

**A Guideline on Pest Free Area Declaration for
Cabbage**

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**Support to capacity enhancement of
National Plant Quarantine Program**

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A Guideline on Pest Free Area Declaration for Cabbage

1. Introduction

1.1 Scope

This guideline prescribes the steps based on scientific justification when declaring pest free area for cabbage and for the export market access in neighboring countries and other WTO member countries/trading partners. It also provides administrative process, phytosanitary measures to maintain the area free of quarantine pest of importing countries and the monitoring system approved by the NPPO to verify that the PFA condition is maintained as required by the trading partner.

This document is based on guidelines and recommendations developed within the framework of the IPPC. This guideline also adopted the principles, recommendations and format of ISPM to achieve international harmonization of phytosanitary measures with the aim to facilitate trade.

2. References

- IPPC**, 1997, *International Plant Protection Convention*. Rome, IPPC, FAO
- ISPM 1**, 1995, *Principles of plant quarantine as related to international trade*, FAO, Rome
- ISPM 4**, 1996 *Requirements for the establishment of pest free areas*, FAO, Rome
- ISPM 5**, 1999, *Glossary of phytosanitary term*, FAO, Rome
- ISPM 6**, 1998, *Guidelines for surveillance*, FAO, Rome.
- ISPM 8**, 1998, *Determination of Pest Status in an Area*, FAO, Rome
- ISPM 10**, 1999, *Requirements for the establishment of pest free places of production and pest free production sites*, FAO, Rome
- ISPM 26**, 2006, *Establishment of pest free areas for fruit flies (Tephritidae)*
- ISPM 29**, 2007, *Recognition of pest free areas and areas of low pest prevalence* FAO, Rome
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- NSPM 11**, 2005, *Requirements for establishment of pest free area for mango nut(seed) weevil (*Sternochetus mangiferae*) and pulp weevil (*S. frigidus*), Gov. of India, Directorate of Plant Protection, quarantine & Storage.*

NSPM, 11, 2013, National standard on Pest Risk Analysis NPQP, Nepal.

NSPM, 2014, Guidelines for detection , monitoring and delimiting survey of plant pests in agriculture ecosystem NPQP, Nepal.

Plant Protection Act, 2007, NPQP, PPD, Nepal

Plant Protection Regulation, 2010. NPQP, PPD, Nepal

Teresa McMaugh, 2005. Guidelines for surveillance for plant pests in Asia and the Pacific, ICIAR, Govt. of Australia

Vegetable Development Directorate (VDD) 1995: A guide on variety Maintenance

WTO. 1994. Agreement on the Application of Sanitary and Phytosanitary Measures. Geneva, World Trade Organization.

3. Definitions

Definitions of phytosanitary terms used in the present guideline can be found in ISPM 5 (*Glossary of phytosanitary terms*) and Plant Protection Act 2007 and Regulation 2010 of GoN

4. Outline of requirements

Cabbage is important high value off-season vegetable in mid hills of Nepal, grown during Mid-June to November. It has been identified as one of the export potential green vegetable commodity to India. There has been a spurt in the export of fresh cabbage from Nepal in recent years. However, complying with the import requirements with respect to quality production, grading, packaging and free from quarantine pests have not been up to the required standard. In view of the existing farming practices and knowledge and skill of the farmers on SPS measures there is need to be upgraded competitive capability to facilitate trade. Furthermore non-heading, loose heading, black rot, soft rot, club root and insect pests like diamond back moth, aphid are the major problems during off season production degrading the quality. At the same time, high dosage of Pesticide application to knock down these pests is also a challenge for export.

The guidelines on declaration of pest free area on cabbage outlines main activities: surveillance, adoption of phytosanitary measures to maintain freedom, verification and maintenance of pest freedom status by regular monitoring and provisions concerning quality packaging, labeling fresh cabbage for export.

This document is first initiative of its kind for the quality production and management of cabbage crop at different stages of crop production, handling, processing and fulfilling the SPS requirement. This guideline supports farmers, traders for producing safe and healthy cabbage and its efficient marketing and prescribes the steps to be undertaken when declaring pest free area for cabbage as a technically justified phytosanitary measures for easing the access to export market with neighboring countries.

Besides, it includes information on the specific pest biology and recommended control measures of these pest. The procedures as set out in this guideline should be endorsed by the National Plant Protection Organization (NPPO) prior to implementation.

5. Background Information

The cabbage price prevailing in Indian side is lower than that of Nepal during the main season production but off season cabbage production in mid hills has market with comparatively better price. Thus becoming price competitive during off season especially with India, the volume increment, access to appropriate agricultural technologies, inputs and knowledge inductions in production & post-harvest handling facilities, refrigerated transportation and fast track custom clearance system need due attention for facilitating fresh vegetable trade Through declaring and maintaining Pest free status helps to expedite the quarantine clearance .

But in view of existing skill and knowledge of Nepalese farmers and traders in enhancing commercialization of agriculture and enhancing trade, it has been accepted that there is urgent need to make the Nepalese farmers and traders well aware of the WTO/SPS requirements to have a better market access.

This require improvements in training and extension services to farmers, declaration of PFA, conduction of PRA and formalization of import permit and a periodic interaction among the trades and producers towards adoption of SPS measures. Especially for smooth marketing of fresh vegetables there is need to enable vehicle to cross the border without loading and unloading to ease the trade as well as quality management.

The Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) of the World Trade Organization (WTO) deals in Article 6 exclusively with regional conditions, including pest- or disease-free areas and areas of low pest or disease prevalence (WTO, 1995). Paragraph 2 of this article requires WTO members

to recognize the concepts of pest- or disease-free areas and areas of low pest or disease prevalence and that the determination of such areas shall be based on factors such as geography, ecosystems, epidemiological surveillance, and the effectiveness of sanitary or phytosanitary controls (WTO, 1995).

Thus it is prerequisite to develop guidelines on pest free area for cabbage and its recognition from India helps to improve the quality production of cabbage as a result both farmers and traders may benefit from market access.

6. General Requirements

6.1 Good Agricultural Practices for cabbage production (see Appendix-1.)

These are practices which, when applied to on-farm production, results in safe and healthy agricultural products. If farmers make it through the first few years of production, results will start to become more satisfactory having higher yields and improvement of soil structure as well.

6.2. Administrative Requirements

6.2.1 Regulation/ Authority

The Plant Protection Regulation, 2010 prescribes in Article II. 4 (a) the functions, duties & power of NPPO to declare the endangered area, pest free area, pest free production site and area of low pest prevalence. The regulation also states in Article III, 16 (b) the functions and duties of inspector to assist NPPO in identifying the PFA.

The Plant Protection Directorate has been designated as National Plant Protection Organization (NPPO) of Nepal as the main authority to operate the plant quarantine activities.

6.2.2 Responsibility of NPPO

The NPPO support and guidance is essential in all aspects of PFA

- NPPO (PPD) shall be the sole authority to prepare the protocols for establishment of PFAs in considered production areas .
- Forward the prepared protocols to Plant Quarantine Committee for the approval and also enforcement of internal quarantine measures in those areas.

- For conducting PFA, the methodologies should be as instructed in this guidelines which is consistent with the ISPM 4, “Establishment of pest free areas” .
- NPPO should maintain lists of stakeholders to assist effective consultation and communication. Stakeholders may be government / non-government organization, NPPO members, individual growers and commercial growers, traders or business houses.
- Regularly update the pest list and records should be officially maintained.

6.3. Requirements for establishment of pest free areas

6.3.1. Determination of Pest free area

The delimitation of a PFA should be done according to the biology of the pest concerned and with full understanding of the occurrence and distribution of the pest as well . In practice, PFAs are generally delimited by readily recognizable boundaries, considered to coincide acceptably with a pest's biological limits. These may be administrative (e.g. country, province or commune borders), physical features (e.g. rivers, seas, mountain ranges, roads) or property boundaries which are clear to all parties. For various practical reasons, it may also be decided to establish a PFA inside an area considered to be pest free, and thus avoid the necessity for exact delimitation of the true limits of the PFA.

