TCP/NEP/3302: (D)
DRAFT

TECHNICAL COOPERATION PROGRAMME

TERMINAL REPORT OF THE PROJECT
COMBATING CITRUS DECLINE PROBLEMS IN NEPAL

THE FOOD AND AGRICULTURE ORGANIZATION OF THE
UNITED NATIONS (FAO), COUNTRY OFFICE, NEPAL
DECEMBER, 2012
### ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APP</td>
<td>Agriculture Perspective Plan</td>
</tr>
<tr>
<td>ASCs</td>
<td>Agriculture Service Centers</td>
</tr>
<tr>
<td>CGD</td>
<td>Citrus Greening Disease</td>
</tr>
<tr>
<td>DoA</td>
<td>Department of Agriculture</td>
</tr>
<tr>
<td>FDD</td>
<td>Fruit Development Directorate of the DoA</td>
</tr>
<tr>
<td>GAP</td>
<td>Good Agricultural Practice</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GoN</td>
<td>Government of Nepal</td>
</tr>
<tr>
<td>GTDs</td>
<td>Graft Transmission Diseases</td>
</tr>
<tr>
<td>HLB</td>
<td>Huanglongbing</td>
</tr>
<tr>
<td>JT</td>
<td>Junior Technician</td>
</tr>
<tr>
<td>JTAs</td>
<td>Junior Technical Assistants</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
</tr>
<tr>
<td>MoAC</td>
<td>Ministry of Agriculture and Cooperatives</td>
</tr>
<tr>
<td>MoAD</td>
<td>Ministry of Agricultural Development</td>
</tr>
<tr>
<td>NAP</td>
<td>National Agriculture Policy</td>
</tr>
<tr>
<td>NARC</td>
<td>National Agricultural Research Council</td>
</tr>
<tr>
<td>NARDF</td>
<td>National Agriculture Research and Development Fund</td>
</tr>
<tr>
<td>NAST</td>
<td>Nepal Academy of Science and Technology</td>
</tr>
<tr>
<td>NCDP</td>
<td>National Citrus Development Programme</td>
</tr>
<tr>
<td>NMTPF</td>
<td>National Medium-term Priority Framework</td>
</tr>
<tr>
<td>NPC</td>
<td>National Project Coordinator</td>
</tr>
<tr>
<td>OVOP</td>
<td>One Village One Product</td>
</tr>
<tr>
<td>PMU</td>
<td>Project Management Unit</td>
</tr>
<tr>
<td>PSC</td>
<td>Project Steering Committee</td>
</tr>
<tr>
<td>STG</td>
<td>Shoot Tip Grafting in Vitro</td>
</tr>
<tr>
<td>TCP</td>
<td>Technical Cooperation Programme of FAO</td>
</tr>
<tr>
<td>ToTs</td>
<td>Training of Trainers</td>
</tr>
<tr>
<td>TYIP</td>
<td>Three-year Interim Plan (2007-2010)</td>
</tr>
<tr>
<td>UNDAF</td>
<td>United Nations Development Assistance Framework</td>
</tr>
<tr>
<td>WTO</td>
<td>World Trade Organization</td>
</tr>
</tbody>
</table>
# Table of Contents

