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Good Agricultural Practices (GAP) for Production of Potato Crop

ICAR - Central Potato Research Institute
Shimla - 171 001 Himachal Pradesh, India

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Abbreviations

a.i.	Active ingredient
CIPC	isopropyl N-(3-chlorophenyl) carbamate
cm	Centimeter
CPRI	Central Potato Research Institute
ETL	Economic Threshold Level
FAO	Food and Agricultural Organization
FC	Field Capacity
FYM	Farm Yard Manure
g	Gram
GAP	Good Agricultural Practices
GEAC	Genetic Engineering Approval Committee
GM	Genetically Modified
ha	Hectare (2.5 acre)
ICAR	Indian Council of Agricultural Research
IndGAP	Indian Good Agricultural Practices
INM	Integrated Nutrient Management
IPM	Integrated Pest Management
kg	Kilogram
kg/ha	Kilogram per hectare
m	Meter
masl	Meter above sea level
mm	Milimeter
MRL	Maximum Residue Limit
t	Metric tonne
QCI	Quality Council of India
t/ha	Tonne per hectare
WHO	World Health Organisation

FOREWORD

The agriculture sector in India is witnessing a paradigm shift in terms of both quantity and quality of farm produce. With a record production of ~285 mt of food grains during 2017-18, India not only achieved self-sufficiency to support its commitment for National Food Security Act (NFSA) but also had a handsome quantity of exportable surplus. Similarly, with a total production of ~307 million tonnes of horticultural produce, India is now witnessing rapid growth in the horticulture sector. Indian agriculture is now thriving for a global presence instead of just satisfying its domestic requirement. In fact, in the recently released Agricultural Export Policy of India a target of doubling agricultural export from ~30 to ~60 billion USD by 2022 has been envisaged. Moreover, nutritive value as well as hygiene & safety of food is becoming a central theme for food preference of domestic consumers. Above all, it has become imperative to produce food and non-food agricultural goods in a sustainable and environmentally safe manner as a commitment to UN resolution of sustainable development goal. It is therefore necessary now to follow standard pre- and post-harvest practices to ensure various aspects of food and environmental safety including workers' health. GAP attempts to fulfil this necessity. The QCI has developed broad guidelines for GAP to cover all agricultural farm produce. Keeping in view the scale of farm operation in India, the QCI has designed a separate procedure as BasicGAP for small and marginal farmers who will be encouraged to follow global GAP standards gradually. The bigger farmers and large farms may straightway go for international standard by following IndGAP certification criteria.

Potato emerged as the principal vegetable crop of India after its introduction about 400 years ago from Europe; today it constitutes about 27% of total vegetable production of India. Potato has also been identified as an important commodity with high potential for export in India's agricultural export policy. Besides, potato processing sector is rapidly growing in the country necessitating production of good quality tubers suitable for the industry. Domestic consumers are also increasingly seeking table potatoes with higher nutritive value and

lower health risk. The whole scenario demands regulations in the chain of production till final consumption of potatoes. It calls for designing a set of procedures for production of ware and processing potato keeping in view the QCI requirement of both BasicGAP as well as IndGAP. The onus for designing the pre-harvest and post-harvest package of practices facilitating GAP certification in potato naturally comes to ICAR-CPRI, which is the premier institution on potato research and development of the country. The present publication is a step towards that direction. I am sure this will provide enough information to all the stakeholders for safe growing, handling and adhering to environmental benchmarks for potato crop in coming time. This will give impetus to brand image of Indian potato for different products, its diversified utilization and export.

I congratulate the authors for compiling this much awaited document, especially in the era of steady potato growth as a quality product in the domestic market and also to enhance export to potential destinations. The publication is expected to provide timely help to all stakeholders involved in potato and potato based entrepreneurs.

Director
ICAR-CPRI,
Shimla

PREFACE

Regulatory measures are pivotal in the food sector for protection of everyone's right in society. Unorganized dealing in the supply chain of any commodity or product does not build trust among stakeholders. Food safety, quality and environmental issues also take a back seat under such market scenario. Potato is no exception in this regard and lack of regulations under the single umbrella are hindering its further growth as a quality product in the domestic market as well as export to potential destinations.

Potato has an important role in assuring food and nutritional security for the increasing Indian population. This crop has reached new dimensions with the development of varieties for different agro-ecologies of the country and diversified use, production, protection and post-harvest technologies and efforts of potato growers by adopting scientific agro-technologies. As a result, the yield, production and acreage have increased recently by 3.4, 27.5 and 8.1 times, respectively, in comparison to the status of this crop at the time of independence. The crop has very optimistic projections for future as targets for area, production and yields have been set at 3.62 m ha, 122 mt and 34.5 t/ha, respectively by 2050. It is envisaged that area would increase by way of adjusting short duration potato varieties in prominent crop sequences and in inter-cropping systems in different potato growing regions of the country. Enhancement of productivity would be achieved by developing input efficient and pest and disease resistant varieties suited to different potato growing regions and fulfilling various requirements.

The whole scenario of this crop is very encouraging for harnessing its economic potential which is yet to be exploited in the domestic and international market. For this, all components of the supply chain have to be made robust so that its production and marketing fulfils international standards. Within this domain, the first and foremost requirement is to manage and raise potato crop sustainably in different agro-climatic zones. Choice of appropriate genotypes, precise production, protection and post-harvest technologies is pertinent for

growing safe potatoes as per global food standards, conservation of the environment and human welfare during the course of this process. So keeping whole development on this aspect in view, work on GAP for production of potato crop was started in the Institute during 2015. Efforts in this direction have resulted in this compiled document covering almost all aspects of GAP followed at the global level. An attempt has been made by us to incorporate the latest information available on different aspects of GAP for eco-friendly management of potato crop. In the meantime, QCI developed a set of broad general guidelines for India known as IndGAP. Keeping in view the predominance of small and marginal farmers in India, QCI has structured the guidelines in a manner to address the small and marginal farmers by developing certification criteria suiting their needs as BasicGAP to allow them a phased approach to international GAP standards while for the bigger farmers and large farms IndGAP certification criteria has been designed which they can go for straightaway. The present document attempts to cover both BasicGAP as well as IndGAP with respect to potato.

Developing GAP is a step in the direction of enhancing diversified utilization of potato crop and its smoother export. It is expected that this document would help potato growers, commercial organizations and researchers having stakes in the potato crop. There is always a scope for reviewing and improving contents of this document and it ought to be updated at a regular interval. Reader's comment on shortcomings and suggestions for the improvement of the document are most welcome and would be commendable.

-Authors

1. Introduction

The extensive research and development of potato in India, has made it possible to raise production from 1.54 million tonnes (1949-50) to 51.3 million tonnes (2017-18). With this production, India has become the second largest potato producing country. Today, potatoes are produced almost round the year in one or the other agro-ecological zones of the country. For the last seven decades, ICAR-CPRI is carrying out basic and strategic research and has developed improved varieties, production technologies, plant protection measures, storage and handling methods etc. All of them have played pivotal role in increasing the production and productivity of potato substantially within the country.

In India, the present scenario of potato production and marketing is optimistic. Potato growers are well aware with the crop management aspects. Seed and processing industry is in good shape by developing quite mature supply chain management strategies. The concept of contract farming is growing and improving with past experiences in different socio-economic situations existing within the country. Export of potato is also gaining momentum with the identification of clusters for Agri-export SEZs in the states of Uttar Pradesh, Punjab, Gujarat and Madhya Pradesh. Thus, potato business is having abundant prospects and now all stakeholders are expected to take one step forward for sustainable potato production and utilisation by conforming to the global norms and standards of farm production and certification.

Today, GAP is a global notion and FAO defines GAP as a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economic, social and environmental sustainability. GAP for food production is a systematic protocol for carrying out all farm operations in a well-planned manner for safe, hygienic and healthy food production. This includes cultivation of best-suited variety in good quality soil by using good quality water followed by carrying out all field and post-harvest operations adhering to set standards. Adoption of GAP will ensure quality food production with environmental safety. This will help in conserving the environment along with safe and quality food to all. GAP for potato production will

ensure the objectives of quality tuber production, environmental safety, minimum wastage of natural resources and optimum use of inputs, good health and safety for farm workers etc. Following GAP for potato production will lead to acceptance of quality potatoes from India in international market for export, premium price for quality potatoes in national as well as international market and thereby improving farm profits in a sustainable manner. Indian GAP for production of potato crop have been developed to realise the potential of this crop in the domestic market and to give a boost to export for various types of potatoes (seed, table, processing).

Considering the growing demand for safe and hygienic food, many developed economies have adopted GAP for their own agro-ecologies. In-line with this rising global trend, QCI has introduced two farm certification schemes viz., Basic GAP/IndGAP basic* and IndGAP/ IndGAP Premium*. The BasicGAP is meant for small or marginal farmers or for those who are interested to introduce quality farm production for fresh consumption or for processing. Whereas, IndGAP is targeted for large farms or farmer's group interested to seek certification for their farm produce either for fresh consumption or for processing purpose. These schemes comprise of control points and compliances, which the producer needs to fulfil for certification of the produce. A detailed description of BasicGAP and IndGAP for potato production, their control points and respective compliances is given in subsequent chapters.

* Brochure for IndGAP Certification Scheme, https://www.qcin.org/india-good-agriculture-practices.php

2. Requirements of BasicGAP

The information for requirements of BasicGAP or IndGAP Basic* has been adopted from regulations prepared by the QCI and is described herein a lucid language for the benefit of small and marginal farmers in context of potato cultivation. A systematic approach will ensure potato growers in identification and managing risks involved in the process of potato production and marketing. This is almost in protocol format which needs to be followed during the entire process of potato production and its marketing. Safe food production, health and welfare of workers, environmental safeguards and issues of hazards and safety etc. have been explained in a simplified manner. Stepwise compliance of the control points will minimise all risk factors and potato growers can work confidently in a competitive market environment. The following twelve control points and their sub-points categorised as critical, major or minor by the certifying body must be recorded. Their level of compliance is as follows:

Critical - 95% compliance of all applicable critical control points

Major - 85% compliance of all major control points is compulsory

Minor - 70% compliance of all applicable minor control points is compulsory

These control points must be complied by potato growers for safe potato production and product acceptability in the market under BasicGAP/ IndGAP Basic certification.

1. SITE SELECTION

This is a key issue for long term sustainable farming as continuous integration of site-specific information and practical experience for future planning, management and practices are required. Selection of site includes four main points.

1.1 Risk assessment for new site: This is a major point for level of compliance and the producer should be aware of farm's soil condition viz., waterlogging, industrial waste and effluents. A wise selection of

the most appropriate site will help in minimizing the risk of quality deterioration of a produce and will ensure safe food production as well as environmental conservation. Therefore, assessment should be done for vicinity to industries, toxic waste, heavy metals, industrial and urban effluents, contamination, land reclamation, irrigation water quality and drainage etc., while screening an agricultural site in initial phase. This risk assessment will help in adoption of proper crop management practices for avoiding failure of consignments at any step of the supply chain.

1.2 Water availability: Water availability is a major issue for compliance criteria and care should be taken whether adequate quality water is available from a reliable source for cultivation of potato crop in a region.

1.3 Risk management plan: Level of compliance is major for this point as producer needs to analyse all risk issues, develop and implement risk management plan to minimize all identified risks and maintain a record of risk analysis and all activities carried out for mitigating different risks. This helps in justifying suitability of a site for potato production.

1.4 Meteorological data collection: It is a minor point from the level of compliance point of view and previous three-year meteorological data should be available with farm management for considering the suitability of a site for potato production system.

2. SOIL CONDITIONS/MANAGEMENT

As soil is the base for farming, its sustainable management is very essential. Five points covered under this should be taken care of from BasicGAP point of view as all require major level for compliance. Detail information on soil management for potato cultivation is described in chapter on suitable soils for potato crop.

2.1 Mapping of soil: Physico-chemical analysis of soil and preparation of soil map of the site is very essential for site-specific management. It would help in assessing the suitability of fields for potato crop and potato based cropping system, sustaining production in the long run and conserving soil.

2.2 Soil health: Soil health and fertility is the most important factor for achieving better production and productivity of any agricultural crop. It should be ascertained, whether the soil is optimum for raising potato crop or not. Soil testing and nutritional profiling are helpful for this.

2.3 Soil test and nutrition profile: Soil analysis reports help in calculating precise nutrient doses and soil amendments for maintaining better soil fertility and higher crop productivity. For this, soil testing is mandatory and its record should be maintained on a regular basis. The producer should have knowledge of physical (soil texture, soil structure, bulk density, field capacity etc.) and chemical (EC, SAR, pH, nutrient availability status etc.) properties of soil.

2.4 Water suitability: Potato growers should ensure that irrigation water quality is up to the mark in terms of total salt concentration, sodium absorption ratio, carbonates and bicarbonate concentration etc. Irrigation water analysis should be in records for these parameters.

2.5 Water quality: Irrigation water quality should conform to the standards of heavy metals and chemical residues for avoiding issues of MRL and contamination in tubers. Information on quality of irrigation water should be available with growers and kept in record. Refer Annexure 5,6 and 7.

3 SEEDS AND PROPAGATION MATERIAL

Use of recommended varieties suited to different agro-ecologies is pivotal as it helps in optimal application of nutrients and reduction in the use of plant protection chemicals. Complete information about potato varieties is given in chapter on potato varieties for different agro-ecologies. There are three control points for compliance.

3.1 Planting material identification: This is the critical control point for compliance and potato growers should maintain all record like the source of seed tubers, variety and purity level etc.

3.2 Sowing record keeping: This is the major control point for compliance and record of planting date, method, seed rate, planting geometry must be kept and made available during inspection.

3.3 Seed: Seed source should be reliable which can provide a certificate of purity and authenticity of seed material. This may be the government institute viz., ICAR-CPRI, state departments of horticulture or agriculture, national seed corporation, state seed corporations and any authorized agency. Whole seed should be mandatorily planted for seed production. Seed size tubers can further be sub-graded for planting and plant to plant distance can be adjusted within rows for achieving optimum stem density, canopy cover and maximum seed size tuber yield at harvest. It should be of proper physiological age, treated and

free from pathogens or pests. This component has further four points either critical or major in terms of compliance and these are as follows:

3.3.1 Seed purity: This is the critical control point for compliance and seed tubers should have varietal purity as per the seed standards. Record or certificates of seed tubers i.e. variety name, purity, batch number and seed vendor etc. should be maintained.

3.3.2 Seed quality: Seed quality is a critical control point for compliance and seed tubers should be free from pest and diseases infection. Records available should show that seeds potato tubers were free from pest and diseases and especially quarantine diseases.

3.3.3 Seed producing record: This is a major control point from the level of compliance and records of planting method, rate and date must be kept and made available to certifying bodies.

3.3.4 Seed treatment protocol: This is a major control point from the level of compliance. Seed treatment protocol should be completed as per the recommendations and well in advance to match planting season. Its record for plant protection chemical used in process and disease/ pest, if identified any, should be available.

4. POTATO CROP MANAGEMENT FOR CULTIVATION

Potato growers can overcome most of the hurdles in implementation of BasicGAP by following the recommended production technologies for their region at their individual farm. A complete package of practices for table, seed and processing potato has been described in potato based crop module chapter.

4.1 Field preparation: Field preparation is the first operation where soil preparation is done precisely to attain the desired soil tilth having optimum soil moisture for faster and uniform crop emergence.

4.1.1 Soil tilth: This is a major control point for compliance as to achieve proper soil tilth suitable for potato emergence and growth.

4.1.2 Soil preparation: This is also a major control point for compliance as all required field operations should make soil environment favourable for better plant growth and make field weed free for initial 20-30 days. Its record is maintained particularly for weeds and their control.

4.2 Planting: Planting contains five control points relevant for potato crop having major or minor accountability for compliance. Precision in

planting is a major control point as optimum variety specific seed rate; planting depth and geometry will result not only into better tuber yield but also reduce the pressure of chemical weed control.

4.2.1 Seed rate: It is a minor control point, however, variety specific recommended seed rate per unit area should be adopted and a chart about this should be prepared and made available at farm site.

4.2.2 Seed planting depth: It is a major control point and a variety specific plan for maintaining the optimum depth of planting for seed tubers should be prepared. This is helpful in placing seed tubers in moist soil zone for rapid emergence and avoid greening of developing tubers in the later phase of the crop season.

4.2.3 Spacing: Although, it is a minor control point for compliance, but recommended row to row and plant to plant spacing should be followed for faster canopy cover and lower weed intensity. Authorized data on this aspect should be available at farm as per the adopted agronomic protocol.

4.2.5 Plant population: It is a minor control point for compliance. Gap filling should be carried out in the initial phase of crop growth to maintain optimum plant population and guidelines for this should be available.

4.2.6 Seed quality document: It is a minor control point for compliance. Seed quality document should be available and a record/ certificate of seed having variety name, purity, batch number and seed supplier etc. should be available for inspection.

4.3 Manures and fertilizers: Nutrient management should be soil test based and variety-specific and it should be the integration of organic and inorganic sources. Apart from macro-nutrients, ensure that micro-nutrient requirements are also fulfilled. It contains four major or minor issues for compliance.

4.3.1 Source of manures/ fertilizers: It is a major control point from the compliance point of view and authenticated source of inorganic fertilizers and manures should be utilized and a record should be available. Record is also maintained for technical competence of the person responsible for making choice of fertilisers/ manures. Manures procured from outside must qualify set parameters.

4.3.2 Organic manure preference: Organic manure preference is a minor control point for compliance, however, organic sources are preferred for plant nutrition over inorganic nutrition which ought

to supplement organic manures. The mineral supplement should be completely based on soil analysis in a competent laboratory and as per requirement of potato crop.

4.3.3 Manure use: Use of manure is minor control point, but use of manures like compost, vermi-compost, green manure and bio-fertilizer should be preferred and inorganic fertilizers should be used as supplemental dose.

4.3.4 Nutritional care: This is a major control point for growing potato crop for a distinct purpose viz., seed, table, processing or any speciality product, therefore, either guidance of specialist must be taken or recommended nutrient doses must be followed for maintaining quality of produce.

4.4 Irrigation: Efficient irrigation water use is the major key in BasicGAP and following five major or minor control points of compliance should be taken care of for adhering to the BasicGAP. Detail information on water management in potato crop is given in the chapter on water management.

4.4.1 Water requirement estimation: It is a major control point for compliance and various approaches such as soil moisture deficit, soil moisture tension and cumulative pan evaporation (CPE) may be followed for scheduling irrigation. Water requirement of potato crop should be calculated and irrigation cycle should be planned. Optimum water usage irrigation methods should be adopted without any wastage and record of irrigation/ fertigation and water use should be maintained.

4.4.2 Water optimization: Water optimization is the major control point for complying most efficient irrigation system available at farm. A document containing steps planned and actions taken to minimize water losses and optimize water use efficiency should be available.

4.4.3 Water harvesting and conservation: Although it is a minor control point of compliance, however, feasible water conservation and water harvesting methods should be adopted.

4.4.4 Water testing: Water testing is the major control point and quality of water should be considered vis-a-vis soil and water test report. The water test report should be available to confirm its quality and suitability for potato production. Therefore, water and soil test report from an accredited laboratory should be available.

4.4.5 Water drainage: It is a major control point for compliance and if

the soil of the site has water stagnation problem than farm should have provision of proper drainage. Written soil and water management practice should be available at farm site.

4.5 Weeding and intercultural operations: Integrated weed control strategy is to be adopted so that minimum herbicides are used. If recommended package for integrated weed control is followed, then MRL issue of GAP would be adhered. It has three major control points for complying the BasicGAP:

4.5.1 Control of initial flush of weeds: There should be a documented plan for weed control and inter-cultural operations to provide weed free environment in initial phase of crop.

4.5.2 Inter-culture operations optimization: Inter-cultural operation (cultivation, weeding and earthing up) schedule should be adhered to reduce weed intensity, avoid use of weedicides and optimize crop productivity. A record for this and schedule followed in crop season should be maintained.

4.5.3 Rare use of herbicides: Integrated weed control is to be adopted so that minimum herbicides are used. Integration of cultural (crop rotation, hot weather cultivation, green manuring, proper seed bed preparation, precise planting and placement of manures and fertilizers, mulching etc.) and mechanical (inter-cultivation and earthing) weed control measures in crop cycle and potato based cropping system should be strictly followed to avoid use of weedicides. If chemical control is required, then only recommended weedicides with the prescribed doses should be applied at right stage of crop growth to avoid any damage to crop. A record of weed control plan and schedule followed in crop season is to be maintained.

4.6 Crop protection: Comprehensive crop protection plan is to be prepared and adhered for minimal use of chemicals which would help in minimizing the risks of exceeding maximum residue limit (MRL) values in produce, for better human health and safe environment. In all this has five critical or major control points for compliance in BasicGAP. Complete information on pest and disease management in potato is given in the chapter on Pest management and Disease management.

4.6.1 Pest management, preventive and control measures: This is a major control point for compliance and a comprehensive crop protection procedure should be in place, which should be adhered during crop cycle to minimize loss of yield and quality.

4.6.2 Bio-control agents: This is a major control point for compliance and cultural, bio-agents and biological control measures are preferred. Plan for this should be available at farm level.

4.6.3 Pest management protocols: It is a critical control point from the compliance point of view. IPM measures are preferred in absence of preventive control measures and bio-control agents. Recommended IPM package by central institutions or state agricultural universities is to be followed. All records on IPM measures, use of various approaches for disease and pest management and safe chemicals, crop stages when control measures were adopted and quantity used are to be maintained.

4.6.4 Smallest effective dosage: It is a major control point based upon crop protection protocols and use of chemicals is restricted as last resort with technical advice and recommendations of institutions for their use, doses, time and mode of application. Failure on this part may exceed the residue limits in potato tubers at marketing time.

4.6.5 Residue analysis: It is a critical control point and potato growers must be aware of current list of MRL values for the markets where the produce is intended to be traded. A written procedure for pesticide use should be available to reduce residues in plant body. Residue analysis of final product should be carried out by accredited laboratory following standard protocol (Annexure 20).

5. HARVEST AND POST-HARVEST MANAGEMENT

This is a very important component for reducing losses at harvest in terms of quantity as well as quality. It consists three major sub-components *i.e.* harvesting, primary processing and packaging, storage and transportation. Please refer a detailed chapter on harvest and post-harvest handling of potatoes for complete information on harvest and post-harvest management of potato.

5.1 Harvesting: Harvesting at proper physiological maturity determines the storability and quality traits in potato crop raised for seed, table or processing purpose. This has three control points which are major for compliance.

5.1.1 Maturity determination: Potato growers must be aware of maturity period of a particular variety as quality productivity is required. Potato variety should show senescence and harvesting should be done only after that. A record of this should be available.

5.1.2 Harvesting devises and careful harvesting: Instructions should

be available to farm workers for using harvesting machines properly, avoiding off-type plants and soil contamination. Harvesting machines and equipment should be cleaned and maintained properly for avoiding any kind of contamination. Record for this should be maintained for external inspections.

5.1.3 Harvesting containers: A documented procedure should be available for cleaning containers, avoiding mixing of different varieties and contamination of produce from any kind of chemicals. The procedures should be followed strictly to comply with the issues of traceability.

5.2 Primary processing: This component deals with washing, cleaning, drying, sorting and grading of final produce and consists of five critical or major control points.

5.2.1 Washing and cleaning methods: This is the major control point of compliance and procedure for this should be available. Recommended methods by the Institute should be adopted like heap making in shade for skin curing, sorting of off type and infected tubers, washing and drying in shade to avoid tuber rottage. Water used in washing should be free from all kind of contamination and declared safe by competent authorities.

5.2.2 Produce drying and handling: This is a major control point and proper drying in shade and handling norms should be adopted. Standard norms should be followed for packaging material, weight per packet, handling of potato during temporary storage and container loading to avoid cut, crack and bruising damages of tubers.

5.2.3 Processing area conditions: This is a major control point for compliance and processing area must be clean, preferably pakka platform with proper shade and maintained in hygienic conditions. It should be well ventilated and properly protected from insects, pests, rodents, dust, sunlight and livestock.

5.2.4 Drying and temperature requirements: It is a critical point for compliance and technology package for this period should be in place. Drying procedure and temperature control should be in conformity to quality needs of the farm produce.

5.2.5 Sorting procedure: It is a major control point for compliance as sorting and grading of tubers should be done in conformity of varietal purity and parameterized tuber size after above mentioned processing. Potato growers must be aware of tuber grades as they vary for seed, table and processing potatoes. Instructions for this process should be available at the farm site.

5.3 Packaging, storage and transportation: Packaging, storage and transportation has five major or minor control points for BasicGAP compliance.

5.3.1 Packaging material: This is a major control point for compliance as storage period and transportation influence this decision. Proper norms should be followed for packaging material of potato tubers during temporary storage and container loading to avoid cut, crack and bruising damages of tubers.

5.3.2 Container filling: Proper norms should be in place as this is also a major control point to avoid deterioration of tuber quality during storage or transportation. Container filling process and knowledge of material required to reduce tuber damages in containers/ vehicles including covered roof should be adopted.

5.3.3 Storage conditions: Storage and packing space should be covered, ventilated, maintained clean and contamination free as it is a major control point for compliance. Storage area must be kept free from animals and rodents and proper measure must be followed for their control. Similarly, pest control procedures are to be followed for storage/ packing space.

5.3.4 Separate storage: It is a major control point for complying proper identification of produce and standard norms should be displayed at farm site. Different varieties must be stored separately with proper labels and signs to avoid their mixing.

5.3.5 Multiple commodities storage: Although it is a minor control point for compliance, however, it is quite significant to avoid mixing of different varieties tubers and contamination with fertilizers and chemicals. So norms for segregation of different produce and separate storage for chemicals should be adopted.