The field survey results, interaction meeting, review of various literatures/ reports, interview and discussion with commercial farmers, traders and relevant GOs/ NGOs revealed that the production areas of mid hills (eg Ilam, Panchthar, Terhathum, Dhankuta, Makawanpur, Sindhupalchowk , Rasuwa, Dolkha , Syangja, Palpa , Rukum , Rolpa, Salyan, Dailekh, Doti, Baitadi, Dadeldhura) have high potential for off season cabbage production.

6.3.1.1 Pest information/status

Field survey and interaction meeting with cabbage growers indicated that major problems in the field are diamondback moth, Club root, and black rot. Majority of the farmers generally apply different pest management practices to control above mentioned pests.

The National pest of cabbage is provided in Annex-2.

The details of biology of important pests are described in Appendix- 2, 3, 4, 5, 6 and 7.

Government of India has amended the Schedule VI of the Plant Quarantine (Regulation of Import into India) Order, 2003, in September, 2014 affirming the consignment of cabbage from Nepal should be accompanied by Phytosanitary certificate/ Phytosanitary certificate re-export with an additional declaration for the freedom from:

- Black leaf spot(*Pseudomonas maculicola*)
- Black rot (*Xanthomonas campestris*)
- Black leg(*Phoma lingam*)
- Soil and other plant debris and soil.

Among these pests, only black rot (*Xanthomonas campestris*) has been reported in Nepal. (Source: Annexure-2 National pest list of cabbage). While establishing pest free area the targeted pest should be clear to all the concerns involved in declaration and maintenance of PFA .

6.3.2 Steps for establishment of Pest free areas

While establishing the cabbage pest free area, the following stepwise requirements should be complied.

- The NPPO should arrange a team of experts to identify the suitable pest free area for off-season cabbage on the basis of targeted pests of cabbage. After conducting survey, the team should provide report of geographic areas of the proposed PFAs, size of the area, natural barriers, buffer zone including mapping of pest distribution, climatic data, growing seasons, production systems, crop variety and submit to Plant Protection Directorate (PPD) for consultation by NPPO with members and relevant stakeholders.
- The team should conduct the delimiting surveys in considered production areas for establishing PFAs & submit the report to PPD for approval process by NPPO.
- The Plant Quarantine Committee (PQC) should issue the domestic regulatory measures for restricting the movement of cabbage plants, seed and seedlings in those PFAs.
- The Department of Agriculture (DOA), National Agriculture Research Council (NARC) and PPD should organize detection surveys and regular monitoring to verify cabbage PFAs and NPPO should document overall survey/pest/measures undertaken/ export data reports

- The National Plant Quarantine Program (NPQP) should inspect cabbage growing PFAs and export consignments to confirm free from the pests indicated above and issue the phytosanitary certificate.
- The Ministry of Agriculture Development (MOAD) should inform the designated PFAs to the NPPO of the importing country for consideration.
- The PPD should prepare the operational plan which specifies the phytosanitary procedures to establish the cabbage PFA. The plan should be in the form of a specific work plan as a part of a bilateral arrangement between the NPPOs of both importing and exporting countries. The plan should focus on the general requirement of an importing country which upon the demand from the importing country should be made available. It is recommended that NPPO of Nepal should consult with importing country in the early stages of the process in order to ensure that importing country's requirements are met.

The details of operational plan are described in Annex-1.

6.3.3 Specific Survey activities:

6.3.3.1 Delimiting surveys

Delimiting surveys are carried out in the event of reported incidence of a pest spreading into new area and or/to initiate the establishment of pest free areas.

The delimiting survey should be done by the expert team as per the survey plan approved by the NPPO to establish boundaries of area (whole or part of country) infested by or free from a pest as mentioned above. Such surveys are carried out initially based on the surveillance data and pest records maintained by the NPPO (Plant Protection Directorate) or any other National institute or organization

The survey should be carried out in the cabbage growing seasons at initial stage including the nursery bed and growing season for disease symptoms on host plants and for the presence or absence of eggs, larvae, pupae and adults.

6.3.3.2 Detection surveys

The purpose of detection survey is to detect the presence or absence of the pest in a given area or production sites. These should be carried out by trained technical personnel on regular basis to determine pest status in an area and should follow a survey plan, approved by the NPPO. Personnel should be skill in identifying capability, sampling techniques, collection/preservation and transportation of specimen for identification and record keeping. These surveys should be carried out

during cabbage growing periods and or/ following the eradication measures applied to a pest in PFA production sites. These survey methodologies should be based on statistical sampling, that are determined after taking into account the biology of the pest and employing appropriate detection techniques such as field diagnostic kits, traps etc. The results of survey should be documented and communicated.

6.3.4 Buffer zone

A “buffer zone” is defined as an area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimize the probability of spread of the target pest into or out of the delimited area, and subject to phytosanitary or other control measures, if appropriate.

The extent of the buffer zone should be determined by the NPPO, on the basis of the distance over which the pest is likely to spread naturally during the course of the growing season. The action to be taken, if the pest is detected in the buffer zone, will depend on the requirements of the NPPO. A Buffer Zone may or may not be required depending on the nature of the incursion.

7. Specific Requirements

7.1 Implementation of phytosanitary measures to maintain freedom

Where applicable, the domestic quarantine should be enforced to restrict the movement of cabbage plants/ products and seed/seedlings along with regulated articles in PFAs

Phytosanitary/ quarantine measures comprise a series of activities aiming that the PFA has been established. Following measures should be used to prevent the introduction and spread of a pest.:

7.1.1 Surveillance activities

The status of the relevant pest situation in the area, and when appropriate of the buffer zone, should be determined by surveillance during growing periods. Surveillance should be conducted according to protocols for the specified pest(s). These protocols should include trapping and sampling procedures (e.g. type of trap, number of traps per hectare, acceptable number of pest individuals per trap per day or week, number of samples per hectare that need to be tested or inspected, part of the plant to be tested or inspected,). Surveillance data should be collected and documented to demonstrate that the populations of the specified pests do not occur. The surveillance data should be relevant to the life cycles of the specified pests and should be statistically validated

to detect and characterize the population levels of the pests. When establishing a PFAs, technical reports of the specified pest(s) detections, and results of the surveillance activities should be recorded and maintained for a sufficient number of years, depending on the biology, reproductive potential and host range of the specified pests.

7.1.2 Pest control for maintaining pest free in PFAs

Phytosanitary procedures should be relevant to the biology and behavior of the specified pests. Examples of procedures used to free pests are: removing alternate hosts; applying pesticides; integrated pest management (IPM) techniques, use of biological control agents; using trapping techniques. When establishing a PFA, control activities should be recorded for a sufficient number of years, depending on the biology, reproductive potential and host range of the specified pest(s). Phytosanitary procedures applied to propose PFAs should be documented.

7.1.3 Reducing the risk of entry of specified pest(s)

Following Phytosanitary measures may be required to reduce the risk of entry of the specified pests into the established PFAs:

- Domestic regulation of the pathways and of the articles that require control to maintain the PFA. All pathways into and out of the PFA should be identified. This may include the designation of points of entry, and requirements for documentation, treatment, inspection or sampling before or at entry into the area.
- Verification of documents and of the phytosanitary status of consignments including identification of intercepted specimens of specified pest and maintenance of sampling records
- Confirmation of the application and effectiveness of required treatments
- Documentation of any other phytosanitary procedures.

7.1.4 Routine Monitoring

The NPPO should regularly monitor to ensure necessary phytosanitary measures to that the pest free status are implemented and maintained in the designated areas. The purpose of monitoring survey is to verify the characteristics of population of a pest to check if the pest freedom is maintained in a given PFA. Ongoing monitoring surveys are of paramount importance, if the pest free area is required to be established in a part of country.

The routine monitoring results should be provided to importing country for consideration before the commencement of each export season.

7.1.5 Extension advice to producers:

- Inform the importance of establishing and maintaining the pest free status of the area
- Provide information on targeted pests for establishing and maintaining PFAs
- Provide awareness raising brochures, leaflets, posters on pests and PFAs
- Enforce internal quarantine regulation for the movement of cabbage seed, seedlings and products into the PFAs for maintaining pest free status in exporting the commodity

8. Requirements for the Recognition of PFA

NPPO is responsible for designation, maintenance and surveillance of PFAs (Article IV.2e of the IPPC). The NPPO should check the regulation of the importing country and/or bilaterally establish conditions to ensure that compliance has been achieved. The MOAD should notify the import contracting party, the designated PFAs or any additional areas for consideration.