1. INTRODUCTION ........................................................................................................... 444
   1.1 Project background ......................................................................................................... 444
   1.2 Outline of management arrangement ............................................................................... 444
   1.3 Project objectives and operational plans ......................................................................... 444
       1.3.1 Project objectives ............... Error! Bookmark not defined.Error! Bookmark not defined 2
       1.3.2 Project operational plans ....................................................................................... 442
       1.3.3 Expected project outputs ....................................................................................... 443
2. DETAILED ACTIVITY PLANS AND METHODOLOGY Error! Bookmark not defined Error! Bookmark not defined
   2.1 Capacity building ................. Error! Bookmark not defined Error! Bookmark not defined 5
       2.1.1 Training Programme (ToTs) to develop 50 master trainers to train citrus growers/farmers
       ........................................ Error! Bookmark not defined Error! Bookmark not defined 5
       2.1.2 Technical Capacity building of Citrus growers (Farmers’ training) ... Error! Bookmark not defined Error! Bookmark not defined 5
   2.2 Improved Production Package (GAP) Demonstrations ... Error! Bookmark not defined Error! Bookmark not defined 6
   2.3 Field survey, indexing for HLB/greening disease and nutrient analysis for decline mapping Error! Bookmark not defined Error! Bookmark not defined 11
       2.3.1 Field survey ...................... Error! Bookmark not defined Error! Bookmark not defined 11
       2.3.2 Nutrient analysis ............... Error! Bookmark not defined Error! Bookmark not defined 12
       2.3.3 HLB/Greening disease indexing procedures Error! Bookmark not defined Error! Bookmark not defined 12
   2.4 Project implementation sites Error! Bookmark not defined Error! Bookmark not defined 12
3. RESULTS AND CONCLUSION ................................................................................... 5443
   3.1 Key performance indicators ......................................................................................... 5443
   3.2 Result of Field Investigations Error! Bookmark not defined Error! Bookmark not defined 18
       3.2.1 Decline survey ............... Error! Bookmark not defined Error! Bookmark not defined 18
       3.2.2 Status of HLB disease in Citrus pockets Error! Bookmark not defined Error! Bookmark not defined 18
       3.2.3 Phytophthora rot diseases status .... Error! Bookmark not defined Error! Bookmark not defined 20
       3.2.4 Leaf Nutrient Status ...... Error! Bookmark not defined Error! Bookmark not defined 20
   3.3 Results of field demonstrations Error! Bookmark not defined Error! Bookmark not defined 24
       3.4 Suggested strategic Actions Error! Bookmark not defined Error! Bookmark not defined 22
4. RECOMMENDATIONS ............................................................................................... 101436
   4.1 General Recommendations ......................................................................................... 101436
   4.2 Specific Recommendations ......................................................................................... 101437
   4.3 Plant protection ......................................................................................................... 114348
   4.4 Training and capacity building .................................................................................. 124248
5. FUTURE LINE OF ACTIONS ..................................................................................... 124239
1. INTRODUCTION

1.1 Project Background

Citrus is one of the most economically important fruit crops of Nepal which contributes about 37 and 32 percent of total production and area of fruit in Nepal.

The existing citrus orchards are predominantly of seedling origin and plants coexist with various seasonal intercrops. Citrus is intercropped with maize, millets, potato, mustard, etc. which is not desirable. Citrus being a surface feeder, winter intercrops like mustard, potato and vegetables directly compete with citrus for moisture during dry months. Since topography is hilly, sustainable soil management and water conservation practices are also equally important. An average grower expects that the plants will establish themselves and bear fruit without much care. Therefore, citrus hardly get any special attention in terms of labour and material inputs.

Trees infected with deadly diseases like foot rot and Huanglongbing (HLB) are not generally removed and they remain as constant sources of infection. All these factors are causing citrus decline in Nepal. Though, the Government of Nepal (GoN) is encouraging the use of grafted planting materials and promoting private nursery for multiplication of grafted plants mainly on two rootstocks namely Seti Jyamir, rough lemon (C. jambhiri) and trifoliate orange (Poncirus trifoliata). However, strategy for combating citrus decline is not well defined in and not much attention is paid in the selection of scion materials and the possibility of using certified bud wood material by the nursery. Hence, this TCP was implemented.

1.2 Project Objectives

This Project was implemented with the objective of finding solutions to citrus decline problem in Nepal. The specific objectives of the project were as follows:

- assessment of severity of citrus decline, mapping of citrus decline and working-out combat strategies;
- institutional and technical capacity building for technology backed citrus development in Nepal; and
- gradual shifting from traditional citrus growing to commercial citriculture for better economic returns.

1.3 Project Management and Implementation Arrangements

The GoN constituted a seven member Project Steering Committee (PSC) with the chairmanship of Director General of Department of Agriculture (DoA). Other members in PSC included three from the relevant institutions of DoA, one member each from Nepal Agricultural Research Council (NARC) and FAO Nepal and the Chief of National Citrus Crop Development Programme of DoA as Member Secretary. A Project Management Unit (PMU) was established for the implementation of daily project activities. The PMU was led by the Member Secretary of PSC and supported by national consultants and other government officials. Detail about Unit is presented in Annex 1.

1.4 Major Project Activities

Field level activities and technical and institutional capacity building were the two major activities of the project. Field activities mainly included - project site selection, group formation and mobilization, participatory demonstrations, and survey and mapping of citrus decline. The technical and institutional capacity building component of the project mainly included - upgradation of knowledge and skills of extension field functionaries and citrus growers, transfer of technology, development of training courses and manuals, study tour, development of combat strategy, and piloting of a bud wood certification system.

1.5 Expected Outputs

Four expected outputs of the project were: (a) strengthening of technical and institutional capacity; (b) identification of technological options for disease management and capacity enhancement of citrus growers; (c) putting monitoring and information system in place and...
better planning in citrus development; and (d) preparation of an acceptable proposal on establishment of bud-wood/scion certification system.

2. RESULTS AND CONCLUSIONS

Following results/outputs were obtained from the project implementation.

2.1 Strengthened Technical and Institutional Capacity

A total of 51 officials of DoA (26 officers and 25 field based non-officer JT/JTAs) were provided with five days Training of Trainers (ToTs) and two officers were sent to National Research Center for Citrus, Nagpur, India for study visit.

In addition, 13 officers were trained on Shoot Tip Grafting in Vitro (STG) and Polymer Chain Reaction (PCR) based diagnosis of HLB at Nepal Academy of Science and Technology (NAST), Khumaltar, 23 officers were trained on Biological Indexing and Budwood Certification System during in Central Horticulture Center, Kirtipur, and 28 field technicians from 28 non-project districts and 60 technicians from 60 citrus pockets of seven project districts were trained on survey technique for Citrus Decline Mapping.

After the ToT, the master trainers trained 1,700 citrus grower farmers of seven project districts on Citrus Orchard Management Technology.

Field demonstrations were also conducted to transfer technology and to strengthen farmers capacity. About 60 demonstrations on rejuvenation of 15-20 years old citrus trees and Improved Production Package or Good Agricultural Practices (GAPs) demonstration for 2-4 years old citrus trees were carried out in 60 pockets.

2.2 Results of Survey

The highlights of the survey and demonstration results are presented below and details are presented in Annex 4.

2.2.1 Status of HLB Disease

a. A total of 148 samples from 21 citrus pockets of seven project districts were collected for indexing by following PCR techniques. Out of 148 samples, 43 samples showed positive HLB reactions (29% infection). The samples were collected only from suspected trees with visual symptoms of HLB disease, thus confirming the fact that HLB detection based on visual symptom alone is not a reliable method.

b. In about 33 percent of citrus pockets surveyed (7 out of 21), HLB could not be detected and may be considered as HLB free area. They were:

<table>
<thead>
<tr>
<th>District</th>
<th>Disease Free Pockets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dhankuta</td>
<td>Belhara, Khoku</td>
</tr>
<tr>
<td>Gorkha</td>
<td>Nareswar, Prithvi Muniaplity</td>
</tr>
<tr>
<td>Kavre</td>
<td>Panauti</td>
</tr>
<tr>
<td>Tanahun</td>
<td>Jamune</td>
</tr>
<tr>
<td>Syangja</td>
<td>Dahthum</td>
</tr>
</tbody>
</table>

c. High incidence of HLB in Dhankuta (Karmitar and Chuliban area) and Kavre (Sankhu area) districts was reported by NAST but absence of insect vector restricted spread of the disease. On the other hand, Satiwara, Dumre, Chok Chisapani, and Bandipur areas in Tanahun district and Malepatan and others areas of Kaski district had high incidence of HLB and it was found directly associated with the presence of Citrus Psylla and its alternate preferential hosts Murraya koeingi and/or M. paniculata.

d. Current HLB status indicates that immediate steps are to be undertaken to remove/destroy the diseased trees (confirmed through indexing only) in the high alarming zones of Tanahun, Kaski, Kavre, Dhading and some areas of Dhankuta districts. In Udipur and Tilhari Danda areas of Lamjung district adjacent to Chok Chisapani pocket of Tanahun district also need attention to control HLB disease.
e. The seven HLB free pockets in Dhankuta, Gorkha, Kavre and Syangja districts did not seem to be at risk of immediate spread of HLB. Area expansion with disease free grafted plants raised on Phytophthora tolerant rootstocks namely Trifoliate orange or citranges may be considered for HLB free citrus pockets.

2.2.2 Status of Phytophthora Rot Disease

The spread of Phytophthora Rot disease was ascertained through field survey of 58 citrus pockets of seven project districts. Three pockets namely Majthana and Kristi of Kaski district and Telia of Dhankuta could not be covered in field survey.

The study results indicated that:

a. out of 570 trees inspected for diseases symptom 161 trees showed Phytophthora rot symptoms (28.2% trees infected), which in all standard is quite high;

b. twenty pockets in seven districts which were reported disease symptom free (representing one third of surveyed pockets) are potential areas for future expansion. Fortunately, majority (14 out of 20 pockets) of the pockets are located in the most important commercial citrus belts in Nepal, where high quality mandarin orange is produced. Apparently the soils in the disease free pockets are not yet contaminated/inhabited by the rot disease causing pathogens, particularly Phytophthora sp. and in such sails planting materials raised on standard rootstocks, namely, Rangpur lime, Carrizo, Citrange, Volkamer lemon (which are comparatively more vigorous compared to Trifoliate orange rootstock) may be used; and

c. seventeen pockets in the alarming category (750% infected trees) need immediate measures to control the disease and replanting done only with plants raised on tolerant/resistant rootstock. Infected trees to be treated with chemicals (Ridomil Gold, Bordeaux mixture).

2.2.3 Status of Leaf Nutrient

Leaf analysis by adopting standard procedure was done by collecting leaf samples from 30 districts. Both major nutrients (Nitrogen, Phosphorous, Potassium, Magnesium and Calcium) and micro nutrients (Iron, Manganese, Zinc, Copper and Boron) were analyzed and compared with leaf nutrients standards for mandarins. Based on the leaf nutrient analysis data recorded, availability status of each nutritional elements was tabulated as - Deficient (D), Low (L), Optimum (O) and High (H) categories.

Initial Stage of Decline: 63 pockets
Moderately Declined: 40 pockets
Severely Declined: 26 pockets

Analysis of survey data also revealed that:

- severity of decline was highest in Dailekh and Salyan districts of Mid-western Region and Bajura district of Far-western Region where all the surveyed pockets (100%) recorded severely declined citrus orchards;

- one third pockets surveyed in Dhankuta district of Eastern Region, Kaski district of Western Region, Surkhet district of Mid-western Region and Achham, Doti and Baitadi districts of Far-western Region were severely declined;

- many pockets of Dhading district of Central Region, Tanahun, Gorkha and Syangja districts of Western Region were at moderate stage of decline; and

- the decline was in the initial stage and not yet a major concern in sweet orange (cv. Junar) producing Ramechhap district of Central Region and mandarin orange producing Dolkha and Nuwakot districts of Central Region, and Palpa and Parbat districts of Western Region. The 63 pockets of low (initial stage) decline and 40 pockets of moderately declined orchards (103 out of 129 pockets surveyed, about 80%) can be rejuvenated and bought back to normal health and productivity.

Status of Major Nutrients
The status of major nutrients such as Nitrogen (N), Phosphorus (P), Magnesium (Mg) and Calcium (Ca) were found ranging from optimum to high in majority of the surveyed districts. The survey results are given below.

- **Nitrogen**: It was deficient in only one district (Terahathum), optimum in eight districts and high in 21 districts.
- **Phosphorus**: It’s deficiency was high in 29 districts and optimum in one district (Kavre).
- **Potassium**: It was deficient in only one district (Gulmi), low in 19 districts and optimum in 10 districts.
- **Calcium**: It was deficient in two districts (Ramechhap and Gorkha) and high in the rest 28 districts.
- **Magnesium**: It’s deficiency was optimum in one district (Bajura) and high in remaining 29 districts.

In overall assessment, deficiency of major nutrients (N, P, Mg and Ca) is not a concern and low levels of potassium can be corrected by soil application of Muriate of Potash or spray of KNO₃ (1-3% aqueous solutions).

**Status of Micro Nutrients**

- **Iron (Fe)**: It was deficient in only one district (Salyan) deficiency, low in Baitadi district and optimum in all remaining 28 districts.
- **Manganese (Mn)**: It’s deficiency was low in 27 districts and optimum in three districts (Kavre, Ramechhap and Doti).
- **Zinc (Zn)**: It’s deficiency was optimum in five districts (Palpa, Ramechhap, Parbat, Dhankuta and Myagdi) and high in the remaining 25 districts.
- **Copper (Cu)**: It’s deficiency was optimum to high in all districts.
- **Boron (B)**: It was deficient in six districts (Nuwakot, Dhading,Illam, Gorkha, Kavre and Terathum), low in eight districts and optimum in remaining 16 districts.

Manganese and Boron levels are in lower side and can be corrected through foliar spray.

In citrus nutrition N followed by Z are considered to be very vital and linked with decline. Zinc is required in a very minute quantity and application of organic manures, (FYM) which is prevalent in many areas might be partially supplying both N and Zn to mandarin. In high rainfall areas leaching and under high pH conditions changing to unavailable from have been reported. Boron deficiency commonly occurs in low boron containing soils.

### 2.3 Result of Demonstrations

#### 2.3.1 Rejuvenation Technology

The severely declined trees in 26 pockets did not respond positively even by rejuvenation technology treatments and it was recommended to remove the severely declined trees and go for replanting with new grafted planting materials.

One rejuvenation demonstration per pocket was established in each 60 pockets of the seven project districts during May-June of 2011. Yields of fruits from 25 trees of each rejuvenation demonstration and status of tree decline were recorded during November-December 2011. Tree health and fruit yield of rejuvenated trees were compared with those recorded in the base year 2010.

In general, the effects of treatments on tree decline and fruit yields were positive. The results of treatment were as follows.
• About 72 percent pockets (or 43 pockets) showed positive effects on fruit yields in terms of improved fruit size and better vegetative growth in rejuvenated trees out of 60 demonstrations in 60 pockets of the seven project districts.

• An average of 30 percent increase in fruit yield was observed over the base year.

The reasons for varied effects on tree health and fruit yield during the first year could be due to:

a. delay in application of manures and fertilizer (May-June);
b. drought during the flowering and fruit setting time in some pockets;
c. selection of over age and/or severely declined trees; and
d. Inappropriate/unsuitable site selection.

Analysis of summarized data at district level revealed that:

• all the districts showed positive effects on both parameters i.e. fruit yield and tree health;
• severely declined trees having more than 60 percent twig drying did not show any response of the treatments;
• similarly, trees with more than 25 years of age were found less responsive to the treatments; and
• both farmers and field technicians expressed satisfaction on the results of demonstrations in all the districts.

2.3.2 Improved Production Package (GAP)

Sixty field demonstrations were established in seven project districts with improved production technologies in 3-5 years young non-bearing orchards during January-February of 2012. Out of these 60 demonstrations, one in each district was conducted by the consultant team with the participation of the trained officers/technicians of DoA who received ToTs.

Orchard owners, field technicians and officers were satisfied on the overall growth of the trees as well as on the general improvement recorded in all the demonstration plots.

2.4 Citrus Decline Combating Strategies in Nepal

a. Map severely declined, moderately declined, low declined and healthy areas through detailed field surveys of the citrus growing areas.

b. Remove severely declined trees by providing compensation to the farmers.

c. Rejuvenate moderately and low declined trees through practicing rejuvenation techniques.

d. Implement citrus bud wood certification system to establish modern nursery system for production of certified disease-free grafts.

e. Practice integrated nursery and orchard management strategies for sustainable citrus production.

2.5 Implementation of Region Differentiated Citrus Development Programme

The TCP intervention generated following data/information: (a) decline mapping through field survey; (b) technology transfer for rejuvenation in older declined orchards; (b) demonstration of proven improved production technologies i.e. GAP in newly established young mandarin orchards; (d) base data generation on leaf nutrient status and status of spread of deadly diseases namely HLB (greening disease) and Phytophthora Rot. These information have helped in the development of decline mapping.

The data suggests that there is a need for implementing ecobelt differentiated citrus development programmes because out of 75 only 37 mid-hill districts are important for commercial citriculture development, this excludes two mid-hill districts namely Sindhuli and Remechhap where sweet orange (cv Junar & others) is predominantly grown and all other
remaining districts largely grow loose skinned mandarin orange. The 12 districts of Western Region with area coverage of 7,879 ha is the largest concentrated belt of mandarins in Nepal.

2.5.1 Citrus Development Programme Common for all Regions in the Mid-hills

- Trees over 25-30 years old and showing severe decline (more than 50% twigs/branch dried, chlorotic and sparse foliage, smaller sized leaves) symptoms need to be replaced.
- Stop deep ploughing in citrus orchard to avoid root injury to the trees and prefer leguminous crops, rather than exhaustive crops that compete with citrus for nutrients and moisture.
- Regulate uncontrolled flow of non-descript/non-certified planting materials across the country by introducing internal quarantine system to avoid further spread of deadly disease, specially Phytophthora rot and HLB.
- Orientation of citrus growers in identified citrus pockets on orchard hygiene and plant health managements.

2.5.2 Citrus Development Program Specific to Region

a. For Eastern Region

- Out of three pockets surveyed, severe decline was reported only in one citrus pocket of Dhankuta district (Dhankuta municipality). Dhankuta municipality pocket also had high in infection (50%) of HLB whereas HLB could not be detected in indexed plants in Belhara and Khoku pockets. The insect vector of HLB (citrus psylla) and alternate host (Murraya sp.) also could not be found at 950-1,000 m altitude. Phytophthora rot disease, however, was spread in most of the surveyed pockets (Bodhe, Mounabudhuk, Chhintang and Khoku). In Dhankuta district any new area expansion programme in future should be done with great care.

- Only quality planting materials (grafted onto Phytophthora tolerant rootstocks) produced by following bud wood certification system should be used. Also, special measures should be taken so that the insect vector and alternate host (Murraya sp.) are not introduced. Seedling dip in Ridomil Gold @ 2.5g + Baviston @ 1 gm per liter of water for 10 minutes before shifting rootstock seedling from primary to secondary nursery is desirable. Chinese fruit fly must be controlled in high infestation pockets by following control measures suggested by research center.

b. Central Region

- Central region as a whole enjoys better potential for future growth. In Dhading, decline is not severe and only in one pocket Jogimara/ syadul some infection (16% of indexed trees) HLB could be detected. Phytophthora rot disease was however, quite high in pockets, namely Katunje and Nalang. Four other citrus pockets with low decline and free from deadly disease are, there comparatively safer area for further area expansion. In Jogimara pockets although HLB infection is still low, presence of insect vector (citrus psylla and alternate host Murraya sp) could be recorded. The infected plants need to be destroyed so that HLB does not spread further. Similarly, in Katunje and Nalang, being Phytophthora prone areas. New planting must be done only by grafted plants raised on resistant rootstocks.

- In Kavre district none of the six citrus pockets experienced severe decline. Phytophthora rot infection was severe in two pockets namely Kasudevi and Sankhu Basti. The disease was recorded in all other pockets except Panauti pocket. The district as a whole is prone to Phytophthora rot disease and large scale intercropping with maize and others causing root injury to citrus predisposes the trees for infection by the soil borne pathogen. Intercropping practice with maize and potato cannot be stopped totally but harmful effects can be minimized with less soil working and by following conservation agriculture practices/GAP. Some grafted plants on volkameria lemon rootstocks (Source: ECARDS-Nepal) was found to be in good health and fruiting even at early age (3-4 years) showing the promise of exotic rootstocks species, which in otherwise would have been vigorous in growth habit. In the same area successful budding of mandarins on 15-18 months old trifoliate orange (budded in March) could be witnessed. HLB could not be detected in Panauti pocket but was found in
c. Western Region

- Western region is the most important concentrated citrus belt with 12 potential districts spread over 7,879 ha (2006-07 data). Average productivity of the region is lesser than that in Eastern and Central Regions. Many of the orchards are quite old (25-30 years) and massive replanting programme is needed to sustain/revive the citiculture in this region. Two pronged approach of rejuvenation of low to moderately declined trees along with removal of severely declined trees as well as replanting with disease free certified grafted plants on Phytophthora rot disease tolerant rootstocks are needed.

3. RECOMMENDATIONS

3.1 General Recommendations

Government initiatives by launching a Special Junar Production Program in 1980-81 covering Ramechham and Sindhuli districts (later supported by JICA) and National Citrus Priority Programs in 20 districts during 1983-84 with an objective of commercializing mandarin production in 20 mid-hill districts are the foundations of today’s citrus industry of Nepal. Vast majority of the orchards established during early eighties are experiencing old age decline problem. Nutrient mining and disease built-up, particularly Phytophthora rot disease, are the main reasons for sub-optimum productivity.

- Massive program of removal of severely declined trees and replanting with healthy grafted plants on tolerant rootstocks is the need of the hour. Simultaneously, rejuvenation of low to moderately declined orchards should also be attempted for sustainability and for maintaining supply chain. The challenge of citrus industry in Nepal is to move forward from sub-optimal yield of 10-11 ton/ha to a level of about 15-20 ton/ha which is otherwise possible by adopting proven production technology. Social mobilization to improve the capacity of communities in relation to adoption of improved cultivation practices and removal of severely declined trees should be the first step towards that direction.

- Junar, a local variety of sweet orange (Citrus sinensis) is the second most important citrus species of Nepal after mandarin orange. It is commercially grown in Sidhuli and Ramechhap districts. In small scale, it is also produced in other mid-hill districts namely Dhankuta, Bhojpur, Dolakha, Sindhupalchok and Kavre. In general, Junar decline is less severe as compared to mandarin. However, its seedling trees and grafted plants on rough lemon rootstocks have been found to be very susceptible to Phytophthora rot disease. Hence, Junar plants in Nepal are now grafted on trifoliate rootstock, which is resistant to Phytophthora. Another problem in Junar production is fruit fly which is more severe in Dhankuta district. NARC has identified this fruit fly as the Chinese fruit fly which could not be controlled by methyl eugenol baiting (a sex pheromone). NCRP (what is its full form ???? ) has initiated some research work to find out effective baiting chemicals to control this fruit fly. As Junar fruits are very juicy and preferred in the market, its production should be increased by increasing productivity as well as expansion of areas. Area expansion is possible in districts namely Kavre, Okhaldhunga, Bhojpur, Dolakha, Dhankuta, and Tehrathum. Rejuvenation measures applied for declined mandarin trees can also be applicable for rejuvenating Junnar orchards. Water management is crucial for quality fruit production and better juice recovery in Junar.

- One Village One Product (OVOP) programme launched by the government in collaboration with Federation of Chambers of Commerce and Industry (FNCCI) has been found effective to commercialize Junar by establishing strong value chain. This OVOP program can also be instrumental to commercialize mandarin production in many districts of Nepal as this program has many models of value chain development.

3.2 Specific Recommendations

3.2.1 Budwood Certification
Citrus Budwood Certification Program should be implemented in Nepal in order to produce certified disease-free quality planting materials grafted on different Phytophthora tolerant rootstocks (eg. Trifoliate orange, Swingle citrumelo, Carrizo citrange, Rangpur lime) for citrus growers. For aiding budwood certification program, support/linkage with Molecular Diagnostic Laboratories (viz. NAST, NARC etc.) will be desirable.

Eco-friendly management options focusing on Integrated Disease Management (IDM)/Integrated Pest Management (IPM) should be encouraged. Use of Pheromon trap for the control of citrus fruit fly, application of neem based pesticides against all citrus insects, use of trap crop for Psylla management, intercropping with guava that acts as repellent for Citrus Psylla, poison baiting for citrus fruit sucking moth, prophylactic application of Bordeaux paste to tree trunk etc are some of the examples that should be advocated to the citrus growers for extensive application.

3.2.2 Nursery Management

Out of the total planting materials produced in the country, only about 30 percent were reported to be grafted. In view of the wide spread of Phytophthora rot disease, switching from seedling plants to grafted plants on tolerant rootstocks is urgent.

The registered nurseries which are already practising grafting/budding in citrus successfully need to be contracted for the production of quality planting materials by sourcing certified budwood from NCRP, Dhankuta, CHC, Kirtipur, CDC, Palpa and ECARD-Nepal and similar other agencies. NCDP should identify such registered nurseries for support and targeted production.

Model citrus nursery with own protected foundation block of mother plants (scion), separate root stock block, containerized nursery system under insect free screen house/nursery structure should be developed in every major citrus growing pockets in a time bound manner.

In Nepal, mandarin, sweet orange and lime are propagated by using side and/or veneer grafting. The commonly used rootstocks are trifoliate orange and rough lemon. Grafting is generally done at low height using those rootstocks. This practice has enhanced the spread of Phytophthora foot rot. Hence, it is recommended to maintain minimum grafting height at 25-30 cm inches from the ground using standard sized rootstocks.

3.2.3 Citrus Nutrition

In the absence of location specific technology, maintenance concept aiming at maintaining soil fertility level slightly above the point of maximum economic yield may be adopted. Fertilizer placement either on circle banding or whole placement beneath the outer canopy of the tree is suggested. Since nutritional disorders result sub-optimal yield level, a maintenance dose of fertilizers is generally suggested. In spite of the fact that leaf nutrient analysis data did not reveal high nutrient deficiency in surveyed pockets, the response of major and micronutrient application in rejuvenation demonstrations suggest the need of nutrient supplementation.

3.2.4 Plant Protection

The citrus decline survey revealed that spread of Phytophthora rot disease is high. Similarly, HLB spread was recorded quite high in certain areas (Tanahun, Lamjung, etc.). In the absence of organized plant protection system for citrus, precautionary measures are suggested as given below.

a. Areas where Phytophthora is a chronic problem, chemical control measures must be applied properly. Seedling dip in Ridomil Gold @ 2.5 gm + Bavistin @ 1 g per liter of water for ten minutes before shifting them from primary to secondary nursery should be made mandatory.

b. Insect vectors are responsible for spreading the diseases like HLB and CTV (what is its full form ???? ) in the field. It is recommended that a systematic study on the monitoring of viruliferous insect vectors be carried out throughout the country during different seasons.
c. Detailed research on identifying strainal variations within CTV, isolation of local biocontrol agent like *Trichoderma harzianum* effective against *Phytophthora* spp.; collection, identification and multiplication of parasitoids (e.g. *Tamaraxia radiata*) and versatile chrysopid predator (e.g. *Mallada boninensis*) for the biological control of citrus psylla (insect vector of HLB) should be done. NCRP should be provided with some research budget to conduct such work early.

- As most of the citrus trees in Nepal are grown on upland without irrigation, managing orchards with conserving moisture is suggested. Applying mulch helps reduce soil evaporation and conserves moisture. In large matured orchards this may be uneconomical. However, it can be a useful option in Nepal as most of the orchards are small and organic residues such as dry leaves, grasses etc. are easily available. Furthermore, there are research evidences in other countries that plastic mulches can be economically viable for young trees even in the large orchards. Mulching just after the monsoon rain is effective to conserve the moisture.

- Package of practices mentioned in detail in the Training Manual towards management of different diseases (*Phytophthora* induced foot rot and root rot, powdery mildew, twig blight etc) and insect pests (psylla, aphids, CLM - please write its full form, citrus fruit fly, bark eating caterpillar, citrus trunk borer etc) should be followed.

3.2.5 Training and Capacity Building

- Knowledge and skill development of field extension functionaries/technicians need to be improved. Training for skill up-gradation as well as orchard management practices with special reference to decline management should be a regular practice. Similarly, awareness building training and motivational tools for the citrus growers need priority attention.

- Declining of orchards due to the lack of basic management practices such as pruning and removal of badly infected twigs and branches exists partly because of the lack of farmers’ knowledge on orchard management and partly due to the belief that fruit trees grow and bear fruits without any management operations/activities. In order to change this type of mind setup of the farmers and develop their skill on orchard management, regular field level practical trainings and awareness program need to be organized.

4. FUTURE LINE OF ACTIONS

- The bud wood certification proposal needs to be formalized at the earliest.

- Based on the results of field investigations conducted under the TCP, it is realized that following intervention is necessary for the sustainable development of citrus crops in the potential districts:
  a. Social mobilization and technical capacity building;
  b. Production support;
  c. Marketing support and value chain development; and
  d. Project management support including provision of technical assistance.