective districts. It provided a good opportunity for discussion among the technicians and the farmers.
5. Two hundred copies of leaflets on *प्लास्टिक घर भित्र एकीकृत शत्रुजीव व्यवस्थापन* published and distributed to farmers of project sites.

To share the project outputs with larger stakeholders and promote dissemination, workshops have been organized at production pockets and at central level to provide forum where all the major stakeholders participated. Vegetable production and related line agencies discussed on the possibility of dissemination of the project outcomes to other parts of the district. District and central level stakeholders have been invited in the workshop. Project coordinator and other expert presented the findings and learning in the workshops

## 5. Discussion

The main off-season of tomato harvesting is August to October when tomato supply is lean in the market and fetches higher prices. For this season tomato planting starts from May/June and fruiting starts from July and tomato starts maturing from August and continues up to November under plastic house protection. During early stage the plants are healthy and diseases attack is less. When rainy season and high humidity prevail from August onward the diseases attack also increases. Disease incidence is highest during August and September. From October onward temperature starts falling down and rain is over and diseases also are reduced. During rainy season precautions must be taken to manage the diseases. Insect and disease incidence monitoring in the plastic houses Palpa and Kaski (Hemja) Pokhara has shown that insects such as Root knot nematodes, whiteflies, aphids and leaf miners were severe problems in several plastic houses in the study areas. Among them root-knot nematodes and white flies were the major problems and prioritized for study and control. Among diseases stem blight, leaf blight and powdery mildews and leaf miners are major problems.

Soil nutrient dynamics under plastic house system in the project sites showed that organic matter content was slightly higher in samples from inside plastic houses compared to those from outside the plastic house. Over all the organic matter content was medium whereas Phosphorus and Potash were high in all the samples. Soil reaction in all the plastic houses were acidic ranging from 5.1 to 6.9. Framers having soil pH less than 6.5 have been advised to apply lime in the soil. To maintain soil inside plastic houses in sustainable way, regular application of well rotten Farm yard Manure and lime has been recommended. Micro-nutrients such as boron have been found decreasing in soil which leads to fruit end blight in tomato and should be added at the rate 1 kg borax per ropani plastic house.

Grafting of commercial tomato varieties on resistant rootstocks of other *Solanum* species such as eggplant accessions EG195 and EG203, *Solanum cicimrifolium* wild species of Solanum such as kantakari also tried as root-stock. Grafting on resistant rootstock produced 50 % to double yield of tomato per plant (average 4 kg per plant in non grafted plant while it was 6-9 kg per plant in grafted plant) under plastic house condition. Grafting techniques is more practical against nematodes and soil borne diseases like *Fusrium oxysporium*.

Rearing of insect parasites and releasing to overcome insect pest is possible, however at farmers level rearing parasitoids is practically difficult. If some specialized agencies could start this as business then it is useful tool to control many insect pests inside plastic houses. Some parasitic agents appear naturally in the host plant but it appears in the late season when considerable damage has already been occurred.

The most practical ways is to keep the plastic houses clean removing old and deceased leaves rotten fruits and picking and burying the borer attacked fruits as and when seen. Application of mustard cake and spraying of diluted urine (1: 5) also suppresses diseases and insects in general

## 5. Conclusion

Efforts have been made to identify major second generation problems and develop simple and sustainable techniques to overcome such problems. Demonstration and practice of simple technique for the grafting of commercial tomato variety on these rootstocks have been transferred to farmers through trainings and demonstration.

Increased pace of commercialization of high value perishable commodities such as off-season tomato involves integrated approach in maintaining plastic houses in well soil management, field sanitation, cleaning of diseased plant parts, dried leaves and application of balanced major and and micro-nutrients through organic sources (FYM, Compost, Mustard cakes etc.). Grafting of commercial variety on resistant root stocks is of prime importance to overcome soil borne pathogens and nematodes. Unless all the fronts are dealt with simultaneously, isolated effort in one front not only leads to wastage of resources but also creates negative environment and frustration on the part of actors on the success of such High Value Crop (HVC) production program.

In the production front, a number of constraints are apparent. First, change in developmental attitude of the poor farmers from subsistence to commercialization, change in skill and capacity of production, based on market demand and development of sizable scale of production blocks in terms of their size and alignment along the major highways. Unless sizable blocks are planned commercialization effort would pay less advantage from scale economies. Proper soil and nutrient management and grafting of tomato on resistant root stock are the fundamental to the suppression disease and insects in the plastic houses. Untiring endeavour on nutrient management, campaign of grafting, and modification of plastic houses to regulate temperature should be initiated by extension agencies (both Government and Non-Government organisations) to disseminate the simple technique for plastic house management. The government and non-government organisation involved in the promotion of vegetable crop production should take the technology to the farmers.

The future impact and implication of the findings of this project will depend upon the dissemination and successful adoption of these technologies in the complex farming system of communities. It is therefore; the means of effective dissemination of technology skill training has been taken care in extension process. In the project areas technologies have been demonstrated in collaboration with GoN extension system through the support of NARDF. Therefore the rate of adoption of techniques of off-season tomato production and its impacts on productivity and income will depend on the effective and practical training carried out in other areas and the extension materials developed are disseminated properly. Hence, any post evaluation of the project should be concentrated in the areas where such demonstration is carried out during uptake pathways.

## 6 Recommendation

Enhancing vegetable production through improved plastic house technologies (FPP 425) project was one of the successful projects implemented by Nepal Horticulture Promotion Centre through farmers' participation. The main reason for the high rate of client participation was the identification of the severe problem and conduction of simple experiments in the farmer’s fields

With the successful completion of the project and lesions learnt the following recommendations have been made for the continuity and sustainable scaling up of the findings:

- Adoption of liming, mustard cake application and grafting of commercial tomato varieties on resistant rootstocks should be regular practice in plastic house off-season tomato production
- Adoption of liming, increased FYM and mustard cake application in the plastic houses before transplanting tomato and other main crops should be the routine work
- Adoption of crop rotation including non-solanacious crops like bitter gourd and cucumber reduces soil borne pathogens.
- Increased awareness about disease and insect manifestation among farmers and adoption of preventive methods for plastic house management.
- Modification of plastic house structures for well ventilation should be adopted in low altitude areas
- Extensive dissemination of project produced extension materials to farmers and stakeholders

## 6. Acknowledgement

Nepal Horticulture Promotion Center is grateful to National Agricultural Research and Development Fund for awarding this very important project " **Enhancing vegetable production through improved plastic house technologies (FPP 425)”** to undertake in Western Development Region where off-season tomato production taking lead.. Marketing was potential in Kathmandu and other local markets. HOPROC/Nepal) also highly appreciates the generosity of the farmers of project areas of Palpa and Kaski. We also highly acknowledge the help and cooperation given to us during project implementation by the field Technician (JT/JTAs) of Agriculture Service Centers of the project areas and DADOs, Horticulture Officers and Plant Protection Officers of Palpa and Kaski districts. HOPROC/Nepal) is highly grateful to Mr. Narendra Pandey of Palpa, Ganapati Pandey Farm Manager Cirtus Development Farm Palpa and plant protection Directorate/ DoA Harharbhawan, Entomology Division NARC/Khumaltar and all concerned scientists and authorities of MOAC. HOPROC/Nepal acknowledges the involvement of team members Messrs Indra Raj Pandey, Dr. Raju Raj Pandey, Mr. Rajenra Prasad Acharya, Mr. Dhruba Raj Bam, Mr. Rajendra Prakash Pandey, Mr. Pradip Neupane, Mr. Prabesh Raj Pandey, and Mr. Diwash Bista and Mr. Netra Badur Thapa.

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**Annex 1: Soil nutrient analysis summary**:

2.1 Soil analysis summary for Palpa

| R. No | Farmer's name | Farmer's Address | I.D | PH (1:1) | Organic matter % | Phosphorus Olsen(ppm) | Potash Exch.(ppm) | Nitrogen % | Recommendation ( per Rppani) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Lime | FYM |
| 1 | Human singh Rana | Chertundhara-6, palpa | In side | 6.5 | 5.9 | 413..3 | 1067.7 | 0.30 | - | 500 kg |
| 2 | Human Singh Rana | Chertungdhara-6 Palpa | Out side | 6.0 | 5.5 | 413.3 | 861.9 | 0.28 | 92 kg | 500 Kg |
| 3 | Ghinisara gaha | Chertungdhara-3 Palpa | Out side | 5.2 | 3.2 | 192.3 | 576.2 | 0.16 | 218 kg | 1000 kg |
| 4 | Ghinisara Gaha | Chertungdhara-3 Palpa | In Side | 5.8 | 2.8 | 92.9 | 324.8 | 0.14 | 128 kg | 1000 kg |
| 5 | Krishna Kala Ghaha | Chertungdhara-3 , Palpa | In Side | 5.1 | 3.3 | 120.5 | 359.1 | 0.17 | 228 kg | 1000 kg |
| 6 | Krishna Kala Ghaha | Chertungdhara-3 , Palpa | Out side | 5.8 | 3.9 | 347.0 | 1027.7 | 0.20 | 128 kg | 1000 kg |
| 7 | Dhanisara gaha | Chertungdhara-3 , Palpa | Out side | 6.2 | 2.8 | 324.9 | 1497.4 | 0.14 | 60 | 1000 kg |
| 8 | Dhanisara gaha | Chertungdhara-3 , Palpa | In side | 6.7 | 3.1 | 115.0 | 1126.3 | 0.15 | 0 | 1000 kg |
| 9 | Ishowri P Dhungana | Chertungdhara-1 , Palpa | Out side | 6.6 | 0.3 | 159.2 | 930.5 | 0.01 | 0 | 1500 |
| 10 | Ishowri P Dhungana | Chertungdhara-1 , Palpa | Out side | 6.0 | 3.3 | 36.6 | 339.2 | 0.16 | 92 | 1000 |
| 11 | Jaman s. Chithi | Chertungdhara- | In side | 5.3 | 3.0 | 208.9 | 227.6 | 0.15 | 204 | 1000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 , Palpa | | | | | | | | |
| 12 | Jaman s. Chithi | Chertungdhara-6 , Palpa | out side | 5.6 | 3.5 | 186.8 | 187.6 | 0.18 | 158 | 1000 |
| 13 | Madan B Dalami | Kaseli 7, Palpa | Out side | 6.1 | 1.8 | 54.2 | 153.4 | 0.09 | 78 | 1500 |
| 14 | Madan B Dalami | Kaseli 7, Palpa | In side | 5.7 | 2.1 | 70.8 | 84.8 | 0.11 | 142 | 1500 |
| 15 | Nagendra Raj Pandey | Madan Pokhara, Palpa | Out side | 6.1 | 1.6 | 70.8 | 381.9 | 0.08 | 78 | 1500 |
| 16 | Nagendra Raj Pandey | Madan Pokhara, Palpa | In side | 6.5 | 1.6 | 87.4 | 393.4 | 0.08 | 0 | 1500 |
| 17 | Kul P Dhungana | Chertungdhara-1 , Palpa | Out side | 6.2 | 3.9 | 48.7 | 536.2 | 0.19 | 60 | 1000 |
| 18 | Kul P Dhungana | Chertungdhara-1 , Palpa | In side | 6.6 | 3.9 | 70.8 | 877.0 | 0.20 | 0 | 1000 |
| 19 | Kul P Dhungana (A) | Chertungdhara-1 , Palpa | Out side | 6.5 | 4.3 | 159.2 | 511.7 | 0.21 | 0 | 1000 |
| 20 | Kul P Dhungana (A) | Chertungdhara-1 , Palpa | Inside | 6.3 | 3.8 | 236.5 | 598.6 | 0.19 | 40 | 1000 |
| 21 | Chet Bahadur B.K | Chertungdhara-1 , Palpa | inside | 5.2 | 3.9 | 428.3 | 570.1 | 0.20 | 218 | 1000 |
| 22 | Chet Bahadur B.K | Chertungdhara-1 , Palpa | Outside | 5.0 | 3.8 | 87.4 | 540.6 | 0.19 | 92 | 1000 |
| 23 | Nirmala Raymajhi | Madan Pokharas Palpa | Inside | 5.5 | 3.0 | 385.7 | 1190 | 0.15 | 170 | 1000 |
| 24 | Nirmala Raymajhi | Madan Pokhara Palpa | Outside | 5.6 | 2.4 | 302.8 | 813.2 | 0.12 | 158 | 1500 |
| 25 | Mr.Bhandar | Palpa | inside | 5.3 | 3.8 | 722.6 | 407.3 | 0.19 | 204 | 1000 |
| 26 | Mr. Bhandari | Palpa | outside | 7.1 | 1.7 | 302.8 | 494.3 | 0.08 | 0 | 1500 |

**<u>Annex 2: </u> Soil nutrient analysis summary**:

2.1 Soil analysis summary for Pokhara, Kaski

| R. No | Farmer's name | Farmer's Address | I.D | PH (1:1) | Organic matter % | Phosphorus Olsen(ppm) | Potash Exch.(ppm) | Nitrogen % | Recommendation ( per Rppani) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Lime | FYM |
| 1 | Durga B. Khadka | Batulichaur 16, Kaski | In side | 6.3 | 4.3 | 637 | 362 | 0.22 | 29 kg | 500 kg |
| 2 | Durga B. Khadka | Batulichaur 16, Kaski | Out side | 6.3 | 5.1 | 7089 | 1092 | 0.25 | 29 kg | 500 Kg |
| 3 | Shalikgram Bastola | Hemja 3, Kaski | Out side | 6.4 | 2.6 | 438 | 679 | 0.13 | 15 kg | 1000 kg |
| 4 | Shalikgram Bastola | Hemja 3, Kaski | In Side | 6.4 | 3.9 | 854 | 614 | 0.19 | 15 kg | 1000 kg |
| 5 | Chitra Nath Paudel | Hemja 2, Kaski | In Side | 5.3 | 4.0 | 462 | 770 | 0.20 | 150 kg | 1000 kg |
| 6 | Chitra Nath Paudel | Hemja 2, Kaski | Out side | 5.3 | 4.0 | 462 | 770 | 0.20 | 150 kg | 1000 kg |
| 7 | Rishiram Paudel | Hemja 2, Kaski | Out side | 6.3 | 5.4 | 7084 | 980 | 0.26 | 29 kg | 1000 kg |
| 8 | Rishiram Paudel | Hemja 2, Kaski | In side | 5.8 | 3.9 | 7089 | 924 | 0.19 | 96 kg | 1000 kg |
| 9 | Sharada Paudel | Hemja 2, Kaski | Out side | 6.4 | 5.3 | 7084 | 579 | 0.26 | 15 kg | 1000 kg |
| 10 | Sharada Paudel | Hemja 2, Kaski | In side | 6.2 | 5.2 | 7084 | 964 | 0.26 | 43 kg | 1000 kg |

Annex 3 Participant farmers for enhancing Vegetable Production through Improved Plastic House Technologies

Palpa

| S. No | Name of farmers | Address | Major activities performed |
|---|---|---|---|
| 1 | Man B Darlami | Kaseni-6 Phulbari,Palpa | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification-Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch (ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |
| 2 | Human shing Rana | Kaseni-6 Phulbari ,Palpa | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |
| 3 | Nagendra Pandey | Madhanpokhara, Palpa | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |

| | | | | |
|---|---|---|---|---|
| | | | | Biological control agents |
| 4 | Dhanishara shah | Chirtudhara, Palpa | | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | | Biological control agents |
| 5 | Ishowri P Dhungana | Chirtudhara, Palpa | | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | | Biological control agents |
| 6 | Kul P Dhungana | Chirtudhara, Palpa | | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | | Biological control agents |
| 7 | Chet B BK | Chirtudhara, Palpa | | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |

| | | | |
|---|---|---|---|
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |
| 8 | Nirmala Raimajhi | Madhanpokhara, Palpa | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |

Kaski Pokhara

| S. No | Name of farmers | Address | Major activities performed |
|---|---|---|---|
| 1 | Shalikram Bastola | Hemja-3, Milan chowk,Kaski | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |
| 2 | Chitranath Paudel | Hemja-3, Milan | Disease monitoring (Pathogen identification-leaf miner, stem |

| | | | |
|---|---|---|---|
| | | chowk,Kaski | blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |
| 3 | Rishiram Paudel | Hemja-3, Milan chowk,Kaski | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |
| 4 | Sharadha Paudel | Hemja-3, Milan chowk,Kaski | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |
| 5 | Lok B. Thapa | Pokhara-16, Batulichaur ,Kaski | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ |

| | | | |
|---|---|---|---|
| | | | Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |
| 6 | Durga B Khadka | Pokhara-16, Batulichaur ,Kaski | Disease monitoring (Pathogen identification-leaf miner, stem blight and leaf blight |
| | | | Insect monitoring(insect monitoring and identification- Aphid, whitefly, fruit fly and leaf eating caterpillar |
| | | | Nutrient analysis (soil testing –PH/ OM%/N%/Olsen (ppm)P/ Exch(ppm) K) |
| | | | Pest management studies (yellow trap/grafting/ pheromone trap |
| | | | Biological control agents |

Annex 4: Name of participation Farmers in tomato grafting

| | | |
|---|---|---|
| 1. Durga Bahadur Khadka | Pokhara 16 | Kaski Batulechaur |
| 2. Lok Bahadur Thapa | Pokhara 16 | Kaski Batulechaur |
| 3. Rishiram Paudel | Hemja 2 | Kaski Hemja |
| 4. Chitranath Paudel | Hemja 2 | Kaski Hemja |
| 5. Salikram Bastola | Hemja 3 | Kaski Hemja |
| 6. Sarada Paudel | Hemja 3 | Kaski Hemja |