6. IDENTIFICATION AND TRACEABILITY

6.1 Identification: Identification of produce from farm to fork and vice-versa is quite pertinent from traceability point of view. It has one major point of compliance in BasicGAP.

6.1.1 Product labelling: This is a major control point for compliance as product labelling contains quantity and quality parameters. Each consignment of produce must be legibly marked with details viz., variety, month and year of harvest, name and address of potato grower etc. following trade practice/ legal requirements.

6.2 Traceability: Traceability facilitates fast, accurate and efficient withdrawal/recall of doubtful produce from supply chain.

6.2.1 Traceability record: It is a critical point for compliance and there should be documented identification and traceability system for each consignment of produce so that produce can be traced back to the registered farm including particular field from where it has been harvested and tracked forward to the immediate customer.

7. PERSONNEL AND EQUIPMENT

Personnel training, awareness and maintenance of equipment are very crucial for complying BasicGAP and it contains six critical or major control points.

7.1 Trained personnel: It is a major control point of compliance as key resource persons at farm (farmer and supervisor) must be familiar with all aspects of potato crop, its management and produce, quality etc. Training record for this should be in place for inspections.

7.2 Safety and hygiene awareness: This is a major control point of compliance and workers should be trained on specific skills, hygiene and safety aspects.

7.3 Calibrations: This is a major control point and machinery and equipment should be in good conditions and maintained at a regular time frame. All machinery used in fertilizer and chemicals application should be calibrated at a prescribed schedule and its record should be available.

7.4 Equipment's cleanliness and placement: It is a major control point for compliance of GAP as cleanliness of equipment and their mounting/ placement at an easily accessible place is essential. Their maintenance schedule should be available at farm.

7.5 Specific parts cleaning: It is a a major control point for compliance and parts which are coming in direct contact with produce (food) during harvesting or post-harvest handling must be clean to avoid any kind of contamination.

7.6 Safe material equipment: It is critical point for compliance of BasicGAP as material (specifically metal) used in fabrication must be of standard quality to avoid any kind of contamination to the produce coming in contact with it.

8. WORKERS HEALTH, SAFETY AND WELFARE

Personnel are the key for safe and efficient farm operation. Their

training, safety and welfare is very important for complying the BasicGAP. There are four components major or minor in nature to be adhered for compliance of GAP.

8.1 Risk assessments: It consists of two major control points for compliance criteria of BasicGAP.

8.1.1 Risk assessment of working conditions: Farm workers are the basis for efficient and better quality production. So a farm should have a written risk assessment document for various operations and this should be updated periodically with changes at farm level.

8.1.2 Safety and hygiene policy: There should be a written policy and procedures for health, safety and hygiene issues. This will include points identified in risk assessment exercise viz., accident, emergency, hygiene etc. This must be reviewed and updated when risk or hygiene concerns change.

8.2 Training: This component contains three points which are major in nature for compliance.

8.2.1 Competence training: All workers should have proper knowledge and training for their respective work such as handling and application of chemicals and fertilizers, operating farm machines and equipment, health and safety measures, wearing of protective gears, clothing and shoes etc. The record must identify workers carrying specific tasks and their certificates/ proof of competence.

8.2.2 Health and safety training: All workers must have training and instructions on health and safety issues. It must be visible during inspections. Regular maintenance of machines/ equipment and cleanliness of protective gears is also important.

8.2.3 First aid training and deployment of trained person: Workers should be trained in first aid and at least one trained worker must be present during all the farm operations.

8.3 Hazards and first aid: It contains two control points to be followed for BasicGAP compliance.

8.3.1 Emergency procedures, display and communication: It is a major control point and a comprehensive procedure for handling an emergency situation should be developed in local language and in pictorial format at farm. It should include farm and building map, farm address, contact person responsible for worker's welfare, nearest communication point of phone, important phone numbers (ambulance, hospital, fire brigade and police), emergency exits, location of fire

extinguishers, emergency cut off for electricity, gas, water supply etc.

8.3.2 Warning signs: Although it is a minor control point for compliance, however, permanent warning signs should be prepared in a readable way to indicate hazardous sites such as fuel tank, plant protection storage, workshops, electricity control panel, disposal area for chemicals etc. and these should be placed appropriately.

8.4 Protective clothing/equipment: It is a major point for compliance in BasicGAP

8.4.1 Availability of protective clothing: Complete set of protective clothing enabling label instructions or legal requirements as authorized by competent authority should be available to farm workers, used and remain in a good state of use.

9. RECORD KEEPING AND INTERNAL SELF-ASSESSMENT/ INTERNAL INSPECTION

Records of farm level operations and input use are to be maintained for internal self-assessment which would help in adoption of corrective measures during process of crop cultivation and marketing. This is also essential for external inspections by accredited certifying agencies. This has three major control points for compliance of the BasicGAP.

9.1 Duration of record keeping: It is mandatory to maintain record of past two years from the date of first/ previous external inspection unless advised specifically for longer period by the certifying bodies.

9.2 Internal self-assessment: Internal self-assessment against set standards is very useful exercise for easier compliance of GAP and it is essential to have one annual internal audit at farm level, wherein, its record should also be maintained for certifying bodies.

9.3 Corrective actions: Effective corrective measures must be documented and followed against non-conformance found for identified control points during whole process of crop cultivation and marketing.

10. WASTE AND POLLUTION MANAGEMENT, RECYCLING AND RE-USE

This component includes waste identification and its minimisation by way of re-use or recycling. It contains four control points for GAP compliance.

10.1 Identification of waste and pollutants: It is major control point

for compliance and all possible waste products (paper, cardboard, plastic, oil, tyre, damaged machine parts etc.) and source of pollutants (fertilizer excess, exhaust smoke, fuel, chemicals, effluents, feed waste etc.) should be identified and listed.

10.2 Waste and pollution action plan: Although this is a minor control point for compliance, a comprehensive, documented strategy should be in place after review of current practices for minimum waste production, waste reduction, recycling and re-use of waste. Procedure of disposal for non-recyclable materials should exist at farm and facility should be developed for organic waste composting for further use as manure. Air, soil, water, noise and litter contamination must be taken into account.

10.3 Clean premises: This is a major control point for compliance of the GAP. Farm and premises should be kept free of litter and waste to avoid building of breeding ground for pests and diseases which could risk food safety. Indoor areas where produce is handled needs to be cleaned regularly on daily basis.

10.4 Designated place for waste storage: This is a minor control point for compliance of the GAP. Farm must have separate identified areas for storing or decomposing different type of litter and waste.

11. ENVIRONMENT AND CONSERVATION

Environmental conservation should be given due priority in farm plan, cropping scheme and individual crop cultivation. Abundance of flora and fauna is beneficial to farming in several ways. Hence, it consists one component of impact of farming on environment and biodiversity to comply for BasicGAP.

11.1 Impact of farming on the environment and biodiversity: Farming and environment are inseparably linked. It consists of four minor control points to be complied for BasicGAP.

11.1.1 Wildlife conservation plan: There must be a written action plan to acknowledge the impact of farming on environment and it should aim for improving habitats and to increase the farm biodiversity.

11.1.2 Benefit to local community: There should be sufficient activities and initiatives for improving environment for the benefit of local community, flora and fauna.

11.1.3 Avoid damage habitat: Action plan for environmental protection must include habitat element and their improvement. Damage done in past must be rectified and deterioration must be stopped for habitat

element at farm.

11.1.4 Increase biodiversity: A baseline survey for flora and fauna should be done and after effects on agriculture should be studied to set priorities in the action plan for increasing biodiversity. Unproductive site (lowlands or unfertile soils) may be identified for conserving natural flora and fauna.

12. COMPLAINTS

Provision of complaint procedure is a right choice for better compliance of BasicGAP and to strengthen confidence among different stakeholders in supply chain. It consists two major control points for compliance.

12.1 Availability of complaint procedure: Complaint handling procedure must be in place and made available on request for GAP related issues and standards.

12.2 Records of complaints: Farm should have an appropriate recorded follow up action for complaints related to GAP standard deficiencies found in products or services. A documented recall procedure for produce should be adopted and person responsible for taking decisions must be identified.

3. Requirements of IndGAP

The Concept of basic requirement of IndGAP/IndGAP Premium has been developed in line with control points and compliance criteria developed by the QCI. These standards are more rigorous than BasicGAP and are in line with international standards for good agricultural practices. Therefore, these need to be adopted by any farm or farmer's group wanting to be assessed for IndGAP for the farm produce in fresh unprocessed form for direct human consumption or for further processing for human consumption by food industry. It would help farmers in producing certified products for organized domestic market and also for export at global level. QCI has developed control points and compliance criteria for All Farm base (AF) and Crop Base module (CB) which includes fruits and vegetables (FV) and combinable crops (CC). The control points are grouped as critical, major and minor and for IndGAP certification their level of compliance is as follows:

Critical - 100% compliance of all the applicable critical control points

Major - 90% compliance of all the major control points is compulsory

Minor - 75% compliance of all the minor control points is compulsory

To seek IndGAP/IndGAP premium certification for potato production, the grower needs to adhere to the following control points from All Farm base module (AF) and Crop base module (CB) and Fruits and Vegetables module (FV) developed by QCI.

CONTROL POINTS AND COMPLIANCE – ALL FARM BASE MODULE (AF)

AF 1 RECORD KEEPING AND INTERNAL SELF-ASSESSMENT / INTERNAL INSPECTION: Important details of farming practices should be recorded and maintained.

AF 1.1 Duration of record keeping: This is a major control point and producers must keep up to date records for a minimum of two years from the date of first inspection unless legally required to do so for a longer period.

AF 1.2 Internal self-assessment: This is a critical control point as documentary evidence must exist that internal self-assessment /internal producer group inspection is being carried out by the producer or producer group(s) annually as per the IndGAP or benchmarked standards.

AF 1.3 Corrective actions on non-conformities: This is a critical control point and effective corrective actions must be taken for non-conformances detected during the internal self-assessment or internal producer group inspection. It should be documented and implemented.

AF 2 SITE HISTORY AND SITE MANAGEMENT: This is one of the key component for sustainable farming and is continuous process of integrating site-specific knowledge and practical experience into future management planning and practices. Main objective in this component is to ensure that all farm resources are managed properly for safe production of food and protection of environment.

AF 2.1 Site history

AF 2.1.1 Recording system: It is a critical control point and current records must provide a history of IndGAP production of all production areas, means all type of activities like crop, livestock or aquaculture taken up at all locations of farm. For crops, new applicants must have full records for at least three months prior to the date of external inspection that has reference of each area covered by a crop with all the agronomic/ agriculture activities related to IndGAP documentation required for this area.

AF 2.1.2 Reference system: It is a major control point for compliance which must include visual identification in the form of a physical sign at each field/ greenhouse/ plot/ livestock building/ pen or other farm or a farm plan or map that could be cross-referenced to the identification system. Each area/ location used in production may be uniquely identified using Global Location Number (GLN).

AF 2.1.3 Vicinity of potential risk: It is a critical control point for compliance as surrounding area is examined for micro-climate like vicinity to brick kilns, chemical or other industries, rivers, canals, other water sources, hill-rocks, forests, pastures and reclaimed land to check contamination or any other potential risks for productivity and quality of crop.

AF 2.2 Site management

AF 2.2.1 Risk assessment of new farm site: It is a critical point for compliance of new agricultural sites or existing sites when risks have changed. A documented risk assessment must be carried out when crop is to be introduced to new sites. This must be revised to take into account any new food safety risk. This must take into account site history and consider impact of proposed enterprises on adjacent stock/crops/environment.

AF 2.2.2 Management plan to minimize all identified risk: It is a major control point for compliance and a management plan should be developed and implemented to minimize all identified risks like pollution, water contamination and soil erosion etc. This plan should include relevant points such as: habitat quality, soil compaction, soil erosion, emission of greenhouses gases, humus balance, phosphorus balance, nitrogen balance, intensity of chemical plant protection etc.

AF 3 WORKERS HEALTH, SAFETY AND WELFARE: Human resource is the key to safe and efficient operations at the farm. Their training, health, safety and overall welfare are of utmost importance.

AF 3.1 Risk Assessments

AF 3.1.1 Risk assessment of working conditions: The farm should have written risk assessment for safe and healthy working conditions. It may be a generic one, but appropriate for farm conditions. Risk assessment must be reviewed and updated with changes in the organization.

AF 3.1.2 Health, safety and welfare policy: The farm must have a written health, safety and welfare policy including points identified in above risk assessment. This can include accident, emergency and hygiene procedures dealing with any identified risks etc. The policy must be reviewed and updated when the risk assessment changes.

AF 3.2 Training

AF 3.2.1 Training activities: It is a major control point for compliance as record should be kept for trainings including topic covered, trainer, date and attendances of workers.

AF 3.2.2 Certification of competence: This is a critical control point for compliance. All workers handling chemicals, disinfectants, plant protection products, biocides or other hazardous substances and operating dangerous or complex

equipment etc. must have certificates of competence and or details of other such qualifications. Farm records must identify person(s) who carry out such tasks.

AF 3.2.3 Health and safety training: It is a major control point for compliance as all workers must receive adequate health and safety training. Workers can demonstrate competence in responsibilities and tasks through visual observation. There must be evidence of instructions at the time of inspections.

AF 3.2.4 Number of persons trained in first aid: This is a major control point for compliance as at least one person must be trained in first aid (within the last 5 years) and present on farm whenever on-farm activities are being carried out. Applicable legislation on first aid training must be followed.

AF 3.2.5 Documentation of hygiene conditions: It is a major control point and hygiene instructions must be displayed by providing clear signs (pictures) or in the predominant language(s) of workforce. The instructions must at least include: the need for hand cleaning, covering of skin cuts, limitation on smoking, eating and drinking, notification of any relevant infections or conditions, use of suitable protective covering etc.

AF 3.2.6 Training on basic hygiene: This is a major control point for compliance as training on hygiene (written and verbal) must be provided to farm workers by qualified people. All new workers must also receive this training and confirm their participation. All workers including owner and manager of farm must review and sign for hygiene instructions annually.

AF 3.2.7 Farm hygiene procedures: It is a major control point and farm hygiene procedures must be implemented so as workers identified for this must demonstrate their competence during the inspection.

AF 3.2.8 Personal safety and hygiene: This is a major control point for compliance for evidence and relevant procedures on personal health, safety and hygiene must be communicated to visitors and subcontractors through relevant instructions visible at places where all can read them.

AF 3.3 Hazards and first aid

AF 3.3.1 Prevention of accidents: It is a major control point for compliance as adequate precautions must be taken to prevent

on farm accidents during operation of farm equipment and machinery. Availability of protective gears, safety mechanism like safety bars, nets, display boards and operating instructions etc. must be in place.

AF 3.3.2 Accident and emergency procedures: This is a major control point for compliance. Permanent accident procedures must be clearly displayed in accessible and visible locations. These must be available in local language(s) understandable to farm labours and/ or pictograms. The procedures must identify farm's map reference or farm address, contact person(s), location of nearest means of communication (telephone etc.), an up-to-date list of relevant phone numbers (police, ambulance, hospital, fire-brigade, emergency health care on site or by means of transport, electricity and water supplier) and their locations. Location of fire extinguisher, emergency exits, emergency cut-offs for electricity, gas and water supplies and how to report accidents or dangerous incidents must be in place at the farm.

AF 3.3.3 Warning signs: It is a major control point so that permanent and legible signs must indicate potential hazards sites like waste pits, fuel tanks, workshops, access doors for plant protection products/ fertilizer and treated crops etc.

AF 3.3.4 Availability of safety advice: This is a major control point for compliance as information (website, mobile number, data sheets etc.) must be accessible, when appropriate action is required.

AF 3.3.5 Availability of first aid kits: It is a major control point for compliance. Complete and maintained first aid kits as per national regulations/ recommendations must be available and accessible at all permanent sites.

AF 3.4 Protective clothing/ equipment

AF 3.4.1 Availability of protective clothing: This is a major control point for compliance as complete sets of protective clothing (rubber boots, waterproof clothing, protective overalls, rubber gloves, face masks etc.), which enable label instructions and/or legal requirements and/or requirements as authorized by a competent authority must be available, used and maintained in good condition.

AF 3.4.2 Cleaning of protective clothing: It is a critical control point for compliance. Protective clothing must be

regularly cleaned according to a schedule adapted to type of use and degree of soiling. Cleaning of protective clothing and equipment includes separate washing from private clothing and glove washing before removal. Dirty, torn and damaged protective clothing and equipment and expired filter cartridges should be disposed of. Single-use items like gloves, overalls etc. should be disposed of after one use. All protective clothing and equipment are stored apart in a well-ventilated area and physically separate from plant protection products/ any other chemicals which might cause contamination of the clothing or equipment.

AF 3.5 Worker welfare

AF 3.5.1 Person responsible for worker's welfare: This is a critical control point for compliance as person from management must be clearly identifiable as responsible for worker's health, safety and welfare. Documentation must be available demonstrating that a clearly identified, named member of management has the responsibility for ensuring compliance with existing and relevant national and local regulations for its implementation.

AF 3.5.2 Communication between worker and management: Although it is a minor control point for compliance, but regular meeting should take place between management and workers for their welfare on annual basis. Records must show that concerns of the workers about their health, safety and welfare are being recorded during such meetings and workers discussing issues openly without fear or intimidation or retribution. However, auditor is not required to make judgments about the content, accuracy or outcome of such meetings.

AF 3.5.3 Overview information of all workers: This is a major control point for compliance as records must be available mentioning clearly an accurate overview of all workers (including seasonal workers) and subcontractors working on the farm. Information must be available for full names, date of entry, period of employment and regular working time and overtime regulations. Records of all workers (also subcontractors) must be kept for the last 24 months from the date of first inspection.

AF 3.5.4 Eating area for workers: It is a major control point

for compliance and a place to store and take food must be available. In addition, hand washing facilities and potable drinking water must be available to all workers.

AF 3.5.5 Hygiene in living quarters: This is a major control point as at farm, living quarters for workers must be habitable having access to clean water, toilets and drains. Septic pits can be accepted, in case of no drains, provided these are hermetic.

AF 3.5.6 On farm electrical installations: It is a critical control point for compliance. All electrical installations at the farm and other working areas must have adequate safety measures.

AF 3.6 Sub-contractors

AF 3.6.1 Information on sub-contractors: Subcontractors must carry out an assessment (or the producer must do it on behalf of the subcontractor) of compliance against the IndGAP control points relevant to the services provided by him at the farm. This assessment record must be available at farm during the external inspection and the subcontractor must accept that IndGAP approved certifiers are allowed to verify the assessments through a physical inspection where there is doubt. The producer is responsible for observance of the control points applicable to the tasks performed by the subcontractor by checking and signing the assessment of the sub-contractor for each task and season contracted.

AF 4 WASTE AND POLLUTION MANAGEMENT, RECYCLING AND RE-USE:

Waste minimization should include review of current practices and avoidance, reduction, re-use and recycling of waste.

AF 4.1 Identification of waste and pollutants

AF 4.1.1 Source of pollution: All possible waste products (paper, cardboard, plastic, oil etc.) and sources of pollution (fertilizer excess, exhaust smoke, oil, fuel, noise, effluent, chemicals, sheep-dip, feed waste, dead or diseased fish, algae produced during net cleaning etc.) at the farm must be listed.

AF 4.2 Waste and pollution action plan

AF 4.2.1 Documentation of farm waste management: It is a minor control point for compliance and a comprehensive and recently documented plan covering reduction of wastage and pollution and recycling should be available at farm. Air, soil, water, noise and litter contamination must be considered. Use

of landfills and burning must be avoided and composting of organic waste must be adopted for improving soil health without the risk of disease carry over.

AF 4.2.2 Implementation of farm waste management plan: This is a minor control point as this plan should be implemented at the farm. There should be visible actions and measures confirming that the objectives of the waste and pollution action plan are being fulfilled.

AF 4.2.3 Cleaning of litter and waste: It is a critical control point for compliance. Farm and premises must be clear of litter and waste to avoid a breeding ground for pests and diseases thus averting food safety risk. Visual assessment can identify that there is no evidence of breeding grounds in areas of waste/ litter in immediate vicinity of production or storage buildings. Produce handling areas in indoors are to be cleaned at least once a day.

AF 4.2.4 Provisions for waste disposal: This is a minor control point and farm should have designated areas to dispose identified litter and waste separately.

AF 5 ENVIRONMENT AND CONSERVATION: Environmental conservation is of utmost importance to preserve diversity of flora and fauna at the farm and in its vicinity for sustainable farming.

AF 5.1 Impact of farming on the environment and biodiversity

AF 5.1.1 Conservation of wild life: It is a major control point for compliance and farm must have a written action plan for enhancing habitats and biodiversity. This can be either a regional activity or individual plan, if the farm is participating in or covered by it. This includes knowledge of IPM practices, nutrient use in crop and conservation sites etc.

AF 5.1.2 Improvement of environment: This is a minor control point as there should be tangible actions and initiatives that can be demonstrated by the producer either on production site or by participation in a group that is active in environmental support schemes looking at habitat quality and habitat elements.

AF 5.1.3 Compatibility with agricultural production: Although it is a minor control point, but contents and objectives of the conservation plan must imply compatibility with sustainable agriculture and demonstrate a reduced environmental impact.

AF 5.1.4 Biodiversity audit plan: Though this is a minor control point, but a base line audit of the current levels, location and condition of fauna and flora must be done at farm so as to serve as the basis for action plan.

AF 5.1.5 Protection of farm habitat: It is a minor control point and there should be a clear list of priorities and actions within the conservation plan to rectify damaged or deteriorated farm habitat.

AF 5.1.6 Enhancement of farm habitat: Although this is a minor control point, but there must be a clear list of priorities and actions within the conservation plan to enhance habitats for fauna and flora for increasing biodiversity at the farm.

AF 5.2 Unproductive sites

AF 5.2.1 Conservation of unproductive sites: There should be a plan to convert unproductive sites like low lying wet lands and identified areas into conservation areas where ever it is viable.

AF 5.3 Energy efficiency

AF 5.3.1 Monitoring of energy use: Energy use records should exist at the farm showing its efficient utilization. Farm equipment should be selected and maintained for optimum consumption of energy. Use of non-renewable energy should be kept at minimum.

AF 6 COMPLAINTS: Complaints should be taken up on priority for developing a better system and efficient compliance of IndGAP.

AF 6.1 Complaint procedure: It must be available on request as a clearly identifiable document for complaints relating to issues covered by IndGAP standards.

AF 6.2 Record of action on complaints: Complaint procedure must have records of the complaints, these should be studied and appropriate follow up actions must be taken to improve upon deficiencies found in the products.

AF 7 TRACEABILITY: This is the ability of a system to track movement of food products and to record information about related attributes from farm to fork and vice versa. It facilitates withdrawal of a product from supply chain in fast, accurate and efficient manner.

AF 7.1 Product recall procedure: This is a critical control point for compliance. All producers must have documented recall procedures which identify the type of event that may result in a withdrawal, persons responsible for taking decisions on possible withdrawal of a product, the mechanism for notifying customers and the IndGAP certification bodies (CB) if a sanction was not issued by the CB and the producer or group recalled the products out of free will and methods of reconciling stock. The procedures must be tested annually to ensure that it is sufficient. Global tracking and tracing may be followed to facilitate product recall. Product recall procedures and processes must facilitate speedy, transparent and accurate product recalls. For this, global traceability standards (GTS) and recall standards may be used.

AF 8 VISITORS SAFETY

AF 8.1 Instructions on visitor safety: The farm should have instructions, communications and procedures displayed for safety of visitors.

CONTROL POINTS AND COMPLIANCE - CROP BASE MODULE (CB)

CB 1 TRACEABILITY

CB 1.1 Feasibility of traceability: It is a critical control point for compliance as IndGAP registered produce must be traceable back to the registered farm. Documented identification and traceability system must be in place to allow IndGAP registered product to be traced back to the registered individual farm or in a farmer's group and tracked forward to the immediate customer. Harvest information must link a batch to the production records or the farms of specific producers.

CB 1.2 Farm location: This is a major control point for compliance as complete identity of the area of production under IndGAP certification must be recorded. Location identification can be done using global location number (GLN).

CB 1.3 Identification of farm infrastructure: It is a major control point for compliance and field/ plots and all structures must be identified on farm layout map displayed at the farm.

CB 2 PROPAGATION MATERIAL

CB 2.1 Quality and health

CB 2.1.1 Seed quality: Although it is minor control point, but it is mandatory to maintain a record/certificate of potato seed tuber stating variety purity, variety name, batch number and seed vendor. It should also guarantee for its freedom from injurious pests, diseases, viruses etc.

CB 2.1.2 Quality of propagation material: It is a minor point for compliance and purchased seed tubers should be of good quality and free from viruses and tuber borne diseases and pests. Potato grower should have a justification about visible signs of diseases or pests, if seed exhibits so.

CB 2.1.3 Documentation of propagation material: It is a major control point of compliance and seed quality guarantee/ certificate/ documents should be available meeting the national legislation or in its absence, sector organization guidelines for quality certificate, terms of deliverance etc. or signed letters supplied by concern authorities that seed supplier has IndGAP or IndGAP recognized certification.

CB 2.1.5 Recommendation of SAU/NRC/Other government organizations: It is a major control point of compliance as only those varieties should be used which are released by ICAR-CPRI or other government approved organizations or varieties produced by registered seed companies in India. Verify, if any, special nutritional qualities are ascribed to the produce. Necessary documentation should be maintained to verify the claim. For potato varieties information please refer Potato varieties for different agro-ecologies chapter.