8.1 Responsibilities of contracting parties

The exporting contracting party is responsible for:

- requesting recognition of an established PFA
- providing appropriate information on the PFA
- designating a point of contact for the recognition process
- providing appropriate additional information if necessary for the recognition process
- Co-operating in the organization of on-site verification visits, if requested.

The importing contracting party is responsible for:

- acknowledging receipt of the request and the associated information
- describing the process to be used for the recognition process including, if possible, an estimated time frame for the evaluation
- designating a point of contact for the recognition process
- technically assessing the information

- communicating and justifying the need for on-site verifications and cooperating in their organization
- communicating the results of the assessment to the exporting contracting party and:
 - if the area is recognized, promptly modifying any phytosanitary regulations, as appropriate;
 - if the area is not recognized, providing an explanation, including technical justification where applicable, to the exporting contracting party.

9. Phytosanitary security of cabbage from PFAs to shipment stage

DOA should authorize Agriculture commodity export promotion Program and Directorate of Vegetable Development to observe the production practices for cabbage in PFAs, examining the cultivation and harvesting methods, proposed pest control, processing, storage condition, packaging and transport protocols to maintain phytosanitary security until export.

10. Verification of pest freedom status attained or maintained

The verification of pest free status is done by the NPPO personnel or by persons duly authorized by the NPPO, who undertakes the specific surveys to assess the pest free status of the pest free area (and the buffer zone, if required). These most often take the form of field inspections (also known as growing-season inspections), but may also include other detection methods (sampling followed by laboratory testing, trapping, soil tests, etc.). Pest free status may be verified by a stated number or frequency of inspections or tests (e.g. three inspections at monthly intervals). The inspections or other procedures may be required over several seasons. Inspection or testing of the harvested commodity should be done by NPQP staff at the place of production for targeted pest freedom.

10.1 Monitoring Survey

NPPO should organize monitoring survey to verify pest free status of the cabbage PFAs and NPPO should document overall reports of designated PFAs.

10.1.1 Survey Area

- Maps showing designated survey area/s with survey routes should be prepared. The areas should be clearly demarked preferably by GPS

coordinated and the boundaries

- Information on size of cabbage production areas (No of farmers/ size of cabbage growing area (in ha) should be collected for each area in which PFAs required to be established and documented prior to initiation of survey
- Information on crop density (plant population/m²); cropping intensity (cropping season/no of crops); cropping patterns; agronomic practices being adopted and agro-climatic data should be collected and documented

10.1.2 Frequency of Survey

Monitoring of the pests should be done at least three times, pre-cropping period, cropping period and post-harvest period in PFAs prior to export of consignments. Survey should be done in environment controlled (cold storage) and normal storage condition also..

10.1.3. Period of Survey

The surveys should be carried out for a minimum of two cropping seasons.

10.1.4 Sampling Unit

Sampling unit can be from parts of the plant to whole plants including roots and to collect the samples walk through the field to obtain or observe the required sample units. To get an accurate population estimate, the best estimate of a population or damage will be achieved with adequate, representative samples taken over a well-distributed pattern. A zigzag route through the field sampling approximately every 10 meters is a commonly used pattern.

10.1.5 Sample size for detection surveys

Sample size should be decided by the NPPO considering the need to survey in order to detect a specified proportion of pest infestation with a specific level of confidence, at the design prevalence selecting a confidence level of, 95 percent.

10.1.6 Sampling method

The choice of any sampling method is best done by knowledge of the biology of the pests in combination with accepted detection methods. In the case of insects, the use of pheromone, light traps and pan traps is suitable to detect the presence of adults. soil sampling (for eggs or larvae,) or host plants for signs of feeding damage would also be suitable, notably where an incursion has been recorded, in surrounding areas.

In addition to above, traps, sweep nets can be used for collecting adults in host crops. Pheromone traps are generally to be preferred.

For diseases, the samples of fresh and affected vegetables or the whole plant with root should be collected from field and identified.

Specimens should be collected and preserved with details information according to NSPM, “Standard technical protocols for collection and handling of disease samples” and ‘Standard technical protocols for collection and handling of insect samples’.

11. Notification of detection of pests in PFA

NPPO should inform Plant quarantine committee of any detection of targeted pests in declared PFA during routine monitoring and surveys conducted in the growing season and take required action. NPPO should immediately notify the import contracting party. Pest free area should be reinstated only after two years of monitoring surveys showing free of targeted pest infestation.

12. Phytosanitary Inspection of Consignments for Export

The National Plant quarantine Program (NPQP) should organize the inspection of export consignments both at the head stage of cabbage in the field and packing house. On that basis a phytosanitary certificate should be issued confirming that targeted quarantine pests are not known to occur in the designated PFAs and that the consignment is free from the pests indicated above.

In case of pests detected in export consignments, further export of consignments should be suspended from that area until the pest free status of that area is reinstated and immediately informed to importing country.

Pesticide residues should also be monitored by DFTQC/PPD by collecting samples at the farm gate. At this point, if the samples are found to breach the Maximum Residue Level (MRL), the produce should be detained.

13. Provisions concerning quality and packaging and labeling

- The products should be: intact and free of rotting or deterioration
- clean, i.e. practically free of all earth-soiled leaves, plant debris and practically free of any visible foreign matter
- fresh in appearance and practically free from pests.
- materials used in the package must be clean and of a quality such as to avoid any external or internal damage to the produce

- the package may include the documents of origin of cabbage that is from declared PFA with proper labeling .

14. Documentation and Review

Documentation should include supporting evidence describing official controls including survey results, survey and monitoring protocols, phytosanitary regulations and measures undertaken. Records of all procedures undertaken in the establishment and maintenance of cabbage-PFA should be adequately documented by NPPO. The procedures should be reviewed and updated regularly. Any corrective measures implemented to refine or re-establish a cabbage-PFA should also be documented (see Annex-3). Such reports should be made available to the NPPO of the importing country on request.

ANNEXES

Annex-1. Operational Plan

The plans should include:

- Title of plan:
- Objective/purpose of plan:
- Description of Management structure:
- Role & Responsibilities of Growers/Exporters:
- Description of area in which PFA/ALP etc. (proposed to be established):
- Resource Requirements (human/equipment & materials/finance resources):
- Targeted pest(s):
- Targeted commodities/host plant species:
- Training requirements/Quality management:
- Survey methodologies:
 - Delimitation survey
 - Detection survey
- Phytosanitary measures to maintain pest freedom:
- Checks to verify pest freedom is maintained:
 - Monitoring Survey
- Work plan:
- Documentation:

Annex-2 Pests of Cabbage (*Brassicae oleracea L. var capitata L.*) in Nepal

SN	Scientific Name	Taxonomic Position	Common Name	Reference
INSECTS				
1	* <i>Agrotis segetum</i> (Denis & Schiffermuller)	Lepidoptera: Noctuidae	Turnip moth	CPC, 2007
2	* <i>Autographa nigrisigna</i> (Walker)	Lepidoptera: Noctuidae	Beet worm	CPC, 2007
3	<i>Bagrada hilaris</i> (Burmeister)	Hemiptera: Pentatomidae	Painted bug	Neupane, 2000
4	* <i>Chrysodeixis chalcites</i> (Esper)	Lepidoptera: Noctuidae	Golden twin-spot moth	Joshi and Manandhar, 2001
5	* <i>Crociodolomia pavonana</i> (Fabricius, 1794)	Lepidoptera: Crambidae	Large cabbage-heart caterpillar	Neupane, 2000
6	* <i>Delia platura</i> (Meigen)	Diptera: Anthomyiidae	Bean seed fly	CPC, 2007
7	<i>Dorylus orientalis</i> (Westwood)	Hymenoptera: Formicidae	Oriental army ant	Joshi and Manandhar, 2001
8	* <i>Gryllotalpa africana</i> (Palisot de Beauvois)	Orthoptera: Gryllotalpidae	African mole cricket	Joshi and Manandhar, 2001
9	* <i>Hadula trifolii</i> (Hufnagel, 1766)	Lepidoptera: Noctuidae	Clover cutworm	CPC, 2007
10	* <i>Hellula undalis</i> (Fabricius)	Lepidoptera: Crambidae	Cabbage webworm	Paneru & Bhattarai, 2010/11
11	* <i>Homona coffearia</i> (Nietner, 1861)	Lepidoptera: Tortricidae	Tea tortrix	Robinson et.al. 1995
12	* <i>Liriomyza bryoniae</i> (Kaltenbach)	Diptera: Agromyzidae	Miner, tomato leaf	CPC, 2007
13	* <i>Mamestra brassicae</i> (Linnaeus, 1758)	Lepidoptera: Noctuidae	Cabbage moth	Smith, 2010
14	* <i>Peridroma saucia</i> (Hubner, 1808)	Lepidoptera: Noctuidae	Pearly underwing moth	Yoshimoto, 1992
15	Phyllotreta	Coleoptera: Chrysomelidae	Flea beetles	Joshi and Manandhar, 2001
16	* <i>Phyllotreta cruciferae</i> (Goeze)	Coleoptera: Chrysomelidae	Crucifer flea beetle	Neupane, 2000
17	* <i>Phyllotreta striolata</i> (Fabricius 1803)	Coleoptera: Chrysomelidae	Cabbage flea beetle	CPC, 2007
18	* <i>Pieris brassicae</i> (Linnaeus, 1758)	Lepidoptera: Pieridae	Cabbage caterpillar	CPC, 2007
19	* <i>Pieris rapae</i> (Linnaeus)	Lepidoptera: Pieridae	Cabbage white butterfly	Paneru & Bhattarai, 2010/11
20	* <i>Plutella xylostella</i> (Linnaeus)	Lepidoptera: Plutellidae	Diamondback moth	CPC, 2007
21	<i>Pontia daplidice</i> (Linnaeus)	Lepidoptera: Pieridae		Joshi and Manandhar, 2001
22	<i>Spilarctia obliqua</i> (Walker)	Lepidoptera: Arctiidae	Hairy, caterpillar, common	Paneru & Bhattarai, 2010/11
23	* <i>Spodoptera exigua</i>	Lepidoptera: Noctuidae	Beet	Yoshimoto, 1992

SN	Scientific Name	Taxonomic Position	Common Name	Reference
	(Hubner)		armyworm	
24	* <i>Spodoptera litura</i> (Fabricius)	Lepidoptera: Noctuidae	Taro caterpillar	CPC, 2007
25	* <i>Thrips tabaci</i> (Lindeman, 1889)	Thysanoptera: Thripidae	Potato thrips	Paneru & Bhattarai, 2010/11
26	* <i>Thysanoplusia orichalcea</i> (Fabricius, 1775)	Lepidoptera: Noctuidae	Slender burnished brass moth	Joshi and Manandhar, 2001
27	* <i>Trichoplusia ni</i> (Hubner)	Lepidoptera: Noctuidae	Cabbage looper	Yoshimoto, 1993a
28	* <i>Xestia c-nigrum</i> (Linnaeus, 1758)	Lepidoptera: Noctuidae	Spotted cutworm	Yoshimoto, 1992
29	<i>Pieris canidia</i> (Sparrmann)	Lepidoptera: Pieridae	Cabbage butterfly	Neupane, 2000
30	<i>Brevicoryne brassicae</i> (Linnaeus)	Homoptera: Aphididae	Cabbage aphid	Neupane, 2000
31	<i>Lipaphis erysimi</i> (Kaltenbach)	Homoptera: Aphididae	Mustard aphid	Neupane, 2000
32	<i>Monolepta signata</i> (Oliver)	Coleoptera: Chrysomelidae	Whitespotted flea beetle	Neupane, 2000
33	<i>Athalia lugens</i> (Klug)	Hymenoptera: Tenthredinidae	Mustard sawfly	Neupane, 2000
SNAILS AND SLUGS				
1.	<i>Bensonies nepalensis</i>	Pulmonata: Ariophatidae		Buda, 2007
2.	<i>Lissachatina fulica</i>	Pulmonata: Achatinidae	African Giant Snail	Buda, 2007
3.	<i>Laevicaulis altae</i>	Pulmonata: Veronicellidae		Buda, 2007
4.	<i>Macrochlamys indica</i>	Pulmonata: Ariophatidae		Buda, 2007
5.	<i>Sinoennea stnopylis</i>	Pulmonata: Streptaxidae	snail	Raheem et.al., 2010
6.	<i>Hemiphaedusa martensiana</i>	Pulmonata: Clausiliidae	snail	Raheem et.al., 2010
7.	<i>Himalodisus echinatus</i>	Pulmonata: Ariophatidae	snail	Raheem et.al., 2010
8.	<i>Limax seticus</i>	Pulmonata: Limacidae	Slug	Raheem et.al., 2010
9.	<i>Turcolimax oli</i>	Pulmonata: Limacidae	Slug	Raheem et.al., 2010
10.	<i>Deroceras leaves</i>	Pulmonata: Agriolimacidae	Slug	Raheem et.al., 2010
11.	<i>Laevozebrinus nepalensis</i>	Pulmonata: Enidae	Snail	Raheem et.al., 2010
12.	<i>Pupinidius tukuchensis</i>	Pulmonata: Enidae	Snail	Raheem et.al., 2010
NEMATODES				
1	* <i>Longidorus</i>	Longidoridae (Tylencholaimidae)	Longidorids (needle nematodes)	CPC , 2007
FUNGI				
1	* <i>Albugo candida</i> (Pers.) Kuntze	Amamorphic fungi (Peronosporapes : Albuginaceae)	White rust of crucifers	CPC , 2007
2	* <i>Alternaria dauci</i> (J. G.	Amamorphic fungi	Leaf blight of	CPC , 2007

SN	Scientific Name	Taxonomic Position	Common Name	Reference
	Kuhu)	(Moniliales: Dematiaceae)	carrot	
3	* <i>Botryotinia fuckeliana</i> (de Bary) whetzel	Helotiales: Sclerotiaceae	Grey mould-rot	CPC , 2007
4	* <i>Corticium rolfsii</i> (Curzi)	Polyporales: Corticaceae	Sclerotium rot	CPC , 2007
5	<i>Fusarium oxysporum</i> (Schlechtendahl)	Hypocreales (Moniliales: Moniliaceae) Teleomorph)	Basal rot	CPC , 2007
6	* <i>Peronospora parasitica</i> (Pers.)	Peronosporales: Peronosporaceae	Downy mildew	CPC , 2007
7	* <i>Sclerotinia sclerotiorum</i> (Lib.)	Helotiales: Sclerotiaceae	Cottony soft rot	CPC , 2007
8	<i>Plasmodiophora brassicae</i>	Plasmodiophorales: Plasmodiophoriaceae)	Club root	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
9	<i>Alternaria brassicicola</i>	Anamorphic fungi (Moniliales: Moniliaceae)	Leaf spot	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
10	<i>Pythium spp.</i>	Saprolegniales (Peronosporales: Pythiaceae	Damping-off	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
11	<i>Sclerospora spp.</i>	Peronosporales: Peronosporaceae	Downy mildew	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
12	<i>Erysiphe spp.</i>	Erysiphales : Erysiphaceae	Powdery mildew	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
13	<i>Colletotrichum spp</i>	Anthracnose (Melanoconiace :	Anthracnose	Paneru & Bhattarai, 2010/11,
14	<i>Botrytis cinerea</i>	Moniliales: Moniliaceae	Gray mold	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
15	<i>Leptosphaeria spp.</i>	Plesoporales: Leptosphaeriaceae	Black rot	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
16	<i>Fusarium oxysporum</i>	Hypocreales (Moniliales: Tuberculariaceae)	Root rot	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066

BACTERIA

1	* <i>Erwinia chrysanthemi</i> (Burkh.)	Enterobacteriales: Enterobacteriaceae	Bacterial wilt of dahlia	CPC, 2007
2	* <i>Pseudomonas viridiflava</i>	Pseudomonadales:	Bacterial leaf	CPC, 2007

SN	Scientific Name	Taxonomic Position	Common Name	Reference
	(Burkholder, 1930)	Pseudomonadaceae	blight of tomato (USA)	
3	* <i>Xanthomonas campestris</i> pv. <i>campestris</i> (Pammel 1895)	Xanthomonadales: Xanthomonadaceae	Black rot	CPC, 2007
4	<i>Pseudomonas</i> spp.	Pseudomonadales: pseudomonadaceae	Wilt	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
5	<i>Xanthomonas campestris</i>	Xanthomonadales: Xanthomonadaceae	Black rot	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
6	<i>Rhizoctonia solani</i> (<i>Thanatephorus cucumeris</i> (Frank))	Ceratobasidiales : Ceratobasidiaceae	Damping off	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
VIRUS				
1	* <i>Turnip mosaic virus</i>	Potyviridae: Potyvirus	Cabbage A virus mosaic	
PLANTS				
1	* <i>Chenopodium album</i> (L. 1753)	Caryophyllales: Chenopodiaceae	Fat hen	CPC , 2007
2	* <i>Chenopodium murale</i> (L. 1753)	Caryophyllales: Chenopodiaceae	Nettleleaf goosefoot	CPC , 2007
3	* <i>Echinochloa crus-galli</i> (L.) Beauv	Cyperales: Poaceae	Barnyard grass	CPC , 2007
4	* <i>Lolium temulentum</i> (L.)	Cyperales: Poaceae	Darnel	CPC , 2007
5	* <i>Orobancha</i>	Scrophulariales: Orobanchaceae	Broomrape	CPC , 2007
6	<i>Ageratum</i> spp	Asteraceae	Goat weed	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
7	<i>Cynodon dactylon</i>	Gramineae	Bermuda grass	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
8	<i>Chenopodium</i> spp.	Caryophyllales: Chenopodiaceae	Common lambsquarters	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
9	<i>Amaranthus</i> spp.	Caryophyllales: Amaranthaceae	Red pigweed	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
10	<i>Cyperus rotundus</i> L	Cyperales: Cyperaceae	Purple nutsedge	Paneru & Bhattarai, 2010/11,

SN	Scientific Name	Taxonomic Position	Common Name	Reference
11	<i>Fimbritylis spp.</i>	Cyperaceae	Bhiruwa	CRPPL, 2065/066 Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
12	<i>Echinochloa spp.</i>	Gramineae : Poaceae	Jungle rice	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
13	<i>Mimosa pudica</i>	Mimosaceae	Touch - me - not	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
14	<i>Stellaria spp.</i>	Caryophyllaceae	common chikweed	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
15	<i>Capsella bursa-pastories Medic</i>	Brassicaceae	Banrayo	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
16	<i>Digitaria spp.</i>	Gramineae	Estern African couchgrass	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
17	<i>Oxalis corniculata L</i>	Oxalidaceae	Creeping woodsorrel	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
18	<i>Eclipta prostrate L</i>	Asteraceae	False daisy	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066
19	<i>Spergula arvenisis L</i>	Caryophyllaceae	Corn spurry	Paneru & Bhattarai, 2010/11, CRPPL, 2065/066

Annex 3: Guidelines on corrective action plans

The detection of a single target pest in the cabbage PFA should trigger enforcement of a corrective action plan. In case of an outbreak, the objective of the corrective action plan is to ensure eradication of the pest to enable reinstatement of pest status in the affected area into the cabbage PFA. The corrective action plan should be prepared taking into account the biology of the target pest, the geography of the cabbage PFA area, climatic conditions and host distribution within the area.

The elements required for implementation of a corrective action plan include:

- legal framework under which the corrective action plan can be applied
- criteria for the declaration of an outbreak
- time scales for the initial response
- technical criteria for delimiting trapping, sampling, application of the eradication actions and establishment of regulatory measures
- availability of sufficient operational resources
- identification capability
- effective communication within the NPPO and with the NPPO(s) of the importing country(ies), including provision of contact details of all parties involved.

Actions to apply the corrective action plan

1) Determination of the phytosanitary status of the detection (actionable or non-actionable)

(1.1) If the detection is a transient non-actionable occurrence (ISPM 8:), no further action is required.

(1.2) If the detection of a target pest may be actionable, a delimiting survey should be implemented immediately after the detection to assess whether the detection represents an outbreak, which will determine necessary responsive actions. If a population is present, this action is also used to determine the size of the affected area.

2) Suspension of FF-PFA status

If after detection it is determined that an outbreak has occurred the affected area should be suspended.

3) Implementation of control measures in the affected area

As per ISPM 9:1998, specific corrective or eradication actions should be implemented immediately in the affected area(s) and adequately communicated to the community. Phytosanitary measures should be immediately enforced for control of movement of regulated articles that can host quarantine pests. These measures may include cancellation of shipments of commodities from the affected area and as appropriate, the operation of internal quarantine measures to prevent the movement of infested commodity from the affected area to the rest of the pest free area. Other measures could be adopted if agreed by the importing country, for example treatment, increased surveys.

4) Criteria for reinstatement of a FF-PFA after an outbreak and actions to be taken

The criteria for determining that eradication has been successful should be included in the corrective action plan for the target pests. The time period will depend on the biology of the species and the prevailing environmental conditions. Once the criteria have been fulfilled the following actions should be taken:

- notification of NPPOs of importing countries
- reinstatement of normal surveillance levels
- reinstatement of the cabbage PFA.

(5) Notification of relevant agencies

Relevant NPPOs and other agencies should be kept informed of any change in cabbage PFA status as appropriate, and IPPC pest reporting obligations observed (ISPM 17: Pest Reporting)

APPENDIXES

Appendix-1 Good agricultural practices for Cabbage Production

Farm Plan:

Cabbage production farmers group should prepare their crop production plan and accordingly the market aspect should be designed.

- The production plan should include Total numbers of plot/area planned for cabbage production.
- General prior history of the plot proposed for cabbage production (e.g. intensive crop management with high inputs).
- Last year yield.
- Follow crop rotation plan. Within crop rotation plan provision should be made for legume cropping.
- Soil test for PH, OM, NPK should be done regularly. Soil should be rich in Organic matter.
- Soil should contain adequate organic matter.
- Production area should have enough sunlight and well managed irrigation and drainage facility.
- Cabbage thrives best in sandy loam soil with pH range of 6-6.5 and temperature in the range of less than 20⁰C to-25⁰C

Nursery Management:

- Quality seed should be used from reliable source.
- Follow standard nursery soil management practices (physical, safe chemical and biological methods for nursery bed treatment, height, and size and substrate ratio). No seedlings from pest infected areas should be used.
- Focus on use of organic source of nutrients (well decomposed and pest free).
- Seed treatment with Trichoderma or Carbendazim should be done.
- Soil treatment (Solarization/bio-agents or use of plastic).
- Apply well decomposed FYM or compost @ 20kg per m².
- Maintain appropriate distance and depth of sowing.

Selection of Variety and Seed Rate

- Selection of varieties should be appropriate to the local condition but as per technical recommendation.
- 30-40 gms (OP) or 10-12 gms (Hybrid) seed for 500 m² production area.
- Early varieties seedling should be transplanted at 40x40 cm and late varieties can be transplanted at 50x50cm.
- Seedling age should be not more than 30-40 days old.
- Commonly grown varieties : Asia express, green hut Super green, green cronet, Copenhagen market, Nepa round etc.

Weed Management

- Weed or crop residue from previous crop should be thoroughly removed and brought for composting except seed bearing species.
- Weed management should be done manually.
- Chemical herbicide use should be discouraged.
- Intercultural operation till 40-45 days should be carefully done

Soil Fertility Management

- Carry out routine soil test for pH, organic matter and major nutrients like NPK. (general dosage NPK::5:3:2.5 per Ropani)
- Apply organic manure as recommended (@ 20 ton per hectare as a basal dose before transplanting of seedlings.
- Application of chemical fertilizer as per recommendation.
- Apply boron and molybdenum @ 500-gms of Borax per 500 m² area, but apply after soil test or after seeing the boron deficiency symptoms.

Tillage Practices

- Deep laughing is recommended and makes the soil pulverized.
- Apply FYM/ compost in pit where seedling is transplanted.
- Any tillage practices should be friendly to soil conservation.
- Soil should be well pulverized before transplanting the cabbage.

Light irrigation must be given after transplanting the seedling.

Plant Protection measures

Preventive Management

- Pest problem should be monitored before applying any external materials.
- Priority should be given for biological materials.
- Follow crop rotation; maintain plant density adjusting spacing, depth of sowing, time of planting, raised beds during summer season, use crop diversity, and minimize the presence of alternate host of pests.
- Use disease tolerant varieties.
- Intercropping with trap crops likes tomato planted earlier than cabbage (2 weeks before) can minimize the problem of DBM, intercropping with spinach or bean can minimize the aphid.
- Along the border planting of marigold may help to repel different pest and diseases

Major Diseases

Damping-off

- Sow the seeds on raised bed.
- Maintain good drainage in nursery bed.
- Establish nursery in sunny place.
- Compost prepared from tree bark/sawdust may help to suppress the pathogen.
- Cover the seed bed with thatching materials or shed.
- As last resort, spray Carbendazim 1 gm/liter of water on seed bed.

Club Root

- Adopt long crop rotation.
- Do not establish nursery in the infected soil.
- Impose internal quarantine, do not bring seedling from the area infected with diseases
- Apply lime to increase soil pH.
- Do not dispose the diseased debris in the field and compost pit.

- Apply sufficient amount of organic manure.
- Use of recommended chemical (fungicide Nebigin (@20-25kg per ha) bigen has been found effective in reducing the damage

Alternaria Leaf Spot

- Use healthy seed.
- Visit the field regularly and take decision accordingly.
- After planting of seedling, DM-45 can be used.
- Remove infected older leaves frequently.
- Maintain good field sanitation

Black Rot

- Follow crop rotation (no crucifer 3 years).
- Seed treatment with hot water (50⁰C for about 30 minutes).
- Use tolerant variety.
- Make appropriate drainage system.
- Transplanting of seedlings on raised bed.
- Rouging of infected plants.

Black Leg

- Plant seed that has been treated with hot water treatment (50⁰C for about 30 minutes) and followed by treatment with a protective fungicide
- Follow crop rotation (no crucifer for 4 years in both field and seedbed).
- If a rotation of the plant bed is impossible, disinfest the soil with heat or a soil fumigant
- Seed treatment with hot water (50⁰C for about 30 minutes).
- Keep fields free of cruciferous weeds
- Do **not** work the seedbed or cultivate fields when the plants are wet with dew or rain
- Maintain good field sanitation.

Major Insect Pests

Flea Beetle

- Use of botanical pesticide like Neemajol @ 5 ml/liter of water.
- Use yellow sticky trap.

Make the seedbed at 1 m height for raising seedling.

Aphid

- Cow urine 1 liter of fermented mixed with 7 liter of water and spray.
- Spray soap water underneath the foliage in the aphid colony.
- Use of botanical pesticide like Neemajol @ 5 ml/liter of water

Diamond-back Moth

- Reduce early population using lures and sex pheromones (Plutella lure).
- Use bio-control agent (BT).
- Use Neem pesticide @ 3 ml/liter of water.
- Adjust planting time so as to avoid its peak infestation.

Cabbage Butterfly

- Collect and disturb egg and larvae masses.
- Spray cow urine (fermented 1 liter per 5 liter of water).
- Extracts of stinging nettle (Sisnu) 1 liter solution, 50 gm of yeast and 10 liter of water can be sprayed.
- Use bio-control agent (BT).
- Use Neemajol @ 3 ml/liter of water.

Snails and Slugs

- Planting repellent plant like Mint, Basil (holy and French).
- Collection of snails in poly bags and destruction by spraying with salt.
- Trap slugs and snails in milk soaked jute sack and destroy physically

Physiological Disorder

Cabbage Head Splitting

- Maintain moisture in the soil and timely sowing of the seeds and planting of the seedlings.
- Adjust harvesting time before loss occurs.

Tip-burn on Cabbage

- Use tolerant varieties.
- Balanced the micro-nutrients in the soil including calcium.

Harvesting of Crops

- Check firmness and rigidity of head.
- Compare varietal characters.
 - Analyze market demand and season
- Avoid physical injury during harvest.
- Cut the cabbage head below 1 to 2 cm of stalk.
- Harvest during either in the morning after the dew gets dry or in the evening

Post Harvest Handling

- **At Growers Level** Cleaning/ sorting/grading.
- Transport with care to avoid physical damage.
- **Collection Centre Level** Maintain hygiene and sanitation.
- Use the Appropriate tray or base and packaging materials.
- Do not use of any chemical for shelf life of products.

Wholesaler and Retailer Level

- Storage area must be free from chemicals.
- Do not use of any chemical for shelf life enhancement of products.
- Packaging materials should be free from any contaminants, dirt or harmful substances (physical, biological and chemical).

Appendix-2 Biology of Diamondback Moth (*Plutella xylostella*)

Diamondback moth populations peak in March and April and again in June through August. If conditions are favorable, this moth can have from four to six generations a year. Diamondback moths can be particularly damaging to cabbage.

The adult diamondback moth is small, slender and gray-brown in color. The name 'diamondback' is derived from the appearance of three diamonds when the male species folds its wings. The female moth lays small eggs on the underside of the leaf. Typically the eggs are laid separately but occasionally can be found in groups of two or three. The larvae are about a 1/3 of an inch long, pale yellow-green and covered with fine bristles. A v-shape is formed by the spreading prolegs on the last segment of the caterpillar. When startled, the larvae will writhe around or drop from the leaf on a silken line.

Diamondback moth larvae attack all stages of plant growth but their damage is most significant during the seedling stage and at harvest. Larvae attack the growing points on young plants, stunting growth and decreasing yield. The larvae will also chew small holes, mostly on the underside of mature leaves, on mature plants. Napa cabbage heads that are contaminated by larvae or larvae frass or damaged by larvae feeding are unmarketable.

Sampling and Treatment Thresholds: Fields should be monitored during; the seedling stage, crop thinning and prior to heading. Fields should also be checked if an adjacent field has recently been harvested or been disked, as the larvae will migrate from such fields. It is recommended that prior to head formation, cabbage should be treated when there is 1 larva per 50 plants. Once the cabbage head has formed, the crop can tolerate 1 larva per 100 plants. All other lepidopterous larvae that are noted should be included in this total.

Biological Control: The ichneumonid wasp (*Diadegma insularis*) will commonly parasitize *Plutella* cocoons. *Trichogramma pretiosum* is a less common parasite that attacks diamondback moth eggs. Lacewing larvae and ladybug larvae (syn: ant lions) can also be used to control small diamondback larvae. Care must be used when spraying insecticides as they can harm populations of beneficial

insects. These beneficial insects, however, usually will not provide complete control of diamondback moth populations.

Chemical Control: Cypermethrin are the most frequently utilized chemistries for the control of diamondback moths. *Plutella* resistance to insecticides has been reported and is a concern in cabbage production.

Cultural Control: Fields should be disked immediately following harvest in order to kill larvae and pupae in the soil and prevent moth migration to adjacent crops.

Post-Harvest Control: There are no effective methods for the post-harvest control of diamondback moths.

Alternative Control: *Bacillus thuringiensis* (Bt) can be used to control diamondback moth larvae. Spraying at night will allow the longest period of efficacy. Neem oil soap, neem emulsion are less effective choices for the control of larvae.

Appendix-3 Biology of Cabbage Aphid (*Brevicoryne brassicae*)

Green aphids are found feeding on the lower surface of mature leaves and will quickly colonize younger leaves as the population increases. Aphid populations peak during the months of November and December and again during February and March. Populations consist entirely of asexual reproducing females producing live young; this allows the population to increase rapidly. Under ideal conditions aphids have as many as 21 generations in one year. When populations become too large or food is scarce, aphids produce winged offspring that can migrate to new hosts.

The majority of aphid damage occurs during the final heading stage of cabbage. Extreme aphid feeding can deplete a plant of enough phloem sap to reduce the plant's vigor or even kill the plant. In addition, as an aphid feeds it excretes phloem sap ("honeydew") onto the plant's surface. This provides an ideal environment for sooty mold infection, which inhibits photosynthesis. Aphid feeding can cause the leaves to become deformed and the head to be distorted. Aphids are most damaging, however, as a contaminant; their presence in a cabbage head will make the head unmarketable.

Sampling and Treatment Thresholds: To control aphid infestations, it is essential to monitor fields frequently and prevent the growth of large populations. These pests migrate into crop fields and reproduce rapidly, quickly infecting a crop. Beginning in January, fields should be monitored no less than twice a week. Yellow waterpan traps are useful for measuring aphid movement into the field. In infested fields, aphids tend to occur in clusters within the field, thus it is important to randomly sample the field. It is recommended that prior to head formation, treatment should begin when populations reach 1 aphid per 10 plants. After head formation, cabbage should be treated when aphid colonization begins.

Biological Control: Parasitoids and predators that attack aphids are available; however, they are usually unable to completely control aphid populations. Lady beetle larvae, lacewing larvae, syrphid fly larva, aphid parasites are some of the insects used to control aphids. Spraying of insecticides should be performed with caution as it can eliminate beneficial insects. These beneficial insects, however, can also become contaminants of cabbage.

Chemical Control: Endosulfan are the most frequently used foliar-applied treatments. The initial foliar-applied treatment should occur once wingless aphids begin to migrate into a crop field. To ensure that the harvested cabbage is not contaminated with aphids, it might be necessary to use repeated applications. Aphids often hide within the protected areas of the cabbage head making insecticide treatment

difficult. If aphids only occur at the field borders or in isolated areas, border or spot applications might be sufficient to control populations.

Cultural Control: Aphids tend to build up in weeds, particularly cruciferous weeds therefore it is important to control weeds in the field and surrounding the field. Fields should be plowed under immediately following harvest, to eliminate any crop refuse that could host aphids

Post-Harvest Control: There are no methods for the post-harvest control of aphids.

Alternative Control: Organic growers use; insecticidal soaps, neem oil soap, neem emulsion, pyrethrin, to control aphid populations.

Appendix-4 Biology of Black leaf spot(*Pseudomonas maculicola*)

Cause: A bacterium, *Pseudomonas syringae* pv. *maculicola*, also known as bacterial leaf spot on cauliflower, broccoli, and Brussels sprouts. Bacteria survive on infested seed and crop residues as well as in soil. Cool, wet weather favors disease development before harvest.

Symptoms: Tiny black to purplish spots appear on outer leaves. Yellow halos appear around the spots, and they eventually grow together to form light brown, papery areas. Symptoms may vary depending on the pathogen strain present in the field.

Ecology: Increased humidity (90% and higher) and temperature (17-20°C) have a great importance for the bacteriosis development. High severity of the disease is possible on seed shoots of late cabbage planting, if the second half of vegetation period is excessively rainy.

Cultural control

- Plant pathogen-free seed.
- Avoid sprinkler irrigation in the seedbed once the crop has germinated and established.
- Shred and turn under diseased crop refuse promptly after harvest to hasten breakdown of infected plant material.
- Do not plant cole crops the following year if the field has a significant level of infection.

Economic significance.

Yield losses depend on a cultivated variety and conditions of cultivation of plants. The yield and quality of marketable heads and seeds are reduced due to this disease. Control measures include optimal agriculture, maintenance of crop rotation, cultivation of relatively resistant varieties, careful removal of plant residues, separating seeds from shrunken grains, pesticide treatment of seeds before sowing, and treatment of plants by pesticides during vegetation period.

Appendix-5 Biology of Black Rot (*Xanthomonas campestris*)

Black rot is occasionally observed in cabbage fields. This bacterium normally only occurs when the weather is warm and humid; however, it can be introduced into crops from infected seed. The pathogen spreads rapidly when there is unusually high rainfall or if overhead irrigation is used. Animals and humans can also spread *Xanthomonas*. The bacterium can enter the plant through the leaf margin or insect wounds. *X. campestris* survives in crop debris, infected weeds and infected seed.

The initial symptoms of black rot are yellow-orange v-shaped lesions along the leaf margins. As the disease progresses, these lesions dry out and the leaves are shed from the plant. Black rot damages the plant's vascular system, giving it characteristic black veins. This disease can become systemic, in which case these black veins are also observed in the main stem. Black rot can be deceiving by not expressing symptoms in cool temperatures, rather only developing small, brown spots that resembles symptoms of other bacterial diseases. Prolonged infection can cause plant stunting, wilting and even death of plants.

Biological Control: There are no available methods for the biological control of black rot.

Chemical Control: Copper-based fungicides are the most effective when applied preventively before the onset of disease. Copper-based fungicides are contact fungicides.

Cultural Control: Planting only certified disease-free seed will help reduce the risk of black rot. If the seed is infected, it can be treated with hot water, which will reduce infection but also reduces the germination percentage of the seed. Cole crops should not be planted in the same field more than once every four years; this reduces the risk of disease carryover between crops. As well, it is important to control volunteer plants and weeds, especially cruciferous weeds, which can act as hosts for black rot. Irrigation should be performed with care, to avoid over watering the crop. It is very important to ensure that tillage and plow equipment is sanitized between uses on different fields, this will prevent the spread of bacterium. Fields should be deeply plowed after harvest to kill

bacterium and speed the decay of plant debris.

Post-Harvest Control: There are no methods for the post-harvest control of black rot.

Alternative Control: Some growers spread compost on the soil to control pathogens.

Appendix-6 Biology of Black leg (*Phoma lingam*)

In warm, wet seasons, blackleg, caused by the fungus *Phoma lingam* is potentially one of the most serious and widespread diseases of cabbage. Blackleg is less important now than formerly due to greatly improved seed quality and the general practice of treating crucifer seed with hot water. However, the disease can still be destructive in a seedbed from the sowing of infested seed, when optimum conditions for disease spread and development prevail.

Symptoms

All parts of susceptible plants, both above and below ground, may be affected from seedbed to harvest and even during storage. The earliest conspicuous symptoms often occur in the seedbed two or three weeks before transplanting time.

1. **Seedlings.** Cotyledon infection, which appears as pale gray lesions, usually causes the seedlings to die early. This loss often goes unnoticed in the seedbed. The fungus produces a tremendous number of microscopic spores (conidia) on the hypocotyls, cotyledons, and first true leaves of prematurely killed seedlings, and thus is able to cause many secondary infections in the seedbed and field.

2. **Stems.** An elongated, light brown, sunken area or lesion with a purplish margin forms on the stem near the soil line. The lesion gradually extends upward and downward until the stem is girdled and turns black.

Numerous, tiny, black, fungus fruiting bodies (pycnidia) soon form in the diseased area. Affected plants often wilt suddenly and die, or they topple over later as the head enlarges.

3. **Roots.** The root system is gradually destroyed, although plants may be kept alive in damp soil when new roots form above the diseased parts. Badly affected cabbage plants may survive until fair-sized heads are formed. The wilting leaves usually remain attached to the stem instead of dropping off, as is characteristic of *Fusarium* yellows and black rot.

Dark cankers develop in the fleshy roots of rutabaga, turnip, and other plants. Dry rot may develop on fleshy roots in storage, where severe losses may occur. Pycnidia are common on the surface of all decayed tissues.

4. **Leaves.** Inconspicuous, somewhat circular, light brown to grayish spots form on the leaves. The lesions soon become well defined and develop ash gray centers in

which a large number of speck-sized, black pycnidia are scattered. These spots may later tear or drop out.

5. **Heads.** Heads from late-infected plants may appear healthy at harvest but later in storage develop sunken black lesions around their base. The presence of abundant, minute pycnidia on the cotyledons, stems, leaves, and roots distinguishes blackleg from other crucifer diseases.

Disease cycle

The causal fungus can live for at least three years in the soil between crops in infected plant refuse and on or within infected seed. When crucifer plants are carried through the winter for seed production the following growing season, the seed pods may become infected. The fungus penetrates into the seed coat, where it remains dormant. Severely infected seeds shrivel and do not germinate. When infected seed is planted, black, flask-shaped pycnidia of the *Phoma* fungus form in the hypocotyls and cotyledons as they are pushed above ground. Each pycnidium contains many thousands of one-celled, thin-walled, microscopic spores called conidia that exude in a gelatinous, pinkish “coil” when in contact with water. The conidia serve as the primary source of infection for nearby plants. Just a few infected seeds in a seedbed or field are enough to start an epidemic during warm, showery weather. Black specks (perithecia), which closely resemble pycnidia, form in clusters on old blackened stems and leaves. The globose perithecia contain large numbers of cylindrical to club-shaped asci each containing eight cylindrical to ellipsoid, yellow-brown, ascospores with rounded ends which contain several cells.

The causal fungus depends entirely on dew, rain, or irrigation water to promote discharge of spores. The spores are spread to healthy plants primarily by splashing water; also, in infested manure, on tools, on cultivation and spray equipment, and perhaps by insects. New lesions will result in 10 to 14 days. Surface drainage water may carry spores from infected debris in fields to the seedbed. Large numbers of the young plants commonly become infected when they are pulled and either sprayed or dipped in water. If *Phoma* spores are present, every transplant may become contaminated.

Control

1. Plant **only** crucifer seed that has been treated with hot water. Proper hot water treatment, followed by treatment with a protective fungicide, also eliminates seedborne

infections of other diseases, such as black rot, Alternaria or black leaf spot, Fusarium yellows, downy mildew, and scab. Losses from blackleg and other seedborne diseases will be lower where direct seeding is used.

2. Plan at least a 4-year rotation between crucifer crops in both field and seedbed. Seedbeds should be located at least one-fourth mile from production fields in a fertile, well-drained soil and where they will not receive surface water from soil likely to be infested with the blackleg or black rot organisms. If a rotation of the plant bed is impossible, disinfest the soil with heat or a soil fumigant.
3. Do **not** plant crucifers in fields next to those where crucifers were grown the year before. Surface water and wind may spread infested crop refuse.
4. When watering plant beds, do not sprinkle the foliage. Careless sprinkling is a common way to disseminate the blackleg fungus.
5. Do **not** work the seedbed or cultivate fields when the plants are wet with dew or rain.
6. Do **not** use seedlings from blackleg-infested seedbeds. Seedbeds should be carefully inspected for disease every 7 to 10 days and especially 2 or 3 days before transplants are pulled.
7. Keep fields free of cruciferous weeds, wild mustards and radishes. Follow current weed control recommendations.
8. Wash all farm equipment with water plus a disinfectant and dry before moving it from a diseased to a healthy field.
9. Control cabbage root maggots, cutworms, cabbage worms, and other insects.
10. Clean up all crop debris and burn or plow it down deeply and cleanly after harvest.
11. Do not feed crucifer debris to livestock.
12. If transplants are purchased, be sure a phytosanitary certificate has been issued and be sure the transplants have been raised from hot-water treated seed, in accordance with the previously mentioned control practices.

Appendix-7 Biology of Clubroot (*Plasmodiophora brassicae*)

Cabbage Clubroot is a disease of Brassicaceae (mustard family or cabbage family) caused by the soil-borne *Plasmodiophora brassicae*. The disease first appears scattered in fields, but in successive seasons it will infect the entire field, reducing the yield significantly and sometimes resulting in no yield at all. Symptoms appear as yellowing, wilting, stunting, and galls on the roots. It is transmitted by contaminated transplants, animals, surface water runoff, contaminated equipment, and irrigation water. The pathogen can survive in a field for years as resting spores without a host present and will infect the next crop planted if it is a susceptible host. This pathogen prefers a wet climate and a pH around 5.7, so proper irrigation and the addition of compounds that raise the pH can be used to control this disease. Other control methods include sanitation to prevent transmission, chemical control, and resistant varieties.

Symptoms

Developing plants may not show any symptoms but as the plants get older they will start to show symptoms of chlorosis or yellowing, wilting during hot days, and exhibit stunted growth. Below ground, the roots experience cell proliferation due to increased auxin or growth hormone production from the plant as well as the pathogen. This causes the formation of galls that can grow big enough to restrict the xylem tissue inhibiting efficient water uptake by the plant. Galls appear like clubs or spindles on the roots. Eventually the roots will rot and the plant will die.

Disease cycle

In the spring, resting spores in the soil germinate and produce zoospores. These zoospores swim through the moist soil and enter host plants through wounds or root hairs. A plasmodium is formed from the division of many amoeba-like cells. This plasmodium eventually divides and forms secondary zoospores that are once again released into the soil. The secondary infection by the zoospores can infect the first host or surrounding hosts. These secondary zoospores can be transmitted to other fields through farm machinery or water erosion. They form a secondary plasmodium that affects plant hormones to cause swelling in root cells. These cells eventually turn into galls or “clubs”. The secondary plasmodium forms the overwintering resting spores which get released into the soil as the “clubs” rot and disintegrate. These resting spores can live in the soil for up to 20 years while they wait for a root tip to come in close proximity for them to infect.

Environment

Clubroot is a disease that prefers warmer temperatures and moist conditions. Ideal conditions for the proliferation of this disease would be a soil temperature between 20-24°C and a pH less than 6.5; Therefore, this disease tends to be prominent in lower fields where water tends to collect.

Management

Clubroot is very hard to control. The primary step for management and long-term control is exclusion of the disease. Good sanitation practice is important with regard to the use of tools and machinery in order to prevent the introduction of the pathogen to a disease-free field. It is not uncommon for an inattentive farmer or gardener to unknowingly carry in the pathogen after being previously exposed to it at a different time. One should avoid purchasing infected transplants of cabbage so as to prohibit the infestation of *P. brassicae*. Soil type is also an important factor in the development and spread of cabbage clubroot; the use of sand will allow for the plants to grow in well-drained soil, thereby eliminating the possibility of the pathogen to proliferate in a hospitable environment.

Although it is difficult to eradicate the pathogen once it is introduced to a field, there are several methods for its control. Keeping the soil at a slightly basic pH of 7.1-7.2 by the addition of agricultural lime as well as the integration of crop rotation will reduce the occurrence of cabbage clubroot in already infected fields.

Liming has been an effective control measure to curb clubroot since the 19th century. This method does not eradicate clubroot but it will slow its development by creating unfavorable conditions. In addition, Calcium and Magnesium can be added to the nutrition profile of the soil to help control clubroot. To get efficient results the field soil [pH] must be kept above 7.5. This takes massive applications to field soil in order to effect all of the soil where spores of clubroot are found. Combining lime with one other treatment has shown most effective.

The best way to prevent contamination between fields is to clean agriculture equipment and vehicles which have come in contact with club root before moving to a new field. All contaminated soil, equipment and tools must not be moved to clean-disease free fields. The best preventative method is field monitoring. Throughout the season plants should be monitored for early symptoms of club root.

Table 1: Data Recording Form

Field Datasheet	
1. Name of Field/Site visited:	
2. Date/Time of Visit:	
3. GPS Reference Point	Latitude:
	Longitude:
	Altitude:
4. Locality:	Village & ward:
	VDC:
	District:
5. Climate Data of Locality:	Average Min. temp (in °C):
	Average Max. temp (in °C):
	Rainfall (in mm)
6. Survey/Field plot No.	
7. Host Plant species inspected	
7.1 Description of habitat (e.g. aspect, vegetation, soil type)	
7.2 Alternate Host Plant species/Variety inspected	
8. Phenological Stage of the plant	
8.1 Main host	
8.2 Alternate host including vectors	
9. Sampling method	
10 Contact detail of local people involved in the survey	

11. Details of pest recorded											
SN	Scientific Name	Common Name	Category	Order	Family	Life Stages	Time	Plant parts affected	Symptom & Sign	Behavioral notes	Intensity
12. Any additional information (including collection of specimens for investigation):											
13. Name/Signature of surveyor with Date:											