CB 2.1.5.1 Recommendation of GEAC: It is critical control point for compliance as if genetically modified seeds are used, then GEAC number permitting its usage along with evidence of source of seed must be recorded and made available to seek certification.

CB 2.1.6 Pest/disease resistance: It is a major control point for compliance and producer should verify seed supplier claim of seed's special quality with reference to resistance for pests and diseases, quality of produce, germination percentage, expiry date, physical or any other characteristics.

CB 2.1.7 Treatment of seeds: It is a major control point for

verification that whether seed tubers have been treated with approved fungicides or pesticides. These should be differentiated by colour to avoid accidental use in feed or food for bio-safety.

CB 2.2 Pest and disease resistance

CB 2.2.1 Varietal selection: The producer should consider pest and disease resistance/tolerance characteristics during potato variety selection and should demonstrate awareness about this.

CB 2.4 Sowing/planting

CB 2.4.1 Record of sowing/planting methods: The grower must keep the record of seed tubers planting method, date of planting, seed rate etc. for the sake of certification.

CB 2.5 Genetically Modified Organisms: This component is crucial for future use of genetically modified organisms and It is applicable only if GMO are used.

CB 2.5.1 Legal compliance of GMOs: It is a critical control point and registered farm or group of registered farms must have a copy of legislation applicable in the country of production and comply accordingly. Records of specific modification and/or unique identifier must be kept. Specific husbandry and management advice must be obtained.

CB 2.5.2 Documentation of GMOs: It is a major control point for compliance in case of GMO cultivars or products derived from genetic modification are used. Documented records for this should be available with producers.

CB 2.5.3 Communication of GMOs: It is a critical control point for compliance and the producer should inform their direct clients about GMO status of the product and documented evidence of communication must be provided.

CB 2.5.4 Handling plan for GMOs: It is a critical control point for compliance as there must be a written plan that explains how GM material (crops and trials) are handled and stored to minimize risk of contamination with the conventional material.

CB 2.5.5 Segregation of GMO crops: It is a critical control point for compliance and GMO crops are to be stored separately from other crops to avoid adventitious mixing, maintaining integrity and identification. A visual assessment must be done for this in stores.

CB 3 SITE HISTORY AND MANAGEMENT

CB 3.1 Rotation

CB 3.1.1 Crop rotation: Although, it is a minor control point, but information about crop rotation should be available, particularly about plant protection product applied in preceding crops.

CB 4 SOIL MANAGEMENT

CB 4.1 Soil mapping

CB 4.1.1 Mapping of soil: This is a minor control point for compliance and soil map will include soil type and analysis report for each site. Class of land is to be decided based on prevailing land classification systems (class 1 to 8) including risk assessment.

CB 4.1.2 Soil health: It is a major control point of compliance which requires verification of suitability of soil for potato cultivation based on soil parameters i.e. E.C., pH and soil nutrient status etc. Soil health card preparation may help for this compliance.

CB 4.2 Cultivation

CB 4.2.1 Soil maintenance: It is a major control point for compliance where techniques should be applied to maintain soil structure and avoid compaction. Soil should be bought to good till and planting and cultivation of potato crop is done across the slope or along contour lines. Soil depth should be adequate to hold the root system of potato. Soil preparation norms of ICAR-CPRI/SAU for growing potato crop should be followed. Please refer Chapter no. 5 for more information.

CB 4.3 Soil erosion

CB 4.3.1 Field cultivation: Field cultivation is a major compliance point to reduce the possibility of soil erosion. Visual evidence is required that there is no soil erosion and good practices such as mulching and/or cross line techniques on slopes and/or drains and/or sowing grasses or green manures, trees and bushes on borders of sites etc. are followed.

CB 5 PLANT NUTRITION MANAGEMENT/ FERTILIZER USE

CB 5.1 Nutrient requirement: This is pertaining to nutritional

demand and optimum application of plant nutrients. Please refer chapter no. 9 for nutrient management in potato.

CB 5.1.1 Proper application of plant nutrient: It is a major control point as application of all plant nutrition products should be timely targeted to maximize the efficacy and uptake by potato crop. The producer must demonstrate that, due consideration has been given to nutritional needs of the crop, soil fertility status and residual nutrients at the farm and records are available as evidence.

CB 5.2 Advice on quantity and type of fertilizer/nutrients

CB 5.2.1 Recommendation on use of fertilizers/nutrients: The producer should seek advice from competent or authorized source for use of fertilizers in potato crop, calculation of accurate doses, rate of application, time and method of application, use of bio-fertilizers etc. Technical persons providing recommendations must have official qualifications/ trainings for this.

CB 5.2.2 Competence of advice: If producer is doing himself the choice and dose of plant nutrients then he should be able to demonstrate his competence like certificates of trainings or knowledge of software tools and knowledge regarding various aspects on use of fertilizers in potato crop.

CB 5.3 Records of application

CB 5.3.1 Record of nutrient application: Keep all record of nutrient application.

CB 5.3.2 Dates of nutrient application: Record of all application dates of soil and foliar fertilizers, both organic and inorganic must be maintained.

CB 5.3.3 Record of applied nutrient types: Records of all fertilizer applications both organic and inorganic, field area, name or reference of the field, trade name, type of fertilizer and their nutrient content must be maintained.

CB 5.3.4 Record of applied quantities: Detailed record of quantity of all fertilizer/ nutrient product both organic and inorganic applied in weight or volume must be available as actual application may differ to recommendation.

CB 5.3.5 Record of method of application: The records of all fertilizer applications, machinery type used and method (via irrigation or mechanical distribution) must be maintained.

CB 5.3.6 Record of operator details: Proper record is maintained for name of operator who has applied the fertilizer or if it is a one-man operation (the producer) than it is also acceptable for record.

CB 5.4 Application machinery

CB 5.4.1 Condition of application machinery: Nutrient application machinery should be properly calibrated, maintained and in good condition for precise fertilizer/ organic product application. Maintenance records (date and type of maintenance and calibration) or invoices of spare parts should be available. A minimum documented records for verification of calibration by a specialized company, supplier of equipment or by technically responsible person of farm should be kept for the last twelve months.

CB 5.5 Storage of fertilizers / nutrients

CB 5.5.1 Inventory of fertilizers: It is a major control point, so stock inventory indicating contents of store (type and amount) should be available which is updated at least every three months.

CB 5.5.2 Segregation of fertilizers from plant protection products: It is a major control point to avoid contamination and minimum requirement is to prevent contamination between fertilizers and plant protection products by using a physical barrier in storage. Fertilizers applied with plant protection products (i.e. micronutrients or foliar fertilizers) can be stored together with plant protection products provided they are packed in a sealed container.

CB 5.5.3 Protection of storage area: This is a major control point and suitable covered area should be available to protect all inorganic fertilizers, i.e. powders, granules or liquids, from atmospheric elements like sunlight, frost and rain. Plastic coverage can be acceptable based on risk assessment (fertilizer type, weather conditions, temporary storage), but it cannot be directly on soil. Lime and gypsum can be stored in field for a day or two before spreading.

CB 5.5.4 Hygiene of storage area: It is a major control point and inorganic fertilizers (powders, granules or liquids) are stored in a clean area free from waste, spillage and is not a breeding place for rodents.

CB 5.5.5 Humidity in storage area: This is a major control point

to avoid humidity and storage area for all types of inorganic fertilizers should be well ventilated, free from rainwater or heavy condensation and not in direct touch of soil.

CB 5.5.6 Reduction in risk of contamination of water: It is a major control point for compliance as all inorganic fertilizers, i.e. powders, granules or liquids are stored in a manner which poses minimum risk of contamination to water sources. Liquid fertilizer stores must be surrounded by an impermeable barrier (according to national and local legislation, or to contain a capacity to 110% of volume of largest container if there is no applicable legislation) and consideration has been given to the proximity to water sources and flood risks, etc.

CB 5.5.7 Reduction in risk of contamination of environment: This is a major control point for storage of organic fertilizers. These must be stored in a designated area and appropriate measures should be taken up to prevent contamination of surface water (such as concrete foundation and walls, or specially built leak proof container etc.) or must be stored at least 25 m away from surface water bodies in particular.

CB 5.5.8 Segregation from produce: It is a critical control point as fertilizers cannot be stored with farm produce harvested fresh or dry. Add information about hazardous chemicals used as plant nutrients.

CB 5.6 Organic fertilizer

CB 5.6.1 Ban on human sewage sludge: This is a critical control point as no human sewage sludge can be used at farm.

CB 5.6.2 Risk assessment of organic fertilizer: It is a major control point and documentary evidence should be available to demonstrate that potential risks like disease transmission, weed seed content, method of composting, heavy metal content, etc. have been considered. This is also applicable to substrates from biogas plants in which case reference must additionally be made to legal requirements in risk assessment.

CB 5.6.3 Nutrient in organic fertilizer: This is a minor control point, however, nutrient contribution from organic sources must be taken into account and analysis is carried out for N, P, K nutrient contents of organic fertilizer applied in field.

CB 5.6.4 Method of organic manure preparation: It is a minor control point and process of organic fertilizer production

(aerobic and anaerobic) should be known and recorded. Analysis of final products should be carried out to check if the nutrient contents are as per National Bio-fertilizer Production Centre guidelines.

CB 5.6.5 Soil enrichment: This is a major control point for compliance as farm wastes carrying pests and diseases related to potato crop should be placed deep into soil. Farmyard manure should be dry and fully decomposed. Use of cow urine as manure is allowed.

CB 5.6.6 Use of green manure: It is a minor control point and soil analysis may be done to see if these manures release weak acids and release the available acid-soluble nutrients for crop and maintain crop and soil health.

CB 5.6.7 Use of bio-fertilizers: This is a major control point for compliance as bio-fertilisers (microbial) application should be in recommended list and it should be ascertained that they have positive effect on soil fertility and uptake of nutrients by plants.

CB 5.6.8 Use of sheep/ poultry manure: It is a minor control point, but sheep and poultry manure should be adequately decomposed and devoid of harmful microorganisms.

CB 5.6.9 Use of municipal /industrial sludge: It is a critical control point for compliance as use of raw municipal/industrial sludge is prohibited in INIGAP certification.

CB 5.6.10 Use of other organic manure: It is a major control point as any organic matter used should be well decomposed, free from bad odours and raw materials. Concentrated organic manures like oil cakes, slaughterhouse wastes should be applied into the soil for natural decomposition before planting of crop.

CB 5.7 Inorganic fertilizers

CB 5.7.1 Composition of inorganic fertilizer: This is a major control point for compliance as documentary evidence for past 12 months having N, P, K content values should be available for all inorganic fertilizer products used in crops grown under IndGAP certification.

CB 5.7.2 Documentary evidence of chemical content: It is a minor control point, but documentary evidence for chemical content including heavy metals should be available for all

inorganic fertilizers used in crops grown under IndGAP for last 12-month period.

CB 5.7.3 Dosage recommendations by SAU/NRC /other approved organizations: This is a critical control point for compliance based upon soil test reports, soil fertility status and crop response. Proportion and quantity of critical nutrients (N-P-K) applied to crop should be adequate for expected yields.

CB 5.7.4 Micro-nutrient content: This is a minor control point, but micronutrient requirements of the crop are to be met based on symptomatic study and quality of the produce. Soil test report, leaf test report and/or water test report should be taken into account.

CB 5.7.5 Stages of nutrient applications: It is major control point for compliance for fertilizer use as per recommended practices and doses for major nutrients. It should be ascertained that these were placed at appropriate depth in soil for easy access to root system at planting and during inter-cultivation or earthing. Foliar spray should be done at appropriate stage without leaving any residues. Products should be soluble and of accepted quality in case of fertigation.

CB 5.7.6 Grower competence on applications: This is a major control point for compliance and producer should demonstrate through documentary proof about her/his competence in using type and quantity of fertilizers/nutrients in potato crop.

CB 5.7.7 Record of applications: It is a major control point as all soil and foliar applications of fertilizers (inorganic, organic and bio-fertilizers) with reference to crop growth and development should be recorded and made available at the time of inspection.

CB 6 IRRIGATION AND FERTIGATION : The main objective of irrigation or fertigation is efficient use of water for attaining optimum crop yield as this resource is limited. Please refer water management chapter for detail information on irrigation in potato.

CB 6.1 Predicting irrigation requirements

CB 6.1.1 Methods of calculation: Systematic methods of irrigation water requirement estimation should be used. Calculations should be done based upon data recorded from

rain gauges, drainage trays for substrate, evaporation meters, water tension meters (% of moisture in the soil) and soil maps.

CB 6.2 Irrigation/ fertigation method

CB 6.2.1 Method of irrigation/ fertigation: This is major control point for compliance and most efficient available irrigation/ fertigation system should be used for crop cultivation. Main idea is to avoid wasting of water and having maximum water use efficiency at farm level.

CB 6.2.2 Water optimization: Although it is a minor control point for compliance, but a documented plan should be available to optimize water usage and reduce its wastage, which outlines the steps and actions to be implemented at the farm.

CB 6.2.3 Record of irrigation/ fertigation: It is a minor control point and records is to be kept indicating the date and volume used per water meter or per irrigation unit. Calculated and actual irrigated water used should be mentioned in the records.

CB 6.3 Quality of irrigation water

CB 6.3.1 Ban on untreated sewage water: This is critical control point in compliance and untreated sewage water is banned for irrigation/fertigation. If treated sewage water is used than water quality should comply with WHO guidelines for safe use of waste water and excreta in agriculture and aquaculture, 1989. When there is any doubt, then the grower has to demonstrate through analysis that the water complies with the WHO guidelines or local legislation for irrigation water.

CB 6.3.2 Annual risk assessment: This is major control point and annual risk assessment for water pollution must be carried out. It should consider potential microbial, chemical or physical pollution from all sources of irrigation/fertigation water. Part of risk assessment should consider irrigation method and the crop, frequency of analysis, sources of water, source and susceptibility for pollutants, drain water and the environment.

CB 6.3.3 Frequency of analysis: It is a major control point related to previous point as water analysis should be carried out at a frequency according to the results of risk assessment, which also takes characteristics of crop into account.

CB 6.3.4 Suitability of laboratory: Although it is a minor control point, but analysis of water should be carried out by an appropriate laboratory capable of performing microbiological analyses as per the requirement of ISO 17025 level or equivalent standard.

CB 6.3.5 Action on adverse results: It is a minor control point as in case of adverse results records should be available for actions taken and what are the results so far.

CB 6.4 Supply of irrigation/fertigation water

CB 6.4.1 Sustainability of water source: This is a major control point as it should ensure that water is utilized from a sustainable source to protect the environment. Sustainable sources supply enough water under normal (average) conditions and are recouped naturally.

CB 6.4.2 Advice on abstraction: It is a major control point for compliance and wherever it is required by law to have advice on abstraction there must be a written communication from local water authority for this purpose.

CB 6.4.3 Water quality: This is a critical control point as water should be potable and free from harmful contaminants and excess of carbonates, bicarbonates, chlorides etc. Water testing from authorized laboratory should be carried out to assess the water quality.

CB 6.4.4 Dependability of water source: This is a major control point for compliance as source should be dependable and sustainable under normal conditions during rain free period. It should be approved source from Govt. / Public source or from private bore wells/open wells.

CB 6.4.5 Water harvesting: It is a minor control point and farmer should practice verifiable water harvesting techniques at farm level.

CB 6.4.6 Water conservation: This is a minor control point however producer should adopt recommended water conservation techniques from a reliable source like drip or sprinkler irrigation, mulching etc.

CB 6.4.7 Irrigation equipment: This is a major control point for compliance and farmer should maintain and calibrate irrigation equipment as per guidelines of the manufacturer. Record of this activity should also be maintained at farm.

CB 6.4.8 Prevention of undesirable water: This is a critical control point and farmer should take adequate measures to prevent flow of water into fields from undesirable sources like municipal landfill areas, hospital and industry waste dump areas etc.

CB 7 INTEGRATED PEST MANAGEMENT (IPM): It involves all recommended cultural, mechanical and chemical disease and pest control techniques with impetus on minimal use of pesticides and fungicides. Please refer pest management and disease management chapters.

CB 7.1 Assistance for IPM: This is a major control point for compliance as technically responsible person at farm for disease and pest control should receive formal documented training and or the external technical IPM consultant should demonstrate their technical qualifications.

CB 7.2 Evidence for prevention: It is a major control point as producer must show evidence of implementing at least one activity that includes adoption of cultivation methods for reducing incidence and intensity of disease/ pest attacks on potato crop thereby reducing the need for intervention.

CB 7.3 Evidence for monitoring: This is a major control point for compliance as producer should implement at least one activity for observation and monitoring. This will determine when and up to what extent pests/ diseases and their natural enemies are present in field so that suitable management techniques can be selected.

CB 7.4 Evidence for intervention: It is a major control point as producer can show evidence that in situations where disease/ pest attack adversely affects the economic value of potato crop, intervention with specific control methods will take place. Wherever possible, non-chemical approaches must be considered.

CB 7.5 Minimum input use: This is a major control point for compliance as plant protection has to be done with minimum input use and all plant protection product inputs are documented and include written justifications for use.

CB 7.6 Anti-resistance label recommendation: It is a major control point as anti-resistance label recommendations are to be followed to maintain effectiveness of available products if the level of a pest, disease or weed requires repeated controls

in the crop. There should be evidence that anti-resistance recommendations (where legal and effective alternatives are available) are followed if specified by the product label.

CB 7.7 IPM for endemic pests /diseases: This is a critical control point for compliance as producer should be aware of IPM practices suggested by competent authorities or approved by any other government agency and follow the same.

CB 7.8 Soil treatment

CB 7.8.1 Soil treatment recommendations: Producer must follow soil treatment recommended by SAU/ NRC or any other government agency for endemic pest and diseases. Maintain record and follow summer ploughing, disposal of crop residues at appropriate time and proper crop rotation or any other suggested practice for potato crop.

CB 7.9 Seed treatment

CB 7.9.1 Methods of sowing: It should be checked that seed is treated using approved methods before sowing. Record of seed treatment, chemicals used and adequacy of time lag between treatment and sowing should be available.

CB 7.10 Cultural methods

CB 7.10.1 Use of cultural practices: It is a major control point and producer must follow recommended cultural practices of the region to prevent pests and disease build up. Cultivate recommended intercrops, catch crops, trap crops etc. Adopt pheromone traps and other suggested preventive measures including crop rotations.

CB 7.10.2 Total use of recommendations: It is a critical control point for compliance as all recommended IPM practices must be followed. Grower must be aware about IPM practices recommended by SAU/ NRC or any other government agency and record should be maintained for action taken.

CB 7.10.3 Use of mechanical methods: Recommended mechanical methods for control of pests and diseases like suitable light traps, insect baits, barrier trenches should be followed for potato crop.

CB 7.10.4 Use of biological methods: Biological methods and bio-control measures recommended by SAU/ NRC or any other government agency should be followed. These may be bird perches, use of neem based products, predators, parasites, NPV and similar bio-control measures etc.

CB 8 PLANT PROTECTION PRODUCTS

CB 8.1 Choice of plant protection products

CB 8.1.1 Use of label recommendations: It is a critical control point for compliance as all plant protection products applied on potato crop must be suitable for target weeds, diseases and pests and can be justified according to label recommendations or official registration body publication. Technically valid (legal) 'off label' uses that are supported by the PPP industry in writing is allowable. If the producer uses off-label PPP there must be evidence of official approval for use of that PPP on that crop in that country. In absence of recommendation on product label, recommendations should be followed as prescribed by APEDA/ NRC/SAU/government approved research organizations under ICAR/ Central Insecticides Board.

CB 8.1.2 Use of registered plant protection products: This is a critical control point for compliance and potato growers must use registered plant protection products. All plant protection products applied should officially be registered or permitted by appropriate governmental organization in the country.

CB 8.1.3 Purchase record: This is a major control point as invoices of registered plant protection products must be kept in record and be available at the time of external inspection.

CB 8.1.4 List of plant protection products: This is a major control point of compliance and an up to date documented list that takes into account any changes in local and national plant protection product legislation should be available for the commercial brand names of plant protection products (including their active ingredient composition or beneficial organisms) that have been used on crops grown at farm under IndGAP within last 12 months. This is an internal management list, customized to the operation and not general information on approved products.

CB 8.1.5 Awareness of banned chemicals: It is a critical control point for compliance as farmer must be aware about banned chemicals for use in plant protection and a documented plant protection product application record maintained at farm must indicate that no such product has been applied in field within past twelve months on crops grown for IndGAP certification.

CB 8.1.6 Competence of advisors: This is a critical control point for compliance as choice of plant protection products is to be made by the advisers and they should demonstrate their competence on this subject. Technically responsible person should be a qualified adviser and technical competence can be judged by official qualifications or specific training course certificates. Fax and emails from advisors, government, APEDA, SAU/Research Organizations are allowable.

CB 8.1.7 Competence of producer: It is a critical control point for compliance as if choice of plant protection products is made by producer, then he should prove his competence about knowledge on the subject. He should have experience complemented by technical knowledge that can be demonstrated by technical documentation i.e. product technical literature, specific training course attended etc.

CB 8.1.8 List of pest/ diseases in the area: It is a major control point for compliance as producer should have list of common pests and diseases endemic to the area and occurred in potato crop during past three crop seasons. Update on their economic threshold level (ETL) should also be taken up from SAU/ NRC/ state department/ any government approved agency.

Approved chemicals targeting the pest and diseases:

CB 8.1.9 Appropriateness of chemical: It is a major control point for compliance and the chemical applied against targeted pest/ disease should be as per the recommendations of label/ ICAR-CPRI/ any other government approved agency concerned with potato crop. Current list of approved chemicals for potato crop should be available with the producer.

CB 8.1.10 Banned chemicals: This is a critical point for compliance and banned chemicals must not be used at farm for growing potato crop under IndGAP certification. Producer must keep a record of banned chemicals.

CB 8.2 Records of application

CB 8.2.1 Record of applications: This is a critical point for compliance and all record of entire plant protection products applied during crop season including crop and variety name must be kept and made available for inspection.

CB 8.2.2 Record of application location: It is a critical control

point for compliance as all the plant protection products application record must include geographical area, reference of farm and field where the crop and variety is located.

CB 8.2.3 Record of application dates: This is a critical control point for compliance as all the plant protection products application record must mention exact dates of application (day/ month/ year) and end date of application, if applied in more than one day.

CB 8.2.4 Record of chemical trade names: It is a critical control point for compliance as all plant protection products application record must specify trade name (including formulation) or beneficial organism. It must be possible to connect trade name information to active ingredient.

CB 8.2.5 Identification of operator: This is a major control point for compliance as the operator for plant protection product applications should be identified and mentioned in records.

CB 8.2.6 Record of justification of application: It is a major control point for compliance as record of all plant protection products application including its justification, common name of pest(s), disease(s) or weed(s) treated should be available.

CB 8.2.7 Record of technical authorization: This is a major control point for compliance as record of all plant protection products application should mention technically responsible person.

CB 8.2.8 Record of quantity of application: It is a major control point for compliance as record of all plant protection products application should specify the amount of product applied in weight or volume, total quantity of water (or other carrier medium) used and dosage in g/l or internationally recognized measures for the product.

CB 8.2.9 Record of application machinery: This is a major control point for compliance as record of application machinery type for all plant protection products applied (if there are various units, these are identified individually) and method used (i.e. knapsack, high volume, U.L.V., via irrigation system, dusting, fogger, aerial or any another method) should be available in detail.

CB 8.2.10 Record of pre-harvest interval: It is a critical control point for compliance as record of pre-harvest interval for

all plant protection products application must be kept for inspection.

CB 8.3 Pre-harvest interval

CB 8.3.1 Observation of pre-harvest intervals: The producer must observe registered pre-harvest intervals as prescribed by CIB or government approved agencies. He can demonstrate this through documentation and putting warning signs in field with application date to comply the pre-harvest intervals.

CB 8.4 Application equipment

CB 8.4.1 Condition of application machinery and calibration: This is a major control point for compliance. Plant protection product application machinery should be kept in a good state and with documented evidence of up to date maintenance sheets for all repairs, oil changes etc. undertaken. It should comply with visual inspection and functional tests of application equipment. The machinery (automatic and non-automatic) is to be verified for correct operation within twelve months and have a certificate or document either by participation in an official scheme (where it exists) or by having been carried out by a person who can demonstrate their competence.

CB 8.4.2 Producer's participation in calibration of equipment: Although it is a minor control point, but the producer's involvement in an independent calibration-certification scheme is better wherever it is available and this may be documented.

CB 8.4.3 Label instructions: This is a major control point for compliance. Label instructions for correct quantity, handling and filling procedures must be followed. Appropriate measuring equipment must be available to comply label instructions.

CB 8.5 Disposal of surplus application mix

CB 8.5.1 Disposal method: It is a major control point for compliance as surplus mix or tank washings must be disposed according to national or local legislation. In its absence, disposal should be done according to two points mentioned below.

CB 8.5.2 Record of surplus application mix: This is a minor control point and surplus application mix or tank washings may be applied over an untreated part of the crop provided there is evidence that the recommended doses (as stated on the

label) does not exceed. All the treatment should be recorded in the same manner and detail as a normal plant protection product application.

CB 8.5.3 Record of surplus application mix in fallow land: It is a minor control point and surplus application mix or tank washings can also be applied in designated fallow land, where it is legally allowed. Risk of surface water contamination must be avoided. Recorded should be kept in same manner and detail as a normal plant protection product application.

CB 8.6 Plant protection product residue analysis

CB 8.6.1 Sampling procedure: This is a major control point for compliance as documentary proof for sampling and procedures should be available. Sampling should be carried out by laboratory approved by APEDA/NABL or by the grower proving that procedure is adhered to.

CB 8.6.2 Record of residue testing: It is a critical control point for compliance and producer must perform annual plant protection product residue analysis for the IndGAP registered potato crops or participate in a third party plant protection product residue monitoring system which is traceable to production location. Current documentary evidence or record must be available for the process adopted.

CB 8.6.3 Knowledge of MRL of target market: This is a critical control point for compliance as producer or the producer's customer must be able to demonstrate about latest information for MRL values of chemicals permissible in the crop for the targeted market(s) where the producer is intended to trade the produce. The producer or producer's customer must have available a list of current applicable MRLs for the targeted market(s) where produce is intended to be traded. Evidence of compliance must be available by demonstrating communication with clients confirming the intended market(s) and with a residue screening system that meets the intended market(s) MRLs.

CB 8.6.4 Action taken to comply with MRL: It is a critical control point for compliance with MRL as action has to be taken to meet the standards of targeted market(s) where the producer is intended to trade the produce and records must be available. If MRLs of targeted market(s) are stricter than those of the country of production, the producer or producer's

customer should follow the production cycle based upon these MRLs. Wherever necessary application of plant protection products and produce residue testing should be modified.

CB 8.6.5 Action on non-compliances of MRL: This is a critical control point for compliance and a clear documented procedure of the remedial steps and actions (communication to customers, product tracking exercise, etc.) must be in place if a plant protection product residue analysis indicates an exceed in MRL values (either of the country of production or of the countries where harvested product is intended to be traded).

CB 8.6.6 Accreditation of laboratory: It is a major control point for compliance as clear documented evidence (letter headings or copies of accreditations etc.) is required for accreditation of the laboratory used for plant protection product residue analysis. It should either be an ISO 17025 certified laboratory by a competent national authority or an equivalent standard or is in the process of accreditation to the applicable scope by a competent national authority to ISO 17025 or an equivalent standard. In all cases, the laboratories must show evidence of participation in proficiency tests, e.g. FAPAS must be available.

CB 8.7 Plant protection product storage

CB 8.7.1 Compliance with local regulations: This is a critical control point for compliance as plant protection product storage facilities must comply with all appropriate current national, regional and local legislation and regulations.

CB 8.7.2 Storage conditions: It is a major control point for compliance as plant protection product storage facilities should be built in a manner which is structurally sound and robust.

CB 8.7.3 Security at location: This is a critical control point for compliance and plant protection product storage facilities must be kept secure under lock and key.

CB 8.7.4 Temperature conditions: It is a major control point for compliance as plant protection product storage facilities should be built of materials or located so as to protect against temperature extremes.

CB 8.7.5 Fire protection: This is a minor control point and plant protection product storage facilities should be built of fire resistant materials.

CB 8.7.6 Ventilation: It is a major control point for compliance as plant protection product storage facilities should have sufficient and constant ventilation of fresh air to avoid a build-up of harmful vapours.

CB 8.7.7 Light arrangement: This is a major control point for compliance as plant protection product storage facilities should have sufficient illumination both by natural and artificial lighting to ensure that all product labels can be read easily on the shelves.

CB 8.7.8 Segregation from other materials: It is a major control point for compliance and plant protection product storage facilities should be separately located in an air space independent from any other materials.

CB 8.7.9 Condition of shelves: Though it is a minor control point, but plant protection product storage facilities should be equipped with shelves which are not absorbent in case of spillage e.g. metal, rigid plastic etc.

CB 8.7.10 Prevention of spillage: This is a major control point for compliance as plant protection product storage facilities should have retaining tanks or bunds according to 110% of volume of the largest container of stored liquid to ensure that there cannot be any leakage, seepage or contamination to the exterior of store.

CB 8.7.11 Measuring equipment: It is a major control point for compliance and plant protection product storage facilities or filling/mixing area should have measuring equipment whose graduation for containers and calibration verification for scales is verified annually by the producer to assure accuracy of mixtures. These should be equipped with utensils i.e. buckets, water supply point etc. for safe and efficient handling of all plant protection products.

CB 8.7.12 Facilities to prevent spillage: This is a major control point and plant protection product storage facilities and all designated fixed filling/mixing areas should be equipped with a container of absorbent inert material such as sand, floor brush and dustpan and plastic bags, that must be signposted and in a fixed location, to be used in case of spillage of plant protection products.

CB 8.7.13 Worker restriction: It is a major control point as plant protection product storage facilities should be kept locked

and physical access is to be granted only for persons who can demonstrate formal training in safe handling and use of plant protection products.

CB 8.7.14 Inventory records: This is a major control point as stock inventory indicating contents (type and quantity) of the store must be regularly updated at least after every three months. Quantity refers to number of bags or bottles etc.

CB 8.7.15 Packaging: This is a critical control point for compliance and all plant protection products that are currently in the store should be kept in original containers and packs. In case of breakage only, these can be packed in new containers provided these have all information of the original label.

CB 8.7.16 Segregation for crop rotation plant protection products: It is a major control point for compliance and all plant protection products currently kept in store or which are indicated on the stock rotation records should be officially approved and registered for application on potato crop within the crop rotation programme. Plant protection products used for purposes other than this should be clearly identified and stored separately within the store.

CB 8.7.17 Positioning in shelves: This is a major control point as all plant protection products that are liquid formulations should be stored on lower shelves and which are never above the products that are of powder or granular formulations.

CB 8.8 Plant protection product handling

CB 8.8.1 Health check of workers: This is a minor control point for compliance, however, all workers who are in contact with plant protection products should be voluntarily submitted to annual health check-up. These Health checks must comply with national, regional or local codes of practice and use of results respect the legality of disclosure of personal data.

CB 8.8.2 Procedures for re-entry of persons: It is a critical control point for compliance as there must be a clear documented procedures regulating all the re-entry intervals of persons in potato crop after plant protection products are applied according to label instructions. Where no re-entry information is available on the label, there are no specific requirements.

CB 8.8.3 Monitoring of re-entry times: This is a major control point for monitoring and documented (e.g. plant protection

products application records) record should be available for all re-entry intervals after plant protection products applied to the crop.

CB 8.8.4 Accident procedures: It is a major control point for compliance as an accident procedure containing all information should be visually displayed with basic steps of primary accident care and be accessible by all persons within 10 meters of the plant protection product/ chemical storage facilities and designated mixing areas.

CB 8.8.5 Prevention accidental contamination: This is a major control point for compliance as all plant protection product / chemical storage facilities and all filling/mixing areas at farm should have eye wash capability, a source of clean water within 10 meters' distance, a complete first aid kit and a clear accident procedure with emergency contact telephone numbers or basic steps of primary accident care, all permanently and clearly signed.

CB 8.9 Empty plant protection product containers

CB 8.9.1 Reuse of containers: It is a major control point for monitoring as re-use of empty plant protection product containers for purposes other than containing and transporting of identical product must be avoided.

CB 8.9.2 Disposal of containers: This is a major control point for management as system used to dispose of empty plant protection product containers should ensures that persons cannot come into physical contact with empty containers by having a secure storage point, safe handling system prior to disposal and a disposal method is in place that avoids exposure to persons.

CB 8.9.3 Environmental protection: It is a major control point for systematic disposal of empty plant protection product containers which should minimize the risk of environmental contamination i.e. water courses, flora and fauna, by having a safe storage point and handling system prior to disposal by an environmentally responsible method.

CB 8.9.4 Official disposal system: This is a major control point for documented display as if official collection and disposal systems exists then producer should be participating in that.

CB 8.9.5 Labelling and handling: It is a major control point for

compliance and all empty plant protection product containers, once emptied, should not be reused and have been adequately stored, labelled and handled, according to the requirements of official collection and disposal schemes wherever it is in place.

CB 8.9.6 Cleaning of empty containers: This is a critical control point for compliance as plant protection product containers must be rinsed thrice either by application machinery having a pressure-rinsing equipment or through clear written instructions to rinse each container three times prior to its disposal.

CB 8.9.7 Rinsing: It is a major control point for compliance as the rinsate from empty plant protection product containers is to be always put back into application equipment tank either via use of a container-handling device or via written procedure for application equipment operators.

CB 8.9.8 Storage of empty containers: This is a major control point for compliance as there should be a designated secure store point for all empty plant protection product containers prior to disposal which is isolated from crop and packaging materials, permanently signed and with physically restricted access for persons and fauna.

CB 8.9.9 Compliance with local regulations: It is a major control point for compliance and all relevant national, regional and local regulations and legislations should be complied with regarding disposal of empty plant protection product containers.

CB 8.10 Obsolete plant protection products

CB 8.10.1 Disposal of obsolete chemicals: This is a major control point for compliance as a documented record must be maintained indicating that obsolete plant protection products have been disposed of by officially authorized channels. When this is not possible, obsolete plant protection products should be securely maintained and identifiable.

CONTROL POINTS AND COMPLIANCE CRITERIA- FRUITS AND VEGETABLES (FV)

(Applicable for potato production)

Control points and their compliances from Fruits and Vegetable scope (FV) which are applicable for potato production are explained here.

FV 1 CHOICE OF VARIETY OR ROOTSTOCK

FV 1.1 Planting material awareness: The choice of variety is a pre-condition for good plant growth, yield and tuber quality. Selection of suitable variety for an agro-ecology will optimize use of fertilisers and plant protection products. Please refer chapter no. 8 for potato variety related information.

FV 2 SOIL AND SUBSTRATE MANAGEMENT

FV 2.1 Soil Fumigation

FV 2.1.1 Justification: It is a major control point. If the farmer is following any type of soil fumigation, then he should maintain a written justification of it. This control point is not applicable if no soil fumigation is practices.

FV2.1.2 Pre-planting Interval: It is a major compliance point. If Soil fumigation is practiced, then its pre-planting interval should be complied as per the crop's requirements. This control point is not applicable if no soil fumigation is practices.

FV 3 IRRIGATION AND FERTIGATION

FV 3.1 Quality of irrigation water: Refer CB 6.3

FV 3.1.1 Risk Analysis: Refer CB 6.3.2

FV 3.1.2 Risk management: If any risk is identified in irrigation water quality, the producer should take action to avoid the identified risk.

FV 3.1.3 Quality of fertigation material: The grower should be aware about the quality of pipes and equipment used for fertigation.

FV 4 HARVESTING: This section contains aspects related to harvest, handling, post-harvest, storage and hygiene issues related to the final produce. A detailed information on harvest and post-harvest handling of potato is given in chapter no.14.

FV 4.1 General

FV 4.1.1 Hygiene risk analysis: This is a critical control point for compliance. There should be a documented and up to date (reviewed annually) risk analysis of possible risks and an assessment of likelihood and severity of the risks covering physical, chemical and microbiological contaminants and human transmissible diseases, customised to the product and operation of the pack house.

FV 4.1.2 Documentation of procedures: It is a critical control point for compliance as documented hygiene procedure for harvesting process must be implemented at farm by farm manager or other nominated person who will be responsible for this component.

FV 4.1.3 Instruction to workers: This is a critical control point for compliance as the workers must be provided training regarding personal cleanliness, clothing, hand washing, wearing of jewellery, fingernail length or cleaning and personal behaviour e.g. no smoking, spitting etc. before handling the final produce.

FV 4.1.4 Implementation of instructions: It is a critical control point for compliance of hygiene instructions and procedures implementation. There must be evidence that workers comply with all hygiene instructions and procedures. Packers must be trained, using written (in appropriate languages) and/ or pictorial instructions to prevent physical (snails, stones, insects, knives, fruit residues, watches, mobile phones etc.), microbiological and chemical contamination of the product during packing.

FV 4.1.5 Cleaning of containers: This is a critical control point for compliance as reusable harvesting containers, tools (scissors, knifes, pruning shears etc.) and equipment (machinery) must be cleaned and maintained. A regular cleaning and disinfection schedule should be in place (at least once a year) to prevent produce contamination.

FV 4.1.6 Cleaning of vehicles: It is a critical control point for compliance as farm vehicles used for transport of harvested produce that are also used for any other purpose, should be cleaned and maintained and a regular cleaning schedule should be in place to prevent produce contamination (soil, dirt, organic fertilizer, spills etc.).

FV 4.1.7 Access to hand washing: This is a critical control point for compliance as harvest workers must have access to fixed or mobile hand washing equipment to clean and disinfect hands.

FV 4.1.8 Access to clean toilets: It is a major control point for compliance at farm. Harvest workers must have access to fix or mobile toilets (including pit latrines) constructed of materials that are easy to clean and with catch basins designed to prevent contamination in the field within 500m distance.

These should be in a good state of hygiene. If an employee is working independently, this distance can be modified to allow the presence of toilets at an increased distance provided that there is reasonable and adequate transport available to the worker.

FV 4.1.9 Produce containers: This is a critical control point for compliance as produce containers are only used to contain harvested product (no agricultural chemicals, lubricants, oil, cleaning chemicals, plant or other debris, lunch bags, tools, etc.). If containers are used for applications other than produce handling, those should be clearly marked and kept separately. If multi-purpose trailers, carts, etc. are used as produce containers, they must be cleaned prior to use.

FV 4.1.10 Compliance with maturity standards: It is a minor control point for following and producer should be aware about the maturity signs (senescence) of potato varieties prior to harvesting.

FV 4.1.11 Compliance with quality parameters: This is a major control point for compliance as quality parameters for potato crop particularly meant for processing should be accomplished at the time of harvest.

FV 4.2 Final produce packing at point of harvest

FV 4.2.1 Hygiene at harvesting/ handling points: It is a critical control point for compliance and all produce packed and handled directly in the field must be removed from field overnight, in accordance with the harvest hygiene risk assessment results. All field packed produce must be covered to prevent contamination.

FV 4.2.2 Documentation of inspection: This is a major control point for compliance as inspection process should be in place to ensure that products are packed according to documented quality criteria as per the market requirement.

FV 4.2.3 Protection from contamination: It is a critical control point for compliance as all field packed produce must be protected from contamination.

FV 4.2.4 Hygiene at handling points: This is a critical control point for compliance and if packed produce is stored at farm, then storage areas must be cleaned.

FV 4.2.5 Storage of packing material: It is a critical control

point for compliance. Packing material must be stored at farm to protect it against contamination.

FV 4.2.6 Waste disposal: This is a major control point for compliance and bits of packaging material or non-produce waste must be removed from the fields.

FV 4.2.7 Climatic conditions at storage: It is a major control point for compliance. Temperature and humidity record should be documented in accordance with hygiene risk assessment results and quality requirements, when packed produce are stored at farm.

FV 4.2.8 Source of ice and water: This is a major control point for compliance and if any ice or water is used at point of harvest, its source should be potable water and handled under sanitary conditions to prevent produce contamination.

FV 5 PRODUCE HANDLING

FV 5.1 Principles of hygiene

FV 5.1.1 Documentation: Documented hygiene procedures must be implemented for produce handling. Farm manager or other nominated person should be identified for implementation of hygiene procedures as a direct result of produce handling hygiene risk analysis.

FV 5.2 Personal hygiene

FV 5.2.1 Basic instruction on hygiene: It is a critical control point for compliance as the workers must receive basic instructions in hygiene before handling produce and this should be recorded. They must be trained on issues concerning transmission of communicable diseases, personal cleanliness and clothing (hand washing, wearing of jewellery and fingernail length and cleaning) and personal behaviour i.e. no smoking, spitting, eating, chewing, perfumes, etc. at produce handling site.

FV 5.2.2 Implementation of instructions: This is a critical control point for compliance as workers must implement hygiene instructions for handling produce and this should be documented.

FV 5.2.3 Condition of outer garments: This is a minor control point for compliance depending upon product and operation. All workers should wear outer garments (e.g. smocks, aprons,

sleeves, gloves) which are clean and fit for purpose for the operation according to risk analysis.

FV 5.2.4 Smoking/ eating instructions: It is a major control point for compliance as designated areas must be there for smoking, eating, chewing and drinking. It should be never allowed in the produce handling or storage areas.

FV 5.2.5 Signages: This is a major control point for compliance and signs with main hygiene instructions must be visibly displayed in the packing facility.

FV 5.3 Sanitary facilities

FV 5.3.1 Access to clean toilets: This is a critical control point for compliance as workers must have access to clean toilets and hand washing facilities in vicinity of produce handling area. Such toilets should be in a good state of hygiene and must not open directly onto produce handling area. Hand washing facilities with non-perfumed soap, water to clean and disinfect hands and hand drying facilities must be accessible near to toilets without probability of cross-contamination.

FV 5.3.2 Hand washing instructions: It is a critical control point for compliance as signs must be visible with clear instructions that hands must be washed before handling produce especially after using toilets, eating, etc.

FV 5.3.3 Changing facilities: This is a major control point for compliance and changing facilities should be constructed and used to change clothing and protective outer garments as required.

FV 5.3.4 Secure place to store personal items: It is a major control point for compliance as secured storage facilities should be provided at the changing facility to protect workers' personal belongings.

FV 5.4 Packing and storage areas

FV 5.4.1 Maintenance: This is a major control point for compliance to prevent contamination during produce handling and storage. Handling of produce, storage facilities and equipment (process lines, machinery, walls, floors, storage areas, pallets, etc.) must be cleaned and/or maintained as per cleaning and maintenance schedule with defined minimum frequency. Documented records for this must be available.

FV 5.4.2 Storage of cleaning agents: It is a major control point

for compliance for storing cleaning agents, lubricants etc. These should be kept in a designated area, away from where produce is packed to avoid chemical contamination of produce.

FV 5.4.3 Approval of cleaning agents: This is a major control point for compliance as documentary evidence must exists for cleaning agents, lubricants etc. (specific label mention or technical data sheet) authorizing their use in food industry to avoid any kind of contamination.

FV 5.4.4 Maintenance of equipment: Though it is a minor control point, but internal transport should be maintained to avoid product contamination with special attention to fume emissions. Forklifts and other driven transport trolleys should be mechanical, electric or gas-driven.

FV 5.4.5 Disinfection: This is a major control point as rejected produce and waste materials must be stored in designated and segregated areas designed to avoid contamination of produce. This area is to be routinely cleaned and/or disinfected according to cleaning schedule.

FV 5.4.6 Lamp protection: It is a critical control point for compliance as light bulbs and fixtures suspended above produce or material used for produce handling must be of a safety type or protected/shielded so as to prevent contamination of produce in case of breakage.

FV 5.4.7 Handling procedures: This is a major control point for compliance. There should be written procedure for handling glass, clear hard plastic and articles with sharp edges breakages in produce handling, preparation and storage areas.

FV 5.4.8 Hygiene of packing material: It is a major control point for compliance as packing materials including re-useable crates must be stored in a clean and hygienic area to prevent product contamination.

FV 5.4.9 Restriction on animals: Measures should be in place to prevent access by animals in packing and storage areas as it is a major control point.

FV 5.4.10 Strength of packaging material: This is a major control point for compliance. Recommended packing materials with proper padding, ventilation and holding strength must be used for packing the produce. It should withstand wear and tear during transportation.

FV 5.4.11 Labelling and track back: It is a critical control point for compliance as all packages are to be suitably fastened and labelled. Proper coding i.e. bar codes, stickers, tags, badges etc. should be done for identity and trace-back. Appropriate procedure for identification and relevant records should be maintained.

FV 5.4.12 Palletization or stacking: This is a major control point for compliance as workers should be trained for stacking. Packages should suitably palletized/stacked and loaded in trucks/ containers.

FV 5.4.13 Temperature stabilization: Wherever applicable, it is a major control point for compliance. Packages should be kept in cold store for stabilising temperatures before loading into refrigerated/ insulated containers for transport.

FV 5.4.14 Suitability of pallets/ stacks: This is a major control point for compliance as pelleted packages must be marked suitably for proper handling and loading into trucks or containers.

FV 5.4.15 Ventilation in vehicles: Vehicle/truck should be suitably covered, padded and ventilated for carrying the cargo by road as it is a major control point.

FV 5.5 Quality control

FV 5.5.1 Documentation of inspection: This is a major control point and a documented inspection process must be in place to ensure that the products are packed according to quality standards.

FV 5.5.2 Documentation of temperature and humidity controls: It is a critical control point for compliance as if packed produce is stored then temperature and humidity controls (where applicable and also for controlled atmosphere storage) must be maintained and documented in accordance with the hygiene risk assessment results.

FV 5.5.3 Light sensitive products: This is a critical control point for potatoes as no daylight ingress in long term storage facilities.

FV 5.5.5 Temperature control equipment: It is a major control point for compliance as weighing and temperature control equipment must be regularly verified for calibration according to risk analysis procedure.

FV 5.6 Rodent and bird control

FV 5.6.1 Blockade at entry points: It is a major control point for compliance as all entry points of buildings or equipment must suitably be protected to prevent the entry of rodents and birds.

FV 5.6.2 Bait points: Site plans with bait points and/or traps must exist building as it is a major control point for compliance.

FV 5.6.3 Protection of non-target species: Baits should be placed in such a manner that non-target species do not have access to it as this is a major control point for compliance.

FV 5.6.4 Record keeping: It is a major control point for compliance. Records of pest control inspections and follow up action plan must be available with the producer. Inspections must take place whenever there is evidence of presence of pests. In case of vermin, the producer must have a contact number of pest controller or evidence of in-house capability to control pests.

FV 5.7 Post-harvest washing

FV 5.7.1 Water source: This is a critical control point for compliance and water must be declared suitable by the competent authorities within the last 12 months and or a water analysis should be carried out at the point of entry into washing machinery. Levels of parameters analysed should be within accepted WHO thresholds or should be accepted as safe for the food industry by the competent authorities.

FV 5.7.2 Re-circulation conditions: It is a critical control point for compliance as if water is re-circulated for final produce washing, then it must be filtered and disinfected and pH, concentration and exposure levels to disinfectant should be routinely monitored along with maintaining documented records. Filtering must be done with an effective system for solids and suspensions that have a documented routine cleaning schedule according to the usage and water volume.

FV 5.7.3 Laboratory: Though it is a minor control point for compliance, but laboratory doing water analysis for the product washing should be accredited to ISO 17025 or its national equivalent. Alternatively, any other government approved testing kits can also be used on farm. In case of single use testing kit, date of test and evidence of testing kit should be preserved.

FV 5.8 Post-harvest treatments

FV 5.8.1 Labelling instructions: This is a critical control point for compliance as there must a be clear procedures and documentation available (application records for post-harvest biocides, waxes and plant protection products), which demonstrate that the label instructions for chemicals applied are compliant.

FV 5.8.2 Registration of biocides: It is a critical control point for compliance and all post-harvest biocides, waxes and plant protection products used on harvested crop must be officially registered or permitted by the appropriate government authority in the country. They should be approved for use on harvested crop to which it is applied as indicated on the biocides, waxes and crop protection products' labels. Where no official registration scheme exists, FAO international code of conduct on the distribution and use of pesticides can be followed.

FV 5.8.3 Selection of biocides: This is a critical control point for compliance as documented post-harvest biocide, wax and crop protection product application records must confirm that no biocides, waxes and crop protection products have been used within the last 12 months on harvested crop grown under IndGAP destined for sale in the intended market or importing countries prohibited by their respective competent authorities.

FV 5.8.4 Updation of list of post-harvest chemicals: It is a major control point for compliance and an up to date documented list, that takes into account any changes in local and national legislation for biocides, waxes and plant protection products should be available for the commercial brand names (including any active ingredient composition) that can be used as post-harvest protection being, or which have been, grown on the farm under IndGAP within last 12 months.

FV 5.8.5 Competence of responsible person: This is a critical control point for compliance as technically responsible person for the post-harvest biocides, waxes and plant protection products applications must demonstrate sufficient level of technical competence via nationally recognized certificates or formal training.

FV 5.8.6 Record of identity of chemicals: It is a critical control point for compliance and lot or batch of harvested crop treated

for all post-harvest biocide, wax and plant protection products and product application records must be documented and available.

FV 5.8.7 Record of formulations made on site: This is a critical control point for compliance and competent authorities must approve the ingredients and formulation preparation of post-harvest biocides, waxes and plant protection products used on site at the farm. Evidence of approval and composition of formulation must be available.

FV 5.8.8 Record of location of chemicals: It is a critical control point for compliance as record of geographical area, name or reference of the farm or harvested crop handling site where the treatment of approved products was undertaken must be in place.

FV 5.8.9 Record of application dates: This is a critical control point for compliance and record of application dates (day/ month/ year) of post-harvest biocide, wax and plant protection product must be available.

FV 5.8.10 Record of treatment: It is a critical control point for compliance and type of treatment used for product application (spraying, drenching, gassing etc.) must be documented in all post-harvest biocide, wax and plant protection products application.

FV 5.8.11 Record of chemical trade names: This is a critical control point for compliance and product trade name of all the post-harvest biocide, wax and plant protection product applications must be recorded.

FV 5.8.12 Record of quantity of chemical applied: It is a critical control point for compliance and amount of product applied in weight or volume per litre of water or other carrier medium must be recorded in all post-harvest biocide, wax and plant protection product applications records. Applicable regulatory provisions should be considered.

FV 5.8.13 Record of operators: This is a major control point for compliance. Name of operator who has applied all post-harvest biocide, wax and plant protection product to harvested produce should be documented in application records.

FV 5.8.14 Record of justification: It is a major control point for compliance as common name of pest and diseases to be

treated is documented in all post-harvest biocide, wax and plant protection product application records.

FV 5.8.15 Completeness of record: This is a critical control point for compliance that all documentary evidence must be kept to demonstrate that the producer has considered all post-harvest biocides control points and plant protection products applications control points for residue analysis and acts accordingly.

4. Certification

Introduction of GAP in rural economy shall improve quality productivity, food safety and optimize the use of human and natural resources in different enterprises of agriculture including potato crop. This will result in better farm profits and livelihoods of all farmers. They will have access to new world markets apart from domestic one. QCI has developed framework of BasicGAP/IndGAP Basic and IndGAP/ IndGAP Premium for efficient implementation of food regulations at national level. Scope of IndGAP covers all agriculture farm produce adhering to norms and standards of global level and to start with it is for bigger farmers and large farms. BasicGAP is for small and marginal farmers to allow them a phased approach to reach up to the quality of international level. Therefore, certification criteria for on-farm production of all farm produce have two sections i.e. BasicGAP catering to small and marginal farmers and IndGAP for bigger farmers and large farms. Accreditation, certification, requirements for certification bodies and rules for use of certification mark are as per ISO 17065, the international standard for product/process certification requirements.

GOVERNING STRUCTURE

National Accreditation Board for Certification Bodies (NABCB) is responsible for accreditation of the Certification Bodies (CB) as per requirements specified in ISO 17065 and additional requirements prescribed by the QCI as the IndGAP certification scheme (Scheme) owner. Accreditation of the CB is mandatory for operating under the Scheme and such agencies desirous of operating under the Scheme shall have to meet the following criteria:

1. General requirements

1.1 Legal entity: CB shall be a legal entity, or shall be a defined part of a legal entity, such that it can be held legally responsible for all its certification activities. A governmental CB is deemed to be a legal entity on the basis of its governmental status. If it is a part of an organization involved in functions other than certification, then it shall be separate and identifiable within that organization.

1.2 Integrity: CB and its personnel shall maintain integrity at all times. It shall implement adequate measures to ensure integrity.

1.3 Impartiality: CB shall be impartial, so structured and managed as to safeguard impartiality. CB and its personnel shall not engage in any activities that may conflict with their impartiality. CB shall require personnel involved in the certification process to sign a contract by which they commit themselves to declare any prior and/or present association on their own part, or on the part of their employer with a supplier or designer of products, or a provider or developer of services or an operator or developer of processes. CB and any part of the same legal entity and entities under its organizational control shall not be the designer, manufacturer, installer, distributor or maintainer of the certified product and offer or provide consultancy to its clients. CB shall ensure that activities of separate legal entities with which the CB or legal entity of which it forms a part has relationships, do not compromise the impartiality of its certification activities. If it's separate legal entity offers or produces the certified product or offers or provides consultancy, the CB's management personnel and personnel in the review and certification decision-making process shall not be involved in activities of the separate legal entity. CB shall act impartially in relation to its applicants and certified clients and shall have a process to identify, analyse, evaluate, monitor and document the threats to impartiality arising from its activities including any conflicts arising from its relationships, or from the relationships of its personnel on an ongoing basis. It shall not certify a system/ product/ personnel on which they have provided consultancy, carried out internal audits or provided training, for a minimum of two years following the completion of consultancy/ internal audits/ training. The CB shall not use personnel in audits/ inspections/ evaluations or other certification/ inspection activities if they have been employed by or involved in consultancy/ training towards the client, for a minimum of two years following the end of employment/ consultancy/ training etc. It shall not have any relationship with its clients other than third party conformity assessment.

1.4 Liability and financing: The CB shall evaluate its finances and sources of income and demonstrate that initially and on an ongoing basis, commercial, financial or other pressures do not compromise its impartiality. It shall be able to demonstrate that it has evaluated the risks arising from its certification/inspection activities and that it has adequate arrangements (e.g. insurance or reserves) to cover liabilities arising from its operations in each of its fields of activities and the geographic areas in which it operates.

1.5 Organizational structure: The CB shall define and document the duties, responsibilities and reporting structure of its personnel and any committee and its place within organization. If it is a defined part of a legal entity, documentation of organizational structure shall include the line of authority and relationship to other parts within the same legal entity.

1.6 Publicly available information: The CB shall maintain a website for providing information about the Scheme and its certification activities under the Scheme. It shall maintain and make publicly available information describing its certification processes for granting, maintaining, extending, renewing, reducing, suspending or withdrawing the certification, about certification activities and geographical areas in which it operates. CB shall make publicly available information about applications registered and certifications granted, suspended or withdrawn. It shall make publicly available its processes for handling appeals and complaints.

1.7 Confidentiality: The CB shall ensure confidentiality of information obtained in the course of its certification activities by having a suitable system.

1.8 Certification agreement: The CB shall have a legally enforceable agreement for provision of certification activities to its client. It shall also ensure its certification agreement requires that the client complies at least with specific requirements of relevant accreditation standards (ISO 17065) and the Scheme document.

1.9 Responsibility for decision on certification: The CB shall be responsible for, shall retain authority for, its decisions relating to certification, including the granting, maintaining, recertifying, expanding and reducing the scope of certification and suspending or withdrawing the certification.

1.10 Use of certificates and marks of conformity: The CB shall ensure that the rules for use of certification and marks as per the Scheme document are adhered.

1.11 Fee: A fee shall be charged from the client for various activities of the Scheme without any discrimination between clients, geographical location and size of the client. The CB's fee structure shall be publicly accessible and also be provided on request. It shall notify and obtain consent to its fee structure from clients prior to grant of certification. If the fee undergoes a change, same shall be communicated to all the clients for their acceptance.

2. Technical requirements

2.1 Personnel: The CB shall have as a part of its own organization, personnel, either employed or on contract, having sufficient competence for managing the certification operations for this Scheme. It shall have defined processes for selecting, training and formally authorizing and monitoring the performance of its personnel involved in carrying out various certification/ inspection activities and for selecting technical experts, if needed, as per the requirements of this Scheme.

2.2 Competence: The CB shall define the competence of personnel involved in application review, evaluation and review of the client and decision making. Evaluators shall meet the requirements of education (degree and/or post-secondary education relevant to agriculture, horticulture, soil sciences or agroforestry etc.), work experience (at least 5 years of full time equivalent post qualification experience in horticulture/ or agriculture production, including at least two years of work experience in quality assurance), training in audit techniques based on ISO 17021/ISO19011 and relevant evaluation experience as per the Scheme document.

2.3 Selection of evaluation team: Evaluation team may consist of one or more members. CB shall ensure the competence of evaluation team. It may include evaluators who do not have requisite qualifications as a part of evaluation team, provided they are supported by technical experts (TE) who meet the qualifications. Time spent by TE on an evaluation shall be in addition to evaluation time which the CB is expected to spend. If an evaluation team having more than one member, then one of the evaluators shall be designated as team leader.

2.4 Personnel records: The CB shall maintain up-to-date personnel records, as per requirements of the Scheme of each of its personnel involved in its certification/ inspection activities.

2.5 Outsourcing/subcontracting: The CB operating the Scheme shall not outsource any activity other than testing. Sending of samples to the CB's own laboratory shall also be considered as sub-contracting.

2.6 Test laboratory: If required, the CB shall test all samples of farm produce or semi-finished produce drawn for independent evaluation in a laboratory accredited to ISO 17025 by NABL for ascertaining conformance to the certification criteria. It shall maintain a directory of laboratories to which it intends to sub-contract. It shall have a formal contract with sub-contracted laboratories for provision of competent services and also for ensuring aspects like impartiality and confidentiality. If CB uses an in-house laboratory (part of the

same legal entity), it shall be ensured that there exists an adequate separation, in terms of organization structure and reporting and defined responsibilities. It shall also ensure through above means and policies and procedures, that there is no possibility of compromising the independence of the laboratory personnel. Certification criteria against which the product is to be tested or if in case of complaint shall be clearly mentioned and communicated to the testing laboratory. The sample(s) shall be so dispatched that they do not get damaged and or contaminated, undergo deterioration and the product integrity is maintained. CB shall have a documented procedure for drawl of samples and their subsequent handling and dispatch to the laboratories. Procedure shall also include aspects like receipt of test reports and their evaluation.

2.7 Certification process: The CB shall assign at least one person to review all information and results related to the evaluation. Review shall be carried out by person(s) who have not been involved in evaluation process. Recommendations for a certification decision based on the review shall be documented, unless review and certification decision are completed concurrently by the same person. CB shall manage the process of certification/ inspection as per document 'IndGAP Certification Scheme- Certification Process'. It shall maintain records to demonstrate that certification/ inspection process is effectively fulfilled. CB shall ensure requirements of the Scheme are met at any point of time. It shall certify only under the Scheme and using logo of the Scheme in certificates issued to the certified organization. It shall have written agreement with them on use of certificate and the Scheme logo. CB shall have a process to handle appeals by the organization/ person against any of its decision. It shall have a process to handle complaints from the users.

2.8 Approval process: Organization interested in approval as a CB for the purpose of this Scheme may apply to QCI in prescribed application form along with prescribed fee. The applicant shall also enclose required information and documents as specified in the application form. Filled in application form for approval shall be duly signed by the CEO/ authorized representative/s of the CB seeking approval. It will then be scrutinized by the secretariat at QCI and those found responsive will be processed further.

2.9 Assessment process: An assessment team comprising a team leader and member(s)/ technical expert(s) will be nominated by QCI for assessment at applicant's office. Assessment at head office will normally be for a total of two man days. Assessment team leader shall provide an

assessment plan to the applicant CB in advance. Office assessment will begin with an opening meeting for explaining the purpose and scope of assessment and methodology of assessment. This process shall cover review of documented system of the organization to assess its adequacy. It will also involve verification of implementation system including scrutiny of records of personnel competence and demonstration of personnel competence through means like interviews etc. At the end of assessment through a formal closing meeting, all the nonconformities and concerns observed shall be conveyed to the applicant CB. Based on report of assessment and action taken by the applicant CB on the nonconformities/ concerns, QCI shall take a decision on whether to grant provisional approval to the applicant as CB under the Scheme.

2.10 Validity of approval: Approval of the CB shall be valid for a period of one year after ensuring complete compliance to approval criteria. The CB shall obtain formal accreditation as per ISO 17065 from NABCB within one year of approval by QCI. QCI shall witness at least one evaluation during the period of approval. This may be waived off in case a witness report from NABCB is provided. Based on the request of CB and review of previous approval status, it may be decided to extend the period of validity. Approval shall be subjected to suspension/ withdrawal with due notice of 15 days in event of any noncompliance to the requirements of the Scheme. Approved CB shall inform QCI without any delay about any changes relevant to its approval in its operations and QCI shall examine such information to decide on the issue on merits with or without a verification.

2.11 Fee: Application fee for approval process is Rs. 10,000/- and man day charges are Rs. 20,000/-, whereas travel/ stay charges shall be on actuals basis. In addition, the CB shall pay to QCI Rs. 1000/- per certificate issued and QCI at its discretion may revise/ levy any other fee required with due notice to the CB.

CERTIFICATION CRITERIA

1. Objective: Fundamental objective is to strengthen GAP in the country and IndGAP provides a mechanism which gives direction to farms irrespective of size and resources to introduce quality in their production system for ensuring food safety and hygiene thereby increasing acceptability of their produce by consumers and food processing industry.

2. Purpose: Certification criteria describes the requirements of GAP against which certification can be obtained by the farmers or group of farmers. It provides an option to farmers depending upon their current

status, either to adopt BasicGAP or IndGAP. This document can be used for benchmarking their own standards for domestic or global market.

3. Limitations: These criteria are exclusively intended to address concerns about the GAP and give market recognition to farm produce that meet the requirements as prescribed in document. Produce of such farms shall be able to achieve a minimum level of safe and hygienic produce for human health and with minimum negative impact on the environment.

4. Scope: This document is applicable to all farm produce, which meet the criteria as prescribed in this document covering control points and compliance criteria. Scope covers production, harvesting and post-harvest handling of farm produce at farm.

5. Criteria: Certification criteria indicates requirements with respect to GAP in farms that details requirements clauses and sections for the producers intending to adhere the GAP.

CERTIFICATION SYSTEM

This section provides a framework for independent verification of the agricultural practices followed by farmers at the farm either for adhering to BasicGAP or IndGAP. If individual farmer or a group of farmers wish to seek certification, then they shall need to go through this document developed by QCI. Framework provided in this document covers control points and compliance criteria required to be followed for BasicGAP or IndGAP or for group certification and are also indicated in different sections of this whole document.

1. Compliance to control points: The producer must demonstrate compliance level of the control points to achieve certification as the levels indicated here. This process is aimed at covering individual farms or group certification. Some of the requirements and quality management system shall be addressed separately for group certification. Compulsory compliance requirements for IndGAP are: Critical- 100% compliance of all applicable critical control points; Major- 90% compliance of all applicable major control points and Minor- 75% compliance of all applicable minor control points. Likewise, compulsory requirements of BasicGAP are: Critical- 95% compliance of all applicable critical control points; Major- 85% compliance of all major control points and Minor- 70% compliance of all applicable minor control points.

2. Labelling requirements: One of the objectives of this Scheme is to provide information to all stakeholders i.e. secondary processors, aggregators, buyers and retailers about the status of produce being

either adhering to BasicGAP or IndGAP. This shall help them to maintain integrity of produce while the produce is being handled in supply chain. Besides all essential information like details of farm and or marketing organisation, batch number or lot number mentioned in transaction documents (invoices, bill of lading etc.), they shall also bear the certification mark (IndGAP or BasicGAP). Invoices, letter head, promotional material shall also be labelled with this certification mark. Labelling requirements as per the relevant regulations of the country where it is produced and will be sold shall also be ensured.

3. Rules for use of the Scheme certification mark

3.1. Purpose: All producers that have been certified under the IndGAP certification by the CB are eligible to use the certification mark. Here the process for approval of producer for use of certification mark and rules for its use by the certified producer is described. Scheme certification mark is a protected mark owned by the scheme owner. Its use would indicate that the processes of producer's farm are in conformity with specified criteria under the Scheme. Certification mark is also commonly known as 'Logo', however it will be referred here as 'Mark' as per international requirements.

3.2 Eligibility for use of mark: Producers or producer groups that have been certified under the Scheme by approved CB are eligible to apply for use of the certification mark. Certified producer shall apply to the Scheme owner through the approved CB which has certified it. Certified producer shall sign a legally enforceable agreement with the Scheme owner to use the mark after agreeing to all relevant conditions as per the document.

3.3 Mark and its usage: There may be more than two mark(s) depending on type of producer's certification *i.e.* BasicGAP or IndGAP or group certification. The mark(s) shall be distinct for each criteria and used in a manner as to imply that the farm produce has been produced using GAP. It shall be used on any document accompanying the lot of certified produce along with the address of the certified farm to indicate to the recipient that the produce is GAP-certified. Mark may be used in publicity material, pamphlet, letter heads, other similar stationary, media for exchange of any communication, for promoting the awareness of the Scheme etc. Certified producer may also use certificate issued by CB as a part of publicity material. While using the above documents, care shall be taken to ensure that the mark is used only with respect to the certified farm(s). The producer shall not make any misleading claims with respect to the mark. It shall not use the mark in any manner so as to bring the Scheme owner into disrepute. Upon

suspension or withdrawal of its certification, certified producer shall discontinue the use of mark in any form. Depending upon the extent of violation, the suitable actions may range from advice for corrective actions to withdrawal of certification. The Scheme owner may direct the CB to take any of the legal actions.

4. Obligations of the approved certification body (CB): The approved CB shall obtain agreement for use of mark duly signed in duplicate from the producer/producer group found conforming to the criteria for certification and forward it to the Scheme owner. The Scheme owner shall keep one original copy with itself, provide one original copy to the certified producer/producer group and one copy to the concerned CB after duly signing the agreement. The CB shall monitor use of mark to assist the Scheme owner in protecting the integrity of mark during their surveillance of the producer/producer group. In case the violation is observed by a certified producer, the CB shall take suitable action in accordance with the relevant requirements of ISO 17065 and those specified in the IndGAP documents.

5. Fee: The certified producer shall pay a fee as prescribed by the Scheme owner to its CB for onward submission to the Scheme owner for use of mark.

CERTIFICATION PROCESS IN Basic GAP/IndGAP

This standard covers the basic requirements of GAP and is henceforth referred as BasicGAP applicable for all farming practices in sustainable manner for maintaining quality and food safety of agricultural produce. This standard covers control points and compliance criteria for any farm desiring to be assessed for BasicGAP. This is mainly for either small or marginal farms or the ones that aspire to introduce quality in their farms for the farm produce in fresh unprocessed form for direct human consumption or for processing for human consumption by the food industry. For common understanding by the stakeholders in uniform manner, applicable terms have been defined and are given in glossary of terms and control points in Annexure 23. The producer must follow internal self-assessment against for all the control points and a checklist has been developed and provided in Annexure 23. This will bring uniformity in evaluation of the system. This also indicates when a violation of a particular criteria leads to critical, major or minor nonconformities. Details regarding BasicGAP have been given in Chapter no.2.

CERTIFICATION PROCESS IN IndGAP/ IndGAP PREMIUM

This standard covers control points and compliance criteria for any farms desiring to be assessed for IndGAP for the farm produce in fresh unprocessed form for direct human consumption or for processing for human consumption by the food industry. IndGAP standards are in conformity with the global GAP, therefore, farmers or farmer's group can expect their role in export market in coming time by adopting this GAP. This will give them an edge in domestic market also. Main components of this standard are base modules and crop based modules, which are all farm base module, crops base module, fresh fruits and vegetables, combinable crops, tea, green coffee. Others may be added in future depending upon the market requirements. In this document, relevant points for potato production have been incorporated in relevant portions for conforming to requirements of the IndGAP. The definitions have been included in glossary of terms for the purpose of this document and similarly entire checklist for IndGAP is cited in Annexure 24 for the benefit of potato growers. Details for IndGAP have been provided in Chapter no.3. List of certified agencies for IndGAP certification is provided in Annexure 22.

CERTIFICATION PROCESS FOR GROUP CERTIFICATION

Although farmers in a group have to adhere to either BasicGAP or IndGAP, but in addition following points are to be taken into consideration when group certification is desired.

1. Objective: Main aim is to ensure objective assessment and certification of the IndGAP group produce and promote uniformity in operation of the certification Scheme for whole producer group through better interaction between the CBs and the producer group.

2. Scope: This component covers group certification process of IndGAP with quality management system (QMS) to achieve certification. Certification shall be carried out by the CBs duly accredited for the Scheme as per ISO Guide 65/ISO 17065 by NABCB.

3. Certification process

3.1. Legality, administration and structure: The producer group shall be registered as a legal entity as Producers Management Unit (PMU). This legal entity shall have ultimate responsibility over the production, handling and ownership of the products. It will be responsible for

compliance with the standards. PMU shall enter into a contractual relationship and will have certification agreement with approved CB, thus becoming sole holder of the certificate. Administrative structure of the producer group shall be documented and clearly identify relationship between the producers and the legal entity. There shall be written signed contracts between each producer and the PMU. The producer group registered members must be legally responsible for their respective production locations. For multi-sites, all PMUs shall be owned or rented under direct control of the legal entity. If they are not owned by the legal entity, there shall be written contract between each PMU owner and the legal entity.

3.2 Producer and site integral register: A register shall be maintained of all contracted group member producers for all applicable sites used for production in accordance with the standard. All producers must be registered individually and register shall contain the information for each producer: name of producer, name of contact person, full address, contact data, Other ID (PAN etc.), growing/ production area and/or quantity for each registered produce, IndGAP status. Additionally, it shall also contain the information for each site: relation of legal entity with PMU, PMU location, product registered, growing/ production area and/ or quantity for each registered produce.

4. Quality management system (QMS) of group facility

4.1. Management and organization: Structure should enable the appropriate implementation of QMS across all registered producer members. The producer group/ PMU shall have a management structure and sufficient suitably trained resources to effectively ensure that the registered producers meet the requirements of GAP at their production sites. The organizational structure shall be documented and shall include individuals responsible for: managing implementation of GAP in the group, managing QMS, annual internal inspections, internal audit of QMS and technical advice to the group.

4.2. Responsibility and duties: The duties and responsibilities of all personnel involved with the compliance of GAP shall be documented and an individual who holds a position of sufficient seniority and resources to serve as the overall responsible person will be nominated for maintenance of the GAP certification.

4.3. Competency and training of staff: The management shall ensure that all personnel with responsibility for compliance with the GAP are adequately trained and meet defined QCI competency requirements. They shall possess degree /diploma in agricultural sciences with

suitable training. The competency requirements, training and qualifications for all key staff shall be documented and records shall be maintained to demonstrate competence. Internal auditor(s) and inspector(s) shall undergo training and evaluation on the job audits/ inspections to ensure consistency in their approach and interpretation of the standards. Systems shall be in place to demonstrate that key staff is informed and aware of development, issues and legislative changes relevant to the compliance to GAP standards.

4.4. Document control: All documents relevant to the operation of QMS for GAP compliance shall be controlled. This documentation shall include: quality manual, operating procedures, work instructions, recording forms, relevant documents of external origin etc. Policies and procedures shall be sufficiently detailed and available to registered members and key staff to demonstrate the group's control of principal requirements of the GAP standards. Quality manual shall be reviewed periodically to ensure that it continues to meet the requirements of the GAP standards and those of the producer group. Any relevant modifications of the GAP standard or published guidelines that come into force must be incorporated into the manual within specified time period.

4.5. Document control requirements: There shall be a written procedure defining the control of documents. All documentation shall be reviewed and approved by authorised personnel before issue and distribution. All documents shall be identified with an issue number, issue date/ review date and be appropriately paged. Any change in these documents shall be reviewed and approved by authorised personnel prior to distribution and withdrawal of obsolete documents. A copy of all documents shall be available at the places where the QMS is being controlled. Documents of external origin used in the management of group certification shall also be controlled.

4.6. Records: Records shall be maintained for a minimum period of 3 years to demonstrate effective control of the GAP quality management requirements and compliance with the GAP standards. Records shall be genuine, legible, stored and maintained in suitable conditions and shall be accessible for inspection as required. On-line or electronic records are also valid.

4.7. Complaint handling: There shall be an effective system for managing customer complaints. There shall be a documented procedure that describes how complaints are received, registered, identified, investigated, followed up and reviewed. The procedure

shall be available to customers and cover both the group and individual producer or site.

4.8. Internal audits and inspections: Internal audit systems shall be in place both to assess the adequacy and compliance of the documented QMS and to inspect the producers for GAP standard. The QMS for the GAP Scheme shall be audited at least annually. Internal auditors shall be suitably trained and independent of the area being audited. The CB will evaluate the competence of internal auditor during external audit. Records of the internal audit plan, audit findings and follow up of corrective actions shall be maintained and available for external audit. Completed QMS checklist with comments for every QMS control point must be available on site for external audit. New members of the group and new PMUs shall always be internally inspected and approved prior to entering into internal GAP register.

4.9. Non-compliances, corrective actions and sanctions: There shall be a procedure to handle non-compliances and corrective actions resulted from internal/ external audits, inspections, customer complaints and or failures of QMS. There shall be documented procedures for the identification and evaluation of non-compliances to QMS by the group or by its members. Corrective actions following non-compliances shall be evaluated and a timescale will be defined for action. Responsibility for implementing and resolving corrective actions shall be defined. A system of sanctions and non-conformances shall be operated with their producers or PMU that meet the certification requirement. The group shall have mechanisms in place to notify the GAP approved CB immediately of suspensions or cancellations of registered producers. All records for this shall be maintained including evidence of corrective actions and decision-making processes for a duration set by the CB.

4.10 Product traceability and segregation: Product meeting the requirements of GAP standards and marketed as such shall be traceable and handled in a manner that prevents mixing with non-GAP approved products. A documented procedure shall be in place for identification and traceability of all products from a specific site. A mass balance exercise must be carried out to demonstrate compliance within the legal entity. Effective system and procedures shall be available to negate any risk of misuse of label or mixing of GAP certified and non-certified products.

4.11 Withdrawal of certified produce: Documented procedures shall be in place to effectively manage the withdrawal of registered product, to identify the types of event for withdrawal, persons responsible for taking decisions, mechanism for notifying customers and the CB and

methods of reconciling stock. Procedure shall be capable of being operated at any time tested in an appropriate manner at least annually for its effectiveness and test records shall be retained.

4.12 Subcontractors: Procedures shall exist to ensure that any services subcontracted to third parties are carried out in accordance with requirements of the GAP standards. Records shall be maintained to demonstrate that the competency of any subcontractor is assessed and meets the required standards. They shall work in accordance with the group's QMS and relevant procedures and this shall be specified in service agreements or contracts.

4.13 Registration of additional producers or PMU to the certificate: New producers and sites may be added to the certificate. It is the responsibility of certificate holder to immediately update the CB on any addition or withdrawal of sites to/ from the list of registered producers. Up to 10% of new producers or sites per year can be added to the approved list by registering them with CB without verification. Further increase requires external sample inspection (minimum is square root of new producers/ sites) of newly added producer or sites and optionally an audit of QMS during the year before adding them to approved list.

5. Suitable Soils for Potato Cultivation

Potatoes are grown on a wide range of soils varying from sands to clay loams preferring well drained soils with a neutral pH (5.5- 7.5) and low salinity. Potatoes are prone to common scab if grown in high pH soils. Managing proper soil structure, moisture and temperature is important for good crop cultivation practices.

Role of soil in plant growth and productivity

Soil particularly its physical component is important for carrying out good cultivation practices as it affects crop at every stage of growth and development and harvesting. Main aim of crop management is to harvest maximum sustainable productivity in long run by maintaining soil health. Decision on crop rotation, water management, minimum required mechanical operations and utilization of crop residue and organic matter is the key for maintaining better soil physical structure in potato cultivation. Good soil structure enhances aeration, root penetration, water holding capacity, drainage and microbial activity. This is very significant aspect for faster emergence, crop growth, prolonged canopy cover, tuber development and bulking with minimum deformities, efficient harvesting and ultimately higher marketable productivity. Tuber shape and size is affected by soil physical conditions. An ideal potato soil should be well structured, with good drainage to allow proper root aeration and tuber development with minimal root disease infestation.

Soil compaction

Soil compaction is reduction in soil pore volume and increase in bulk density. Soil compaction is usually caused by pressure on soil greater than the soil structure can stand. Pressure exerted by machines decreases pore space as the air or water is squeezed out. Soil compaction leads to formation of clearly distinct compacted layer of 20-100 mm thickness normally below the ploughing depth. Compaction of soil may reduce crop growth, root development and tuber yield. Reduction in root

density and depth leads to inefficient water utilization from soil which increases the requirement for frequent irrigation. Soil compaction reduces amount of pores, especially large pores. This affects water holding capacity and infiltration rate, thus compact soils are more prone to water logging and risks of tuber rot diseases due to unseasonal rains. Tuber deformities and secondary growth may increase in compacted soils as a result of changing soil moisture conditions. Restricted early root growth can decrease nutrient uptake, leaf and tuber concentrations of macro and micro-elements. Mechanical and agronomic methods are used for reducing soil compaction. Among mechanical means, sub-soiling is best non-inverse tillage for loosening the soil. To reduce wet period of soil and risk of compaction an efficient drainage system should be developed on a farm. All cultivation equipment causes soil compaction so the soil must have optimum soil moisture for seed bed preparation, planting and other for mechanical activities. Inclusion of deep rooted crops like sowing green manure crop viz., *Sesbania aculeata* before potato crop improves soil structure. Soil organic carbon should be improved by way of crop residue incorporation, cover crops, application of farm yard manure and livestock slurry.

Soil moisture

Potato crop is very sensitive to water stress and requires high soil moisture availability. It is also more sensitive to fluctuations in soil water for better yields and good quality. Fluctuations in soil moisture between irrigations should be less. Relatively shallow (usually not more than 60 cm deep) and fibrous root system of potato plants limits their capacity to extract water from deep soil thus making them sensitive to drought. Soil moisture affects pre-plant, post-plant tillage operations. Maintaining proper soil moisture content is important for seed bed preparation with a proper tilth, emergence and growth of crop, inter-cultural operations and harvesting of crop with greater tuber exposure and minimum damages. Soil moisture of 70-80% field capacity (FC) is considered ideal for most soils. From planting to pre-emergence soil moisture in top 30 cm of soil should be maintained at 65- 80% FC. High soil moisture lowers soil aeration which may support several pathogens, most notably bacterial soft rot or black leg (*Erwinia carotovora*) and stem and stolon canker (*Rhizoctonia solani*). Excess moisture will decrease tuber respiration thereby putting them under metabolic stress due to anoxia. Under excess soil moisture conditions soil population of *Verticillium alboatrum* will increase and cause early dying of plants in mid-season.

Soil temperature

Soil temperatures affect emergence, root and stolon formation, tuber initiation and bulking significantly. Sprout development in planted seed tubers depends on soil temperature. Maximum elongation of sprouts occurs at about 18-24°C. Higher temperature reduces the pace of emergence. Root-zone temperatures impact root growth and root biomass which is reduced to a greater extent above 30°C due to reduction in cell division. Soil temperature affect stimulus for stolon formation, tuber initiation and tuber bulking. High soil temperatures adversely affect stolon formation and further no tuber initiation will take place. Optimum soil temperature for initiating tubers ranges between 16-19°C. Tuber development declines above 20°C and tuber growth practically stops at soil temperatures above 30°C. Numbers of tubers per plant are also lower at higher temperatures. Soil temperature affects tuber quality and yield. Tuber yield, specific gravity and starch content is generally higher and sugar content is lower at soil temperatures between 15-24°C. Temperature oscillations during tuber enlargement phase encourage tuber deformities. Tuber temperatures which are determined by soil temperatures at harvest are the major determinant of tuber resistance to bruising. A positive linear relationship exists with bruise resistance with increasing soil temperature. Crop management practices such as planting density, use of mulch and irrigation may substantially modify soil temperature regime within the root zone for optimum tuber development. Maintaining optimum plant population is effective in improving tuber yields as it increases the amounts of intercepted solar radiation, which brings a significant decline on soil temperatures during tuber growth. Organic mulches are able to keep soil cooler in day time depending upon available solar radiation and retain more heat at night. Mulching is effective in improving tuber yields as mulch can decrease daily maximum soil temperature by 1.5 to 4.5°C at 15 cm-depth.

6. Field Preparation

Seed bed preparation is vital for potato crop as roots and tuber growth largely depend on it. Proper tillage ensures better root development as it helps in proper retention and movement of water and nutrients to the roots. Seed bed quality affects weed management plan, magnitude of harvest damages and post-harvest losses. Number and type of cultivations that is required for achieving these objectives depend upon soil type. Light soil requires lesser number of operations than heavy soil. Crop in rotation also affect this as crop like paddy would require more ploughing. Pre-plant field operations are mainly decided by soil physical conditions viz., soil moisture, temperature, compaction and any region specific issues like requirement of stone removal etc. Therefore, tillage requirements should be decided depending upon the soil type and topography to minimise energy consumption and soil erosion.

Hot weather cultivation

Hot weather cultivation during May and June is highly desirable in plains. This reduces the infestation of weeds and incidence of soil borne pathogens and pests.

Seed bed preparation (Hills)

Land preparation should start at least two weeks before planting of potato. FYM (20-25 t/ha) should be spread and one deep ploughing (25-30 cm) is done against slope. It helps in breaking hard pan, loosening of soil and proper mixing of FYM. After this two normal ploughing are done and every ploughing is followed by planking so that clods are broken. Mould board plough and normal plough is used in seed bed preparation. A gentle slope is provided towards drainage channel during this operation.

Seed bed preparation (Plateau)

Ploughing with disc or mould board plough should be done after harvest of preceding crop. FYM (20-25 t/ha) should be applied at this time. This helps in rain water absorption and its percolation in soil to

conserve moisture better. As crop is rainfed so field preparation starts after first rain. Three to four tillage operations are done followed by cross planking. Bullock drawn ploughs and planks are normally used in this region and as farm mechanization is picking up, so tractor drawn implements are also used for field preparation.

Seed bed preparation (Plains)

FYM (20-25 t/ha) is applied two-three weeks before potato planting. Pre-planting irrigation is recommended 7-10 days before field preparation if sufficient soil moisture is not available to ensure uniform emergence. Ploughing of field is done with a mould board plough or disc harrow up to a depth of 20-25 cm followed by one or two tilling and cross planking. Finally, the field should have fine tilth and levelled to have efficient use of irrigation water and provide good drainage. Small farmers can use animal-drawn mould board and normal plough for land preparation. Tractor drawn laser leveller, disc or mould board plough, reversible harrow, sub-soiler, tiller, plank and clod breaker can be used in big fields.

7. Seed and Planting

This component mainly deals with seed preparation, optimum planting time, planting geometry and seed rate as all these aspects contribute significantly in tuber yields at harvesting. Region specific information has also been summarized in Annexure 2.

Physiological age of seed tubers

Dormancy of seed tuber is a state when it will not sprout even when placed under optimum growing conditions i.e. 18-20°C and 90% RH. Practically period of dormancy is counted from the date of harvest or haulm cutting. It depends mainly upon genotypes, growth and storage environment. Genotypes have shorter (<6 weeks), medium (6-8 weeks) and longer (>8 weeks) dormancy period. Cooler and wet conditions increase this period, while dry and warm weather shorten dormancy. Short day growing conditions have shorter dormancy and long day condition promotes longer dormancy period. Sprouting is not observed below 4°C, it starts above this and optimum temperatures are 15-20°C, whereas, it starts declining above 30°C. Humidity also affects sprout growth particularly at higher temperature where higher relative humidity (90% RH) stimulates sprouting. More branching is observed at lower humidity and rooting is induced at higher relative humidity. Diffused light produces short and stout sprouts with typical pigmentation or colours other than chlorophyll. Red light above 650 nm and blue light below 500 nm inhibits sprouting. Decrease in oxygen and increase in carbon dioxide concentration induces sprouting. Carbon dioxide concentration up to 10% at 10°C and up to 15% at 20-25°C stimulates sprouting. Sprouting of seed tubers begins at the breaking of dormancy and this determines shoot number and vigour, growth, tuberisation and yield of a cultivar.

Right physiological age of seed potato is very important at planting. It affects rate of emergence and vigour of stems, establishment of crop, optimum tuber set and bulking for achieving higher productivity. After breaking of dormancy, physiological quality of seed tubers is determined by physiological age. Different stages of physiological ageing are dormancy (no sprout), apical dominance (only one sprout),

early stage of normal sprouting (only a few sprouts per tuber), late stage of normal sprouting (many sprouts per tuber which are often branched), senility (excessive sprouting with very weak sprouts) and incubation (little tuber formation). Physiological age can be manipulated for best crop growth, tuber yield and quality with right tuber size distribution. It can also be an agronomic tool for adjusting growing conditions and maximizing crop performance. When seed tuber is exposed to cool temperatures during dormancy, number of sprouts per seed tuber increase after natural dormancy break and with an increase in number of weeks of exposure to cool temperatures due to decrease in apical dominance. De-sprouting advances physiological ageing. Regions exporting seed and having more than one growing season per year should monitor and control physiological age. Similarly, seed storage and trade should take physiological age into account.

Seed preparation

Period of sprouting is shortest at optimum temperature (15-20°C) while it is longer at lower or higher ambient temperatures. For early crop in plains, temperatures are relatively high so it takes more time (20-25 days) for sprouting. Seed preparation (removal from cold stores and its pre-sprouting) should be scheduled in such a way that well sprouted tuber with stout sprouts are used in planting for rapid and uniform plant emergence. It can be planned about a month earlier to the date of planting in early crop and spring crop. In main crop, seed potatoes can be withdrawn from cold store about 10-15 days before planting. Seed tubers should be kept in diffused light under shades with proper provision of ventilation for 10-15 days after withdrawal from cold stores/ country storage. Tubers can be kept in baskets, wooden boxes, plastic trays or may be spread in a thin layer on floor.

Optimum climatic conditions

Temperature is the most important factor determining the planting date and subsequently affecting crop duration, harvesting and tuber yields. Planting for main crop is done when maximum temperatures fall below 32°C. Further it requires low night temperatures (< 20°C) for tuberisation, which occurs about 25-30 days after planting. Better growth, tuber initiation and bulking take place between 15-25°C. So cultural practices like seed preparation, planting time and depth of planting etc. are so adjusted that tuber initiation and development coincides with night (< 20°C) and day (< 30°C) temperature for harnessing potential of a variety. The early and spring season potato

faces high and low temperature stress either in early growth or bulking phase. Pest and disease pressure is also high for these crops which culminates into lower tuber yields. Adoption of cultural practices like mulching and variation in depth of planting etc. can improve yield potential of a variety.

Planting time (Hills)

Optimum planting time depends upon altitude and location (latitude) in hills and there is variation in planting time from Jammu & Kashmir to Uttarakhand. In north western hill region, planting is done during May in very high hills (>2000 m), during mid-March- April in high hills (1800-2000 m), during January-February (spring crop) in mid-hills (650-1800 m) and September- November (early/ main crop) in lower hill and valley area (<650 m). In north- eastern hills, main crop is planted in February and autumn crop is planted during July- August. Potato crop can be taken up round the year in southern hills. Optimum planting time for summer, autumn and spring crop is April- May, August- September and January- February respectively, while in lower hills winter crop is planted during October- November.

Planting time (Plateau)

Mainly rainy season crop is taken up in this region under rain fed condition. Planting is done with onset of monsoon in last week of May or in first fortnight of June. Winter season crop is also raised under irrigated condition where crop is planted during October- November.

Planting time (Plains)

Planting time varies from first week of October to first week of November from west to east in northern plains as day and night temperatures lower down. Optimum planting time is first to second week of October in north western plains, second to third week of October in north central plains and first fortnight of November in north eastern plains. Early crop is planted during September and spring crop is planted during January in north western plains.

Plant spacing (Hills)

Planting geometry is like conventional method (60 × 20 cm) followed in plains. However, planting method differs as planting is done in furrows with deeper seed depth of more than 10 cm (around 15 cm) due to rain fed crop. Ridging is done only after plant emergence.

Plant spacing (Plateau)

Plant spacing and depth of planting are similar to method recommended in plain region. Light irrigation is recommended just after planting if soil moisture content is low in field.

Plant spacing (Plains)

Whole seed tubers (25-125 g) are planted in seed crop with a row spacing of 60 cm while row to row spacing varies between 15-35 cm depending upon tuber size. In table crop, 40-60 g tubers are planted at 60 × 20 cm plant spacing to maintain optimum density of 83,333 plants per ha. Average seed rate in this case works out to be about 3.5-4.0 t/ha. Seed rate can be economized in ware and processing crop by cutting large tubers into two or three pieces (35-40 g), treated with mancozeb @ 0.2% and dried afterwards in shade for 24 hours for suberisation of cut surface. Cut seed pieces should only be planted when maximum temperature is not above 25°C as they are sensitive to high temperature and easily rot. Wider row spacing of 67.5 cm has been adopted now due to mechanisation particularly in processing crop to maintain quality of raw material. Plant to plant spacing is adjusted depending upon seed size and requirement of desirable size in final produce in all types of potato crop. Crop geometry has another dimension in micro-irrigated crop where wide bed planting (120-154 cm) is recommended with two or three rows and planting density is again adjusted for specific size tubers desired in marketable produce.

8. Potato Based Crop Module

In this segment specific information and concepts of selecting a variety, cultivation of potato crop for different purposes, agro-technologies, harvest and post-harvest handling in major potato growing zone of the country is discussed. Step by step potato cultivation has been explained in simple language and potato growers can overcome major hurdles of GAP by following these packages and practices. This information would help them in cultivating potato crop for its specific utilization at assured destinations, improving and achieving sustainable yields along with quality and safe handling of the produce.

Ecological zones and varietal requirements

India has diverse soil types and agro-climatic conditions. Successful potato cultivation requires maximum and minimum temperatures of 32°C and 15°C with sunny days and cool nights. The optimum temperature for the growth of haulm is about 25 °C, whereas for rapid tuberization, moderate mean temperature (18-20°C) is beneficial. Minimum night temperature plays a crucial role in potatoes as tuberization is reduced at night temperatures above 20°C. Indian sub-tropical plains offer optimum conditions for potato cultivation, where 86% of potatoes are grown during short winter days from October to February. Hills account for less than 6 per cent of total potato production where the crop is grown during long summer days from April to September/October. Plateau regions of south-eastern, central and peninsular India constitutes about 8 per cent area where potato is grown mainly as rainfed or irrigated winter crop. Based on the diverse soil, agro-climate and varietal requirements, potato growing areas in India can be divided into eight zones (Table-1).

Table 1: Major potato growing zones in India and their varietal requirements

Zone	Major areas	Crop season	Varietal requirements
Plains			
North-western plains (< 300 m amsl*)	Punjab, Haryana & north Rajasthan	***Early autumn:*** September-November/ December ***Main autumn:*** October to January/ February ***Spring:*** December/ January to April/May	Short day adapted, early bulking/ maturity, resistance to early blight, late blight, black scurf, scab and viruses, tolerance to frost
West-central plains (< 300 m amsl)	Uttar Pradesh, north-western districts of Gujarat & Madhya Pradesh	***Early autumn:*** September to November/December ***Main autumn:*** October to January/February ***Late autumn:*** November/December to March	Short day adapted, early bulking, early to medium maturity, resistance to early blight, late blight and viruses and tolerance to frost, slow rate of degeneration
North-eastern plains (< 300 m amsl)	Assam, Bihar, Jharkhand, West Bengal, Orissa, eastern Uttar Pradesh, north-eastern Madhya Pradesh & eastern Chhattisgarh	***Winter:*** November to February/March	Short day adapted, early bulking/ maturity, resistance to early blight, late blight, charcoal rot and viruses, preference of red skin tubers
Plateau			
Parts of central and peninsular India (500-1000 m amsl)	Maharashtra, Karnataka, parts of Gujarat, Madhya Pradesh & Orissa	***Winter:*** November to January/February ***Rainy:*** June/July to September/October	Early bulking, ability to tuberize under higher temperature, resistance to early blight, late blight, bacterial wilt, viruses, tuber rots, mite and potato tuber moth, slow rate of degeneration
Hills			
North-western and central hills a. Very high hills (3000-3500 m amsl)	Jammu and Kashmir, Himachal Pradesh & Uttaranchal	***Summer:*** June to September	Long day adapted, resistance to late blight

Contd.

b. High hills (1800-3000 m amsl)		***Summer:*** March/April to August/September	Long day adapted, high resistance to late blight
c. Mid hills (1000- 1800 m amsl)		***Spring:*** January/ February to May/June ***Early autumn:*** August/September to November /December	Resistance to early blight, late blight, bacterial wilt and viruses
d, Low hills (600-1000 m amsl)		***Early autumn:*** September-November/ December ***Spring:*** December/ January to April	Resistance to early blight, late blight, bacterial wilt, viruses and tuber rots
e. North-eastern hills (500-2400m amsl)	Meghalaya, Manipur, Mizoram, Tripura, Nagaland & Arunachal Pradesh	***Spring:*** February/ March to June/July ***Autumn:*** August/ September to December	Long day adaptation and resistance to late blight, bacterial wilt.
f. Southern hills (1000 –2000 m amsl)	Nilgiris & Palini hills of Tamil Nadu	***Summer:*** March /April to August/ September ***Spring:*** January/ February to May/June ***Autumn:*** September to December	Long day adapted, early bulking, resistance to late blight and cyst nematodes
g. Sikkim and North-Bengal hills (1000 –2000 m amsl)	Sikkim & hills of West Bengal	***Spring:*** January/ February to June /July ***Autumn:*** September/ October to November/ December	Resistance to late blight and wart and distinct preference of red skin tubers

*m amsl-meter above mean sea level

Potato varieties for different agro-ecologies

Selection of right variety as per agro-climatic requirements, duration of crop, purpose viz., table purpose or processing, type (red skin, white skin) etc. is the crucial aspect of GAP for potato production. A crop's performance is affected by its climatic requirements and its purpose of cultivation. Hence the wise selection of variety as per requirement is mandatory.

Concerted breeding efforts of potato varietal improvement programmes at ICAR-CPRI, Shimla has led to development of 61 improved potato varieties for cultivation under diverse agro-climatic zones of the country. Besides table varieties, processing varieties have also been developed. Most of these varieties possess resistance/tolerance to major

pests and diseases. The institute now provides a wide range of varieties suitable to different conditions and thus farmers have more flexibility with regard to the choice of varieties. Indian potato breeding has in particular the distinction of developing very early bulking varieties those can be harvested as early as 60-70 days of planting and also there are varieties which can be harvested as and when required from 60 to 100 days.

So far 33 potatoes varieties are under breeder seed production and many of them contribute to significant areas in potato cultivation (Table 2, 3, 4 and 5). Details of potato varieties suitable for different agro-ecologies and purposes are described for subtropical plains having white/yellow skin colour (Table 2, Fig. 1), red skin colour (Table 3, Fig. 2), for hills (Table 4, Fig.3) and processing purposes (Table 5, Fig.4). Presently nearly 95% area under potato in the country is grown with improved varieties developed by the ICAR-CRPI. These varieties have contributed substantially to the observed increase in production and productivity in the country.

Fig.1. Tuber photographs of potato varieties (white/yellow skin) suitable for growing in north Indian plains and plateau region

Fig.2. Tuber photographs of potato varieties (red / purple skin)

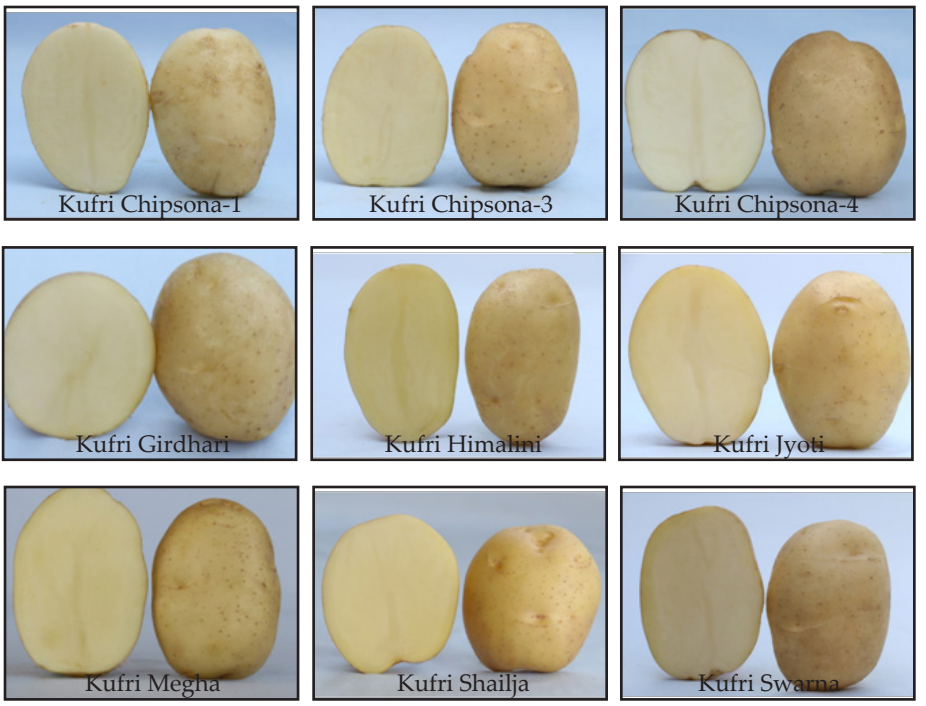

Fig.3. Tuber photographs of potato varieties suitable for growing in hills

Fig.4. Tuber photographs of potato varieties suitable for processing purpose for north Indian plains or hills

Table 2: Potato varieties (white/yellow skin) for plains or plateau regions

Variety (Release year)	Adaptability	Maturity	Yield (t/ha)	Keeping quality	Tuber characters	Remarks
Kufri Anand (1999)	North Indian plains	Medium	35-40	Good	White cream, oblong tubers with shallow eyes and white flesh	Moderately resistant to late blight and immune to wart, tolerant to frost and hopper. Can be grown in spring season also.
Kufri Ashoka (1996)	North Indian plains	Early	25-30	Good	White-cream, ovoid tubers with medium-deep eyes and white cream flesh	Susceptible to all major diseases.
Kufri Badshah (1979)	North Indian plains & plateau regions	Medium	30-35	Good	White cream, ovoid tubers with shallow eyes and cream flesh	Resistant to early blight, late blight and PVX.
Kufri Bahar (1980)	North Indian plains	Medium	30-35	Good	White-cream, ovoid tubers with medium eyes and white flesh	Immune to wart and tolerance to gemini virus, early bulking.
Kufri Chandramukhi (1968)	North Indian plains & plateau regions	Early	20-25	Very good	White cream, ovoid tubers with shallow eyes and white flesh	Susceptible to all major diseases. Excellent flavour and taste.
Kufri Ganga (2017)	North Indian plains	Medium	35-40	Good	White-cream, ovoid tubers with shallow eyes and cream flesh	Moderately resistant to late blight and tolerant to moderate drought conditions.
Kufri Garima (2012)	Indo-Gangetic plains & plateau regions	Medium	30-35	Good	Light yellow, ovoid tubers with shallow eyes and light yellow flesh	Resistant to late blight.

Table contd. .....

Kufri Gaurav (2012)	North Indian plains	Medium	30-35	Good	White-cream, ovoid tubers with medium-deep eyes and white cream flesh	Susceptible to all major diseases. Nutrient use efficient even at sub-optimal doses.
Kufri Khyati (2008)	North Indian plains	Early	25-30	Good	White cream, ovoid tubers with medium eyes and cream flesh	Resistant to early blight and late blight. Early bulker and suitable for high cropping intensity.
Kufri Lauvkar (1972)	Plateau regions	Early	20-25	Good	White-cream, round tubers with medium-deep eyes and cream flesh	Possesses heat tolerance.
Kufri Lima (2017)	North Indian plains	Medium to late	30-35*	Good	White-cream, ovoid tubers with shallow eyes and cream flesh	Tolerant to early heat, leaf hopper and mite. *15-20 t/ha under early/ heat stress.
Kufri Mohan (2015)	Northern & Eastern plains	Medium	35-40	Good	White-cream ovoid tubers with shallow eyes, white flesh	Moderately resistance to late blight. Early bulker.
Kufri Pukhraj (1998)	North Indian plains & plateau regions	Medium	35-40	Medium	Yellow, ovoid tubers with shallow-medium eyes and yellow flesh	Resistant to early blight, moderately resistant to late blight & immune to wart. Early Bulking, suitable for low-input eco-system.
Kufri Pushkar (2005)	Noth Indian plains	Medium	30-35	Very good	Yellow, ovoid tubers with medium-deep eyes and cream flesh	Resistant to late blight, immune to wart.
Kufri Sadabhar (2008)	Uttar Pradesh & adjoining areas	Medium	30-35	Good	White cream, ovoid tubers with shallow eyes and white flesh	Moderately resistant to late blight, Early bulker.
Kufri Surya (2006)	Northern plains & plateau regions	Early	25-30	Very good	White cream, oblong tubers with shallow eyes and yellow flesh	Heat tolerant, immune to wart, tolerant to hopper and mite. Suitable for early planting.

Table 3: Potato varieties (red / purple skin) for plains or hilly regions

Variety (Release year)	Adaptability	Maturity	Yield (t/ha)	Keeping quality	Tuber characters	Remarks
Kufri Arun (2005)	North Indian plains	Medium	30-35	Good	Red, ovoid with medium eyes and cream flesh	Moderate resistant to late blight.
Kufri Kanchan (1999)	North Bengal hills & Sikkim	Medium	25-30	Good	Pink, ovoid with shallow medium eyes and cream flesh	Moderate resistant to late blight and immune to wart. Slow rate of degeneration.
Kufri Lalima (1982)	North Indian plains	Medium	20-25	Very good	Red, round tubers with medium deep eyes and white flesh	Moderately resistant to early blight, resistant to PVY.
Kufri Lalit (2013)	Eastern plains	Medium	30-35	Good	Light red, round tubers, medium deep eyes and light yellow flesh	Resistant to late blight.
Kufri Neelkanth (2017)	North Indian plains	Medium	35-38	Good	Purple, ovoid tubers with shallow eyes and cream flesh	Moderately resistant to late blight. Speciality potatoes. Rich in antioxidants and very good taste.
Kufri Sindhuri (1967)	North Indian plains	Late	30-35	Very good	Red, round tubers with deep eyes and cream flesh	Moderately resistant to early blight, tolerant to leaf roll. Suitable for low-input system.

Table 4: Potato varieties for hilly regions

Variety (Release year)	Adaptability	Maturity	Yield (t/ha)	Keeping quality	Tuber characters	Remarks
Kufri Girdhari (2008)	Indian hills	Medium	30-35	Good	White cream, ovoid tubers with shallow eyes and white flesh	Highly resistant to late blight, long dormancy of tubers.
Kufri Himalini (2006)	North Indian hills	Medium maturity	30-35	Good	White cream, ovoid tubers with medium-deep eyes and cream flesh	Moderately resistant to late blight. Possesses day neutral feature.
Kufri Jyoti (1968)	Hills, plains & plateau regions	Medium	25-30	Very good	White-cream, ovoid tubers with shallow eyes and cream flesh	Moderately resistant to early and late blight and immune to wart. Early bulker with slow rate of degeneration. Suitable for processing when grown in warmer areas.
Kufri Mehga (1989)	North eastern hills	Medium	25-30	Good	White-cream, ovoid tubers with medium-deep eyes and cream flesh	Moderately resistant to early blight and resistant to late blight.
Kufri Shailza (2005)	North Indian hills	Medium	30-35	Average	White-cream, ovoid tubers with shallow eyes and white flesh	Moderately resistant to late blight.
Kufri Swarna (1985)	South Indian hills	Medium	30-35	Poor	White-cream, ovoid tubers with shallow eyes and white flesh	Resistant to early blight, late blight, immune to wart, highly resistant to cyst nematode.

Table 5: Potato varieties for processing purposes (tubers having high dry matter, low reducing sugars and phenols)

Variety (Release year)	Adaptability	Maturity	Yield (t/ha)	Keeping quality	Tuber characters	Processing attributes	Remarks
Kufri Chipsona-1 (1998)	North Indian plains	Medium	30-35	Very good	White-cream, ovoid tubers with shallow eyes and white cream flesh	High dry matter, low reducing sugars and phenols. Suitable for making chips.	Resistant to late blight, excellent taste.
Kufri Chipsona-3 (2006)	North Indian plains	Medium	30-35	Good	white cream, ovoid tubers with shallow eyes and white flesh	High dry matter, low reducing sugars and phenols. Suitable for making chips.	Resistant to late blight.
Kufri Chipsona-4 (2010)	Karnataka, West Bengal and Madhya Pradesh	Medium	30-35	Good	White cream, round tubers with shallow eyes and white flesh	High dry matter, low reducing and phenols sugars. Suitable for making chips.	Resistant to late blight.
Kufri Frysona (2009)	North Indian plains	Medium maturity	30-35	Good	White-cream, long-oblong tubers with shallow eyes and white flesh	High dry matter, low reducing sugars and phenols. Suitable for making French Fries.	Field resistant to late blight but immune to wart.
Kufri Himsona (2008)	Indian hills	Late	15-20	Good	White-cream, round tubers with shallow eyes and cream flesh	High dry matter, low reducing sugars and phenols. Suitable for chip making.	Moderately resistant to late blight and immune to wart.

SEED POTATOES

Potato crop is grown commercially by vegetative propagation method and potato tuber which is a modified stem, is used for this purpose. Tubers used for raising next potato crop can be defined as seed potatoes provided they have been produced after following set protocol for them. Healthy seed should be free from viral, fungal, bacterial diseases and nematodes. It should have varietal purity, tuber size and right physiological age as defined in the seed standards. Seed potato production is thus a specialized activity, so farmers and other stakeholders must be aware of production technologies in order to develop and establish successful venture. Critical component of production technology specifically for seed potato have been covered in this part. Common points of agro-technology for all type of potatoes have been discussed in subsequent chapters.

Suitable regions

Areas should have low aphid population period at least for 75 days from planting. Site should be free from soil borne pathogens and pests like wart, nematode, bacterial wilt, black scurf and common scab etc. North-western hills, north-western plain, north-central plains and north-eastern plains are suitable for potato seed production.

Crop rotation

Potato crop should be cultivated in alternate years in same field and green manuring should essentially be a part of crop rotation for disease free seed production. Do not cultivate crops like tomato, brinjal, chilli, capsicum, okra and cucurbits etc in the same field as they are common host for some of the viral, fungal and bacterial diseases. Region specific cropping systems may be developed for seed potato crop by keeping these points and timely planting of potato crop in view.

Planting time

Timely planting of seed crop is important to give sufficient growth period and to avoid critical period of vectors in later phase of crop. Seed potato is cultivated mainly during summer (March-October) in hills and autumn (October-March) in plains. Optimum planting time is when maximum day temperature is below 32°C and low night temperatures (<20°C) occur during tuberisation which is about 25-30 days after planting. Better growth, tuber initiation and bulking take place in between 15-25°C. Hence planting time is so adjusted that

tuber initiation and development coincides with night temperatures less than 20°C and day temperature remains below 30°C and available growing period is more than 70 days. In hills, March and April has optimum time for planting of the crop depending upon altitude and available soil moisture as majority of crop is rain fed. In plains, optimum planting time for Punjab is 5-15 October, for Haryana and Western Uttar Pradesh is 15-25 October and for Eastern Uttar Pradesh and Bihar is 25 October-05 November.

Plant nutrition

Moderate nutrition is provided to seed potato crop to avoid masking effect in leaves as detection and roguing of virus and other disease affected plants is critical activity during crop season. Another objective is to get maximum seed size tuber yield at harvest. Recommended macro-nutrient dose for seed potato production is 120 N: 100 P_2O_5: 100 K_2O kg/ha for hills and 175 N: 80 P_2O_5: 100 K_2O kg/ha for plains. Half of nitrogen and full of phosphorous and potassium is applied as basal dose and remaining half dose of nitrogen is applied at the time of inter-cultivation and earthing up operation at 20-25 days after planting. Detail concepts have been described in chapter of integrated nutrient management.

Seed for seed potato crop

Seed source should be reliable which can provide certificate of purity and authenticity of seed material. This may be the government institute viz., ICAR-CPRI, state departments of horticulture or agriculture, national seed corporation, state seed corporations and any authorized Agency. Whole tuber should be mandatorily planted for seed production. Seed size tubers can further be sub-graded for planting and plant to plant distance can be adjusted within rows for achieving optimum stem density, canopy cover and maximum seed size tuber yield at harvest. It should be of proper physiological age, treated and free from pathogens or pests.

Isolation distance

Minimum isolation distance of 15m should be kept between seed and ware crop to avoid disease transmission. Similarly, minimum isolation distance of 5m is maintained between different stages of seed crop and between different varieties to maintain varietal purity.

Seed crop scouting and rouging

As per seed certification norms a minimum of 4 field scouting must be carried out. Diseased and off type plants are rouged out during this process to maintain high seed quality. Roguing should be done in morning hours after drying of dew and afternoon in clear weather for proper plant identification. First scouting and rouging is done at 45 days after planting in hills and 35 days after planting in plains. This process is repeated at 60-65 days after planting for early varieties and 70-75 days after planting for late varieties or at appropriate crop growth stage depending upon crop duration of the variety to check the isolation, off types, mild and severe mosaic, leaf roll, mycoplasma diseases, brown rot and other relevant identified factors. Third scouting is done immediately after haulm cutting to verify that haulm cutting/ killing has been properly done at decided date. Last scouting is done after 10 days of haulm destruction to verify that no haulm re-growth is there in field. Failure to proper scouting and roguing at specified dates will render the crop liable for rejection during inspection by seed certification agency.

Haulm killing

Haulm killing is done after appearance of critical aphid population *i.e.* 20 aphid/100 compound leaves are observed. This can be done manually using sickle, mechanically by using tractor drawn haulm cutter or by chemical means (spray of paraquat @ 0.4-0.6 kg a.i. per hectare). Exposed tubers should be covered with soil before haulm killing and if re-growth of haulms occurs than it should be removed without any delay. This operation is generally completed by the end of December in Punjab, Haryana and Western Uttar Pradesh, by 10th January in Central Uttar Pradesh and Madhya Pradesh and by 15th January in Eastern Uttar Pradesh and Bihar.

Harvesting

Irrigation should be stopped 7-10 days before haulm killing for better skin maturity. The crop should be harvested 15-20 days after haulm killing as tuber skin would be hard and cut, crack and bruising losses would be reduced. Tubers are than kept in a heap of 1.5 m height in a cool shady place covered with locally available farm residues (paddy straw, sugarcane trash, leguminous stover etc) having thickness of 30-60 cm. Perforated PVC pipes (10-15 cm diameter) can be kept at the bottom (mid-point) of heap for improving the ventilation in large heaps. Tubers are kept in such heaps for 15-20 days for skin curing.

Grading

Grading is done before storage or seed disposal. Damaged (cut, crack & bruised), disease infected and deformed tubers are sorted out. As per seed act, hill produced seed is graded as large (more than 60 mm size or equivalent to more than 150 g), seed size (30-60 mm or 25-150 g) and small (less than 30 mm or less than 25 g). Plain seed is graded as large (more than 55 mm or equivalent to more than 125g), seed size (30-55 mm or 25-125 g) and small (less than 30 mm or less than 25 g). Seed size tubers are regarded as seed and marketed for seed purpose.

Seed treatment

Seed tubers are washed in clean water to avoid dirt and then dipped in 3% commercial grade boric acid solution for 30 minutes. This solution can be used for 20 times. Alternatively spray method can also be used for this purpose where 3% laboratory grade boric acid solution is prepared in warm water and sprayed on clean tuber so as these are drenched completely. Seed treatment devices are available for seed treatment. Treated tubers are then dried in shade, bagged, sealed and labelled either stored or marketed.

TABLE POTATOES

Approximately 90% of potatoes consumed at national level are fresh potatoes. Variety, taste, texture and tuber size preference varies from region to region. Crop season and duration also has distinct differences in different agro-climatic regions. So production technologies should be specific, precise and suitable for a particular zone. In this part critical points for table potato production have been discussed.

Season/ type of crop (early/main/late)

In plains, ware crop is raised as early (September- November), main (October- February) and spring (January- March) crop with the objective of either selling produce immediately after harvest for fetching premium price in early season or in summers. However, majority of produce from plain region is stored in cold stores, which is disposed of during lengthy off-season (April- November) depending upon consumer demand and market behaviour. Early crop is mostly grown in foot hills of north western hills and north western plain region. This crop has duration of 55-75 days depending upon market demand. Spring crop has very less area and this is also grown in same

region for a crop duration of approximately 75 days. Both crop have same objective of fetching better price by selling fresh potatoes. Main crop has major share in table potatoes and is taken up in all regions. Its crop duration varies from 90 to 110 days and only part of it goes fresh in market. Most of the produce is either traditionally stored or cold stored for having higher profits in long summer season. In hills, potato crop is grown depending upon altitude. Potato crop is taken during April/ May- August/ September in high hills (more than 2000 m) and mid hills (1800-2000 m). However, early (September- November) or spring (January- March) crop is possible in lower hills (lower than 1800 m). In plateau region majority of crop is taken during rainy season (May/ June- September) while some acreage is also there in winter season (October/ November- February) with irrigation facility.

Potato based cropping and inter-cropping systems

Ware crop production and its duration is affected by principal crops of an agro-climatic region. Farmers should select potato varieties and adjust crop duration suitable to their overall farming situation. Similar is the case with inter-cropping systems as these are mostly followed by farmers having smaller acreage north-central and north-eastern plains and hill regions. Suitable cropping and inter-cropping systems for different regions are as follows:

Agro-climatic zones	Suitable cropping system	Suitable inter-cropping system
North-western plains (Punjab, Haryana, part of Jammu & Kashmir, northern parts of Rajasthan)	Rice-Potato-late Wheat, Rice-Potato-Potato, Rice-Potato-Sunflower, Maize-Potato-late Wheat, Okra-Potato-Tomato, Groundnut-Potato-Onion, Black Gram-Potato-Radish, Potato-Mentha	Potato+ Mustard/Gobhi, Potato+ Onion (Seed), Potato+ Fennel, Potato+ Pea, Potato+ Fenugreek
North-central plains (Western and central Uttar Pradesh, plains of Uttarakhand, Madhya Pradesh, Chhattisgarh and Rajasthan)	Rice-Potato, Potato-Sugarcane, Maize-Potato-late Wheat, Maize-Potato-Sunflower, Rice-Potato-Green Gram, Rice-Potato-Sunflower, Maize-Potato-Cowpea, Soybean-Potato-Okra	Sugarcane+ Potato, Potato+ Mustard, Potato+ Onion, Potato+ winter Maize, Potato+ Fennel, Potato+ Barley

North-eastern plains (Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam and Orissa)	Rice-Potato-Rice, Rice-Potato-Jute, Rice-Potato-Black Gram, Maize-Potato-Black Gram, Rice-Potato-Onion, Rice-Potato-Sesame, Rice-Potato-Mentha, Rice-Potato-late Wheat, Rice-Potato-Groundnut, Rice-Potato-Bottle Gourd	Sugarcane+ Potato, Potato+ winter Maize, Potato+ Wheat, Potato+ Radish, Potato+ Mustard, Potato+ Linseed, Potato+ Pumpkin
Plateau region (Karnataka, Maharashtra and part of Gujarat)	Groundnut-Potato-Pearl Millet, Sesame-Potato Groundnut, Potato-Potato, Potato-Groundnut, Potato- Finger Millet, Potato-Chick Pea, Potato-Onion	Sugarcane (autumn) + Potato, Sugarcane (summer)+ Potato, Potato + French Bean, Potato + Maize
North-western hills (Jammu & Kashmir, Himachal Pradesh and Uttarakhand)	**High Hills:** Potato- vegetable Pea; **Mid Hills:** Potato- Potato, Potato- Radish, Potato-Turnip, Potato- Carrot, Potato- Fenugreek, Potato-Spinach, Potato- Radish- Radish; **Lower Hills:** Maize- Potato- spring Potato, Maize- Wheat Potato, Maize- Toria Potato, Maize- vegetable Pea-Potato- Maize	Potato+ French Bean, Potato+ Maize, Potato+ Garlic
North-eastern hills (Assam, Meghalaya, Arunachal Pradesh, Manipur, Nagaland, Mizoram and Tripura)	Potato- Potato, Rice- Potato, Maize- Potato, Radish- Potato, Cauliflower- Potato, Cabbage- Potato, Potato- Beans, Potato (summer)- Barley (autumn), Rice- Potato- Rice, Rice- Potato -Green Gram	
North Bengal and Sikkim hills	Potato- Potato, Maize- Potato	

Southern hills (Nilgiris)	Potato- Cabbage, Potato- Carrot, Potato- Potato, Potato- Radish, Potato- Cabbage- Potato, Potato- Cabbage- Radish	Potato (summer)+ French Beans

Inter-culture and earthing up

These operations are essential for reducing negative impact on environment. Inter-cultural operations are essential for reduction in soil compaction, better root aeration and weed control. Remaining half dose of nitrogen is applied and earthing up is done. Nitrogen use efficiency is improved by these operations and re-ridging is necessary to provide better soil cover to emerging stolon and developing tubers. Soil cover at planting is not sufficient as irrigation erodes the ridge particularly in light soils and exposure of stolon to light may make it an aerial stem. This also reduce tuber greening and improve marketable tuber yield. Earthing up is done by using hand tools like *Khurpa*, *khilna* and spades in small fields. Whereas bullocks drawn mould board plough can also be used in small fields for earthing up. For mechanical cultivation tractor drawn two or four rows ridger is used for this operation.

PROCESSING POTATOES

Potatoes are processed into various products such as chips, French fries, dehydrated products (flakes, granules and flour, dehydrated chips, dice or cubes, baris, papad etc), canned products and potato starch etc. Among processed products, chips, French fries and flakes are more popular forms. All products require certain quality traits in raw material. So, production technology developed for processing potatoes is different from seed or table potatoes and should be carefully followed during crop cycle to achieve desired standards in final produce.

Suitable areas

Regions with mean night temperature of 10°C or more especially during last 30 days of crop season produce good processing quality tubers having high dry matter content and low reducing sugars. State of Gujarat, Madhya Pradesh, Rajasthan, West Bengal, Bihar, Assam and Karnataka are more suitable for producing better processing quality potatoes.

Quality requirement

Quality of raw material is judged by two factors viz. morphological characters and biochemical composition. Among morphological characters' shape and size of potatoes is of utmost importance. Round to round-oval potatoes (45-80 mm) are required for chipping to have attractive shape in finished product and minimum peeling losses. Oblong potatoes (75-110 mm) are required for preparation of French fries. French fry industry normally procures potatoes more than 40 mm tuber size for making other frozen products. Dehydrated products (flakes, granules and flour) also require round to round-oval potatoes (> 30 mm) to avoid peeling losses. In case of canned potatoes, smaller sizes round to round-oval shaped potatoes (20-35 mm) are suitable. Processing potatoes with shallow eyes are preferred to avoid peeling losses and to maintain shape of slices particularly in chips and French fries. Physiological disorders like green, deformed, cracked and knobby potatoes are not acceptable at all in process grade tubers. Processing potatoes should meet certain standards for getting acceptable colour, crispiness and taste in finished product. Agro-technologies play significant role in meeting quality benchmark. Among biochemical attributes, tuber dry matter content and reducing sugars are most important. Potatoes with high tuber dry matter (> 20%) are better for fried and dehydrated products for getting higher output of finished product and /or lower oil absorption. In canning, low dry matter content tubers (less than 18%) are preferred. Acceptability of fried potato products depends upon level of reducing sugars (glucose and fructose) present in the raw material. Reducing sugars content should be less than 100 and 150 mg/100g tuber fresh weight for preparing good quality potato chips and French fries, respectively. Raw material for dehydrated products and canned potatoes should have less than 250 and 500 mg/100g tuber fresh weight, respectively. Higher reducing sugars deteriorate product quality and colour score becomes unacceptable. Product colour particularly in chips and French fries should be less than 3 on a scale of 1-10. After cooking darkening is not at all a desirable trait in processed products. Texture is also defined for all products, but it is largely dependent on genetic traits of a genotype. French fries require fairly firm texture, while fairly firm to mealy texture is needed for chips and dehydrated products. In contrast, canned products require waxy texture. Production technology for processing potatoes has been developed to get maximum processing grade tubers with desired quality levels. Critical points of this have been taken up in this segment.

Planting geometry

Row to row and plant to plant spacing should be kept at 67.5 cm and 20-35 cm, respectively for chips and flakes. Plant to plant spacing varies with size of seed tuber. Medium seed size tubers (35-45 mm) are planted at a spacing of 20 cm. In case of French fries, planting geometry of 67.5× 26.5 cm for seed size tubers is optimum. Planting depth should be kept at 8-10 cm.

Inter-culture and earthing up

One inter-culture and earthing up operation is recommended for potato crop meant for processing at 20-25 days after planting to avoid the problem of tuber greening in later phase of crop.

Manures and Fertilizers

Indian processing varieties require higher doses of nitrogen and potassium due to their crop duration (110-120 days) and higher dry matter content in tubers. Phosphoros requirement is comparable to ware potato crop. Optimum nitrogen, phosphoros and potassium requirement is 270, 80 and 150 kg N, P_2O_5 and K_2O per ha for getting maximum proportion of process grade tubers without affecting the processing quality at harvest and during storage at elevated temperatures (10-12°C) with treatment of sprout suppressant CIPC. Nitrogen should be applied in two equal splits, half at planting and remaining half quantity before earthing up. While phosphorous and potassium is applied only at the time of planting. Part of these doses (25-30%) should be applied through organic sources as this help in meeting micro-nutrient requirement and improve water holding capacity of soil. Balance nutrition helps in decreasing the reducing sugars and improving product colour. Application of calcium (200 kg/ha) in two equal splits (at planting and earthing up) as gypsum is beneficial in reducing the problem of internal brown spot (IBS) particularly in light soils.

Irrigation

Pre-planting irrigation is essential for uniform emergence. Light and frequent irrigation (8-10 days' interval) is desired to avoid moisture stress to the crop as it stimulates tuber deformities during active bulking phase. Irrigation should be stopped 7-10 days before haulm cutting for better skin maturity.

9. Nutrient Management

Potato crop is shallow rooted as around 75% root mass is in the 15-20 cm of top soil layer. It is a short duration (60-120 days) crop and is heavy feeder due to higher dry matter yield in terms of per unit area and time. Cropping sequence followed in the field also affects planning of crop nutrition. Environmental issues are becoming top priority at the global level. So, other crops in rotation, soil health data, duration and purpose of crop and available organic resources at farm should invariably be taken into consideration for calculating quantity of inorganic fertilizers required for the crop to achieve optimum marketable yields. Integrated nutrient management (INM) is essentially to be adopted by potato growers for smoother compliance of relevant GAP control points. Optimum nutrient doses for different regions and deficiency symptoms of major nutrients have been described in Annexure 2 and 3 respectively for the benefit of potato growers.

Soil health card

Soil health card scheme is being implemented at national level by Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India for the benefit of farmers. Potato growers should take advantage of this scheme where twelve parameters (pH, electrical conductivity, organic carbon, available nitrogen, phosphorous, potassium, sulphur, zinc, boron, iron, manganese and copper) are analysed and crop based recommendations for manures, fertilizers and soil amendments are provided. This card would be replaced after every three years for ascertaining probable changes in soil due to land use. Farmers can take advice from experts for carrying out the corrective measures in soil. Thus farmers will have a proper idea about nutrient status of their soil and they can follow balanced nutrient application after selecting suitable crops in potato based cropping system. Ultimately, there will be economy in manure and fertilizer use, crop yield will rise and environmental pollution will also be checked with sustainable use of recyclable farm resources.

Please refer soil health card (https://soilhealth.dac.gov.in) for additional information on this topic. Also, farmers can analyse the soil and water samples from various laboratories across the country (Annexure 21).

Right crop stage

When sprouted seed tubers are planted under optimal conditions of seed bed and soil moisture level then root initiation begins within 4-6 days of crop planting and root growth is fast in first 30-35 days. Uptake of nutrients from soil starts with root emergence and newly emerging plant stops absorbing nutrients from mother tuber. Therefore, crop require sufficient nutrients availability in the rhizosphere immediately after planting. Among nutrients, requirement of nitrogen and potassium is quite high followed by phosphorous and other secondary or micro-nutrients. Experimental conclusions suggest that two splits of nitrogen (half at planting and half at earthing up *i.e.* 20-25 days) are better for plant growth and yield. In many case, nitrogen should be applied after complete canopy cover (40-60 days after planting) otherwise quality and storability will degrade. Rest of the nutrients should be applied as basal dose. Two- three sprays of micro-nutrients can be done during active growth period if these were not applied at planting and deficiency symptoms appear. In micro-irrigation, fertigation provide uniform and precise doses of nutrients to crop during growth phase, however, this is again being done up to 40-60 days depending upon variety and purpose of crop.

Precise calculation of nutrient doses

Information from soil health card, recommendation for crop in different regions, variety and purpose of the crop and available option for crop nutrition helps in precising the nutrient doses for potato crop. Integration of organic sources and inorganic fertilizers not only economises crop cultivation but also contribute in compliance of GAP control points. ICAR-CPRI has developed model for decision support that helps in calculating accurate dose of fertilizers for a particular area based upon available soil data for desired planting date. Potato growers would be benefitted by using this easy and simple software for calculating precise fertilizer doses.

Efficient application of inorganic fertilizers

Uptake and efficacy of nitrogenous fertilizer depend upon the method of application, splitting of doses and method of irrigation. Placement of N fertilizer in sidebands (10 cm deep and 5 cm away from seed tubers)

at the time of planting has been found beneficial. Second dose can be given after completing the inter-cultural operation but before earthing operation. Phosphate and potash fertilizers are invariably placed in bands near the seed tubers at planting. If soil data exhibit deficiency in case of micro-nutrients, then these should be applied as basal dose at planting time. If deficiency symptoms are visible during crop growth phase, then crop can be sprayed once or twice. Nutrient application is done in small doses with more frequency based upon crop requirement under fertigation. This helps to improve nutrient use efficiency (NUE) and reduce leaching losses.

Green manure

Green manuring crop should invariably be included in potato based cropping systems for improving soil productivity and disease/ pest control. This crop supplies organic matter as well as additional nitrogen, particularly if it is a legume crop. A leguminous crop producing 10-20 tons of green manure per hectare adds about 60-100 kg N/ha. The increase in tuber yield is usually in order of 30-50 per cent. It also helps in reducing the incidence of soil-borne diseases like black scurf and common scab etc. So green manure crops like oat or bean in hills during early summer and sun hemp, dhaincha, cowpea and brassica etc. in plains during summer or rainy season is advised. Incorporate green manure crop in soil 6-7 weeks after its sowing and before potato planting for allowing it to decompose properly before planting of potato crop in coming season.

Organic sources

Application of well decomposed biogas slurry, farmyard manure, compost, vermi-compost and any safe organic source is beneficial for potato crop. Available crop residues of preceding crop should never be burnt as these are beneficial for soil fertility and productivity. These can either be used as fodder for cattle or in-situ incorporated into soil. Machines like combine harvester with attachment for cutting crop shoot into small pieces, tractor drawn reaper, reversible mould board plough, disc harrow and rotavator are available for safe in situ recycling of crop residue. Use of organics improves soil physical condition, soil fertility and water holding capacity of the soil.

Inorganic fertilizers:

High yielding potato genotypes require higher amount of macro, secondary and micro nutrients. However, as misconceived not all

amount is to be given through the inorganic sources. Therefore, soil available nutrients and quantity available from organic sources is taken into consideration before computing inorganic fertilizer doses. Up to half dose of nitrogen and full dose of other required nutrients can easily be saved with efficient use of available organic sources at farm. So, only optimal level of fertilizers is applied to potato crop. Within these products, with high nutrient use efficiency and slow nutrient release fertilizers should be preferred.

Nitrogen (N)

It is the most yield limiting nutrient in majority of potato growing soils. It is required in large amounts to maintain optimum shoot and tuber growth. Nitrogen has a great influence on crop growth, tuber yield and its quality. Potato plants having sufficient N have vigorous growth, increased leaf area index produce large tuber size as well as numbers. Sufficient N is needed in early stages to build up crop canopy and to enhance leaf area, thus giving longer period for tuber development during tuber bulking phase which is 40-60 days in plains. Ammonium sulphate containing 20% nitrogen in ammonical form and 24% sulphur is generally recommended in neutral soils as well as for production of processing potatoes. Neem coated urea (46.4% N) is generally advocated to apply at top dressing to avoid both leaching and sprout injury in early growth stage.

Phosphorous (P)

In potato, phosphoros application increases number of tubers, produces tubers of uniform size, boosts bulking and increases yield of tubers and hastens maturity. Application of P at optimum rates increases tuber starch and vitamin C content. Most common P fertilizers used in potato cultivation are single super phosphate (SSP) with 16% P_2O_5, di-ammonium phosphate (DAP) with 46% P_2O_5 and complex fertilizers (N : P : K). Proper placement of fertilizer has a great influence on phosphorous use efficiency and its application in furrows at planting time is better than broadcasting.

Potassium (K)

Potassium is the third yield limiting nutrient element in potato production. It imparts resistance against drought, frost and diseases. Its application activates number of enzymes involved in photosynthesis, carbohydrate metabolism and proteins and assists in translocation of

carbohydrates from leaves to tubers. It also increases yield by increasing number and yield of large sized tubers, therefore, its management has special significance in processing potato production. Potassium chloride (60%) popularly known as muriate of potash (MOP) and potassium sulphate (approx. 50%) are main source of potassium.

Calcium (Ca)

Calcium plays an important role in maintaining tuber quality in storage and reducing internal tuber disorders. Calcium sulphate and calcium nitrate can be used as Calcium sources. Gypsum can be applied at or before planting and calcium nitrate is applied at planting.

Magnesium (Mg)

Magnesium plays a central role in photosynthesis, as it is present in the centre of each chlorophyll molecule. It is also involved in various key steps of sugar and protein. Magnesium deficiency can be a problem in soils where high rates of potassium fertilizer have been used. Magnesium sulphate (20%) is the most common source for magnesium.

Sulphur (S)

Sulphur is recognized as fourth major nutrient after N, P and K and in view of its role in improving crop quality. It is required in many metabolic activities and its deficiency is similar to N in many ways. Elemental sulphur (80%), single super phosphate (12%), potassium sulphate (18%) and gypsum (13- 15%) are common source of sulphur.

Micro-nutrients

Although micronutrient elements are needed only in traces but many soils may not supply them in sufficient quantity for healthy growth and optimum yield of potato. Zinc (Zn), boron (B), iron (Fe), molybdenum (Mo), copper (Cu), manganese (Mn) are the examples of micronutrients. Use of inorganic fertilizers and high yielding potato varieties has resulted in higher demand for these elements. This has resulted in micronutrient deficiencies particularly B and Zn in many soils. Micronutrients play an important role in suppressing plant diseases and improving the resistance of potato plant. Sulphate salts of different micro-nutrients are common source of micro-nutrients at planting. Foliar spray is another option after planting of crop for correcting their deficiencies in standing crop. Optimum dose of different micro-nutrients is given in Annexure 4. Diagnosis is the first

step for precise monitoring and efficient correction of micro-nutrient disorders in potato crop and soil. Visual diagnosis of symptoms is possible as soon as symptoms appear. Each element develops its own characteristic deficiency symptoms in growing plant (Annexure 3).

Fertigation

In drip irrigation, one third dose of N-P-K fertilizers is applied as basal at the time of planting in broad ridges or beds at about 5 cm below seed tubers. Remaining two third dose of fertilizers is applied through fertilizer tank in eight- nine equal splits, twice in a week starting from plant emergence to six- seventh weeks of planting. Fertilizer tank is filled with water and calculated dose of fertilizer and then the system runs for half an hour for applying the nutrients in root zone. In case of sprinkler fertigation, one third dose of recommended N, full dose of P and K is applied as basal in the ridges or beds at about 5 cm below seed tubers. Remaining two third nitrogen is applied through fertigation like drip irrigation.

10. Weed Management

The main objective of weed management is to decrease weed intensity below the economic threshold level (ETL) with minimum damage to environment by incorporating all feasible ways in weed management for a given farming situation. Adopting optimum agronomic practices for rapid growth of potato plants, including crops in rotation which suppress the weeds, summer cultivation and combination of cultural and chemical methods of weed control are some of the practices which can be adopted to reduce weed infestation in potato crop. A brief list of all important weeds in potato crop is given in Annexure 8.

Interaction of weeds and potato crop

Weeds in potato compete for moisture, nutrients, space and light and also harbour several pests and diseases as alternate hosts. Potato crop is usually raised in wider geometry with liberal use of manures and fertilizers. Further, irrigations are frequent in plains and generally rains are heavy in hills during crop growth season. All these practices augment for early and faster growth of weeds even before the crop emerge out. The most critical period of crop-weed competition is 4-6 weeks after planting. In hills, duration of 35-55 days after planting is crucial, while in plains period of 20-40 days after planting the most critical period. Potato plants tend to drop between ridges after 65-70 days of planting as crop moves towards maturity and at this stage second flush of weeds come up. These weeds do not cause significant damage to tuber productivity but play a major role in increasing weed seed bank and cause hindrance in crop harvesting. Therefore, weeds in this stage have to be controlled for reducing the weed intensity for future crop.

Methods of weed control in potato crop

Decision of selecting a suitable method of weed control would depend upon severity of specific weeds, stage of weed growth, weather conditions and socio-economic condition of farm enterprise. These are mainly cultural, mechanical and chemical methods.

Cultural weed control

This component includes crop competition, planting date and plant population, companion cropping, crop rotations and fertility manipulation. Weeds are suppressed out specifically in initial phases of crop growth by way of crop competition through adoption of best crop production practices and making major components of crop growth in favour of potato crop. It includes vigorous and faster growth of potato plants and having crop environment such that it always smothers weeds. The weeds emerging out under better crop canopy are generally frail and will not be much harmful to tuber productivity. The potato cultivars having vigorous and rapid growing habits may prove better competitors for weeds as they cover fields quickly and overwhelm these undesirable plants.

Crop rotation may be done following at least two-year crop rotation in a particular field or having green manure crops like *dhaincha*, cowpea etc. for smothering weeds. Two-year crop rotation will assist in reducing weed seed bank in field, while in green manuring even for a shorter period (45-50 days), weeds get buried along with the green manure crops and are decomposed, which also add to the soil organic carbon. This operation facilitates better potato growth for posing tough competition to these detrimental plants.

Seed bed should be prepared thoroughly depending upon soil type of a region. Pre-plant tillage operations for making a proper soil tilth not only accelerate faster emergence of potato plant, but also destroy weeds and give an edge to the crop. Seed bed should contain sufficient soil moisture and if moisture is low then pre-planting irrigation is advised before cultivation.

A competitive edge is given to potato crop by way of optimized planting time. First of all, a variety should be planted at an optimum date and well-sprouted seed tubers should to be used at optimum crop geometry and planting depth.

At planting, manures and fertilizers should be precisely placed in bands 5-6 cm below seed tubers, so that these inputs remain in root zone of the crop for efficient nutrient utilisation. Inter-cultivation is done 20-25 days after planting when plants attain 10-15 cm height. Weeds are removed and field is left open for a day for desiccation of remaining weeds. Remaining dose of nitrogen is applied and ridging is done in the morning of next day to have proper ridging. Soil application of granular pesticides is also done at the time of nitrogen application in case of seed potato crop.

Hot weather cultivation and mulching

Hot and dry summer season in a cropping system helps for weed's desiccation. Two-three deep field cultivations in this period are very useful for the control of annuals and also for perennials like *Cynodon dactylon* L. Similarly, soil solarisation may be quite useful in specific situations or for premium potato crop like seed etc. Soil solarization is done using transparent polyethylene (TPE) film of 0.05 and 0.10 mm thickness for 30 and 40 days with and without conventional weeding in potato crop.

Mulching is a very efficient way for smothering weed growth during crop season and more specifically for annuals. Main objective of mulching is to deprive weeds of solar radiation and thus inhibition of crop growth. Germination of weeds is also hampered and this practice helps in conserving soil moisture, which facilitate quick emergence of potato plants. Crop residue, dry straw, dry grasses, pine needles and other vegetative material may be utilized in this operation. Plastic mulching has also come up as a promising technique for weed control in combination with micro-irrigation.

Mechanical weed control

Mechanical methods include manual weeding with the help of hands, *khurpi* or hand hoe etc, animal drawn implements and tractor-operated machines. It is very significant due to concerns for the environment and emphasis on avoidance of chemicals. Removal of weed plants by hand or by manual implements like *khurpi*, hand hoe, spades etc is followed in many parts of the country. This may be a feasible and efficient method provided manual labour is available and cheap. This method is particularly better as it destroys weeds within the rows, which are generally not controlled by the cultivation.

Animal-drawn three-tine cultivators are quite efficient and cost effective implements for inter-cultivation in potato crop. Narrow shovels are better for weeding operation as it will not damage roots and stolons of potato plants growing over ridges. One pair of bullocks per day can cover approximately one hectare of land. After inter-cultivation, animal-drawn single bottom ridger is used for earthing up of the crop. Tractor operated machines are very efficient and can cover larger fields in a day. Spring tine cultivators consisting of spring tines with narrow reversible shovels fitted to a tractor tool bar may cultivate three or more potato rows at a time. Tractor based mechanization can cover 3-5 hectare of crop field per day. Mechanical weed control has proved comparable to chemicals in terms of crop growth, yields and economics of weed management in potato crop.

Chemical weed control

Although chemical weed control is last resort, but it is quicker and less laborious and large area can be covered in a short period of time. This method minimizes the spread of contagious virus X and S in seed production programme since possibilities of contact with the plants are reduced. Contact and systemic herbicides are used depending upon weed flora and crop stage. The herbicides effective for weed control in potato crop are mentioned in Annexure 9. These are mainly pre-planting molecules which are applied before planting and mixed with the soil to avoid volatilization losses. Pre-emergence herbicides are applied within 3-5 days after planting of crop. Post-emergence herbicides are applied after emergence of weeds or crop (at about 5% emergence) or up to 1-3 leaf stage of weeds depending upon type of chemicals.

Precautions in herbicide application

Chemical based weed control requires attention in detail of molecule for its probable hazardous effect on human or animal health. All given label instructions should always be followed while working with these chemicals. Label claim indicates recommendation for particular crop; timing of its application related to crop stage and weeds growth, doses, coverage, manufacturing and expiry date, suitable environmental conditions (*e.g.* wind speed, atmospheric temperature) and its antidote/ first aid. Worker must follow all safety instructions during spraying. Wear suitable protective clothing, gloves and glasses while handling and spraying the herbicides. Wash chemical from skin or eyes immediately, if it has touched these organs. Avoid all contacts with mouth and do not breathe spray. Wash hands and exposed skin before meals and after work. Herbicides should be kept in original containers, tightly closed in a safe, cool, dry and properly ventilated place. Re-use of packing materials is prohibited to avoid any contamination.

Application

Information regarding direction for use should strictly be followed for better efficacy of herbicide and safety. Avoid drift as herbicide may damage sensitive crops in vicinity of potato crop, so do not spray in windy conditions. Care should be taken in avoiding spray overlap, as crop may be damaged due to over dose. Do not apply herbicide to potato crop if it is suffering from diseases, abiotic stress or nutrient deficiencies, or grown in acidic conditions. Herbicide should not be used if a previously applied residual herbicide is persisting in the soil

and this is especially significant for high organic content soils. Pre or post emergence herbicides are applied to soil surfaces in such a way that they cover both sides of ridges uniformly. In case of post-emergence applications where crop is sheltering the weeds, it is essential that the spray penetrate weed canopy. Filters of 80 mesh size should be used in sprayers for avoiding nozzle clogging. It is important to clean sprayers after use, especially if they are used for more than one crop and for application of insecticides and fungicides.

Environmental protection

These products are generally toxic to wildlife, so do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high water mark. Contamination of water bodies should be avoided when cleaning equipment, disposing equipment wash waters and containers. Do not allow direct spray from horizontal boom sprayers to fall within 5 m of top of bank of a static or flowing water body, unless a local environment risk assessment organization permits a statutory buffer zone, or within 1 m of the top of a ditch, which is dry at the time of application. Similarly, contamination of drainage is to be evaded. Care must be taken to ensure that off-target drift is minimized on food, forage and plantation crops. Refer to the state laws, regulations and guidelines for environmental safety.

11. Water Management

Water plays the most important role in crop production and potato is no exception to that. Judicious use of irrigation water is the key good agricultural practice. Both optimum irrigation and water conservation are required for sustaining higher crop productivity and environmental safety. Water use efficient technologies i.e. micro-irrigation technologies should be encouraged. Issue of water quality for avoiding residue problem and maintaining food hygiene is also equally imperative.

Irrigation water quality

As discussed in earlier chapter, consideration for irrigation water quality is vital for proper crop growth and yield, avoiding issues of MRL and contamination of food. So, only recommended quality of water should be applied while irrigating the crop. Recommended maximum concentration of trace elements in irrigation water and laboratory determinations needed to be evaluated for common irrigation water problems is described in Annexure 5 and 6 respectively. Standards of water quality have been described in Annexure 7.

Irrigation

Potato is very sensitive to water stress. As regards when irrigation has to be done, this would depend upon method of irrigation adopted as well as the scheduling criteria. Various approaches such as soil moisture deficit, soil moisture tension and cumulative pan evaporation (CPE) are followed for scheduling irrigation. In moisture deficit approach, irrigation is applied at 15-30% depletion of available soil moisture at field capacity. In soil moisture tension method, irrigation is given at 0.2-0.3 atm tension at 15 cm soil depth. In CPE irrigation is provided at 15-25 mm CPE. Crop requires continuous supply of water, but, stolon formation and tuber initiation stages are most sensitive to water stress. Normally time interval approach is adopted in autumn season in the Northern Indo-Gangetic plains. In this case, irrigation is scheduled at

an interval of 8-10 days initially when the temperatures are warm and later the interval is increased to 12-15 days as the winter sets in and the temperatures cool down. Water application is stopped 10-12 days before haulm destruction for better skin setting. Irrigation on the basis of CPE has also been advocated in potato particularly with micro-irrigation. In this case irrigation is done when cumulative pan evaporation reaches 15-25 mm depending upon soil type and variety. Either data of nearby metrological laboratory can be used or recommendations of research institutions at regional level can be adopted for this purpose.

Surface irrigation

Normally surface irrigation is adopted where seed bed of 8-10 furrows and 6-8 m in length are prepared and water is let into them till water level reaches half of the ridge height, if water level is more, then soil aeration is affected. About 50 mm water is applied at each irrigation through surface method. It is difficult to apply lesser depth of water through this method and this is a big disadvantage of this system in addition to conveyance loss, which is also relatively high in this case. Water use efficiency (WUE) is only around 50% in this system. Laser based levelling of fields can reduce water losses.

Micro-irrigation

Here basic principle is applying irrigation water in root zone of plant as per the requirement. This makes system very efficient in terms of water and nutrient use. Problem of weeds is also significantly lower in this system. In this case the conveyance losses are minimal and depth of irrigation can be regulated for required depth. Water losses are minimum under drip (4-5%) and sprinkler irrigation (15-20%) as compared to 40-50% under furrow irrigation. Mainly sprinkler and drip irrigation system have been adopted by potato growers.

Sprinkler irrigation

Several makes and model of sprinklers are available which can be profitably adopted for potato crop and its preceding or succeeding crops. This system gives uniform distribution of water without compaction of the soil surface and reduces water losses in terms of deep percolation. Sprinkler irrigation can be practices in undulating topographies in hill and Plateau region where soils have variable depths and not amenable to levelling. This system is suitable for sandy soils with very high water intake rate or fine textured soils with very

low intake rate. In this case conveyance losses are minimal and depth of irrigation can be maintained to the required depth. However, it is a high pressure irrigation system and requires energy for conveyance as well as pumping. The investment cost therefore is high. In late blight prone areas this system has to be used with caution during the favourable period for late blight incidence.

Drip system

This system is suitable for most of the crops as well also for potato. Water losses in terms of conveyance losses, deep percolation and evaporation are minimized with this system and required depth of irrigation can be managed precisely. Amount of water applied almost equals to actual daily consumption of a crop. Fertilizers can be easily applied in irrigation water as mechanism exists for this purpose. Raised bed with two or three row planting methods are beneficial for potato cultivation with drip irrigation. This is comparatively a low pressure system and so energy requirement is lesser than that for sprinkler system. However, the initial investment is high due to close spacing of the plants which increases the requirement of pipes for main lines, laterals emitters etc which makes the cost exorbitant.

Water management in plains

Water requirement of potato varies between 400-600 mm depending upon soil type, length of the growing season and climatic conditions. Irrigation is generally applied in furrows and the length of the furrow varies with intake rate of the soil and slope. About 50 mm water is applied to ensure adequate supply to the plant. Several ways are there to improve the water use efficiency. Crop should be raised under optimal standards of cultivation including use of fertilizers, weedicides and pesticides etc. Nitrogen fertilizer gives a positive interaction with irrigation and helps in improving the water use efficiency. Intercropping of deep rooted cereals like wheat in potato could also help in improving water use efficiency. Alternate furrow method of irrigation could help in saving on water input by 25%. Mulching reduces evaporation especially during early stages of potato growth. Use of mulch reduces maximum soil temperature by 2-3°C in day time and raise minimum soil temperature by 1-2°C during night thus helps in maintaining diurnal temperature fluctuations. Many recyclable materials like paddy straw can be used to conserve moisture during initial stages of crop growth. Cultural practices like manuring and fertilizer use, weed control help in increasing WUE. Interaction of

nitrogen and irrigation, timely control of weeds, intercropping with crops can help in enhancing the WUE in potato crop. Under scarcity of water alternate furrow irrigation method can be adopted to save irrigation water.

Water management in hills

Potato is cultivated as rainfed crop in these regions. Use of farmyard manure and green manures can help in retaining soil moisture and imparting drought tolerance to crop. Water storage can be followed during excess rainfall and stored water can be used in irrigation in drought period. *In situ* water harvesting with the help of mulches is also a feasible approach as it helps in increasing potato yield. Pine needle, farmyard manure or any vegetative matter can be used for this purpose. Mulching provides optimum soil environment for quick plant emergence and plant establishment. Besides conserving moisture by checking evaporation it reduces soil, water and nutrient losses and regulates soil temperatures to a certain extent. It stimulates availability of nutrients and thus improves potato yield and soil water utilization. It also checks the weed growth and thus saves water and nutrients. Ridge and furrow type soil configuration should be formed before snowfall to conserve snow melting water particularly on southern part of the hills. Fields should be properly drained in hills otherwise rotting of tubers and wilting of plants may occur.

12. Pest Management

Potato crop is infested by diversity of pests. Major damaging pests are sap feeders or sucking type, foliage feeders or defoliators, soil and storage pest and nematodes. Pests damage potato plant by feeding on leaves, by attacking stems and by feeding on tubers. Pest infestation damages the crop in one and many ways; which ultimately reduce the tuber quality and lowers crop productivity. Integrated management of potato pest is an environment friendly approach which aims in strengthening sustainable crop production with minimum use of chemical pesticides. Individual pest wise GAP is suggested in the context of IndGAP and Global GAP norms and also their biological and chemical controls have been described region wise in Annexure 14.

SAP FEEDERS OR SUCKING PESTS

This class of insect damage potato plant by sucking the cell sap from leaves or stems. The main sucking pests are aphids, whiteflies, leafhoppers and mites. Among them aphids and white fly act as vectors of various potato diseases.

a. Aphids

Although several other aphids have been found in potato crop in India, but *Myzus persicae* and *Aphis gossypii* are main vectors. In north-western and in north- eastern hills, they attain critical level (20 aphids per 100 compound leaves) by the end of July. In north- western plains, aphids start appearing from second week of November moving towards eastern plains in early December and reaching critical level by the end of December and during 2nd week of January, respectively. In plateau region, aphid infestation remains almost negligible in *Kharif* crop, while it appears in second week of November and reaches at critical level in third week of December in *rabi* season. Aphids acts as vectors of several potato viruses. Adults and nymphs suck the leaf sap and mainly transmit potato virus Y and potato leaf roll virus. Planting

early bulking or maturing varieties can help in seed production in areas having short aphid-free periods. Introduction and conservation of bio-agents that can establish themselves quickly in a crop season helps in checking the initial build-up of these vectors. Application of effective insecticides at right time in recommended manner and adjustment of planting and harvesting dates in different potato seed producing areas to avoid their population pressure can improve seed health.

b. Whiteflies (*Bemisia tabaci*)

Cotton whitefly is distributed throughout northern and western regions of India, whereas, green-house whitefly is cosmopolitan. Both nymphs and adults of white fly suck the cell sap. Whitefly transmits viruses including Gemini viruses (PALCV). Infected plants exhibit one or combination of symptoms like vein yellowing, inter-vein yellowing, yellow blotching of leaves, leaf yellowing, yellow mosaic of leaves, leaf curling, vein thickening, leaf cupping, plant stunting. Whitefly lower the vitality of plants. They also excrete honey-dew on which sooty mould grows which interferes with photosynthesis process. Affected plants give a sickly black appearance. Removal of weed hosts and heavily infested plants for clean cultivation, avoidance of excess irrigation and fertilizer application should be done. Regular monitoring by using yellow sticky traps is very useful.

c. Leafhopper (*Amrasca b. biguttula and other species*)

Leafhoppers are predominantly present in mid-hills during May to August and these are widely distributed all over in potato growing regions. Leafhopper can damage potato crop both as vector and direct pest. The species like *Alebroides nigroscutulatus* Dist. and *Seriana equata* Singh damage the crop as vectors of phytoplasmal diseases, viz. purple top roll and marginal flavescence. It regularly causes serious damage to early planted potato crop in north- western India. Adults and nymphs cause damage by sucking the sap from foliage and depleting cell content. First symptom is seen as black spot at tip of leaf or end of each lateral vein let. Entire margin of infested leaf may roll upward which subsequently turns brown and looks as if scorched by fire or drought. These brown margins continue to increase in width until a narrow strip of leaflet along the mid rib remains green while rest of the portions shrivel and die. Normally older leaves below growing tips burn first. However, upon heavy infestation, every leaf succumbs rapidly and dies much before normal tuber bulking. This type of foliar damage is popularly known as 'hopper burn' and leads to 20-30% yield losses to

early-planted potato crop. Clean cultivation, isolation of potato crop from alternate hosts, delayed planting (around 25th September) in early crop and during mid-October in main crop, encouragement of natural enemies and need based insecticide sprays are quite effective control measures.

d. Mites (*Polyphagotarsonemus latus Banks or Hemitarsonemus latus Banks*)

Mite generally appears in the 3rd week of October on potato crop planted around mid-September in western plains. However, it causes little damage on main and spring crop. In peninsular India, it appears in early August on *kharif* crop and is active during August-September. High humidity accompanied with moderate temperatures are favourable for its multiplication. Infestation normally starts from top leaves and gradually proceeds downward. Adults and nymphs feed on lower surface of leaves by sucking cell sap. Lower side of infested leaves first turn oily later reddish and finally bronze coloured. In case of severe infestation, leaves become short and leathery. Its management includes adoption of suitable crop rotations with non-host crop like wheat, proper isolation of potato from susceptible crops like chillies and brinjal, delayed planting of potato preferably beyond 15th October in western plains for main crop and need based use of acaricides.

FOLIAGE FEEDERS OR DEFOLIATORS

Defoliating insects attack potato at various stages of growth and these are mainly larvae or caterpillars of lepidopterans, beetles or weevils (coleopterans) and their young ones (grubs).

a. Lepidopterans

These include cabbage semi-looper (*Trichoplusia ni*), tobacco caterpillar (*Spodoptera litura* Hubner), gram pod borer (*Helicoverpa armigera* Hubner), bihar hairy caterpillar (*Spilosoma obliqua* Walker), army worms (*Mythimna separata* Walker) and brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen). Clean cultivation includes exposure of larvae to natural enemies, deep summer ploughing to expose pupae to sunlight and natural enemies, hand picking, destruction of egg masses and early gregarious instars. African marigold as trap crop for *H. armigera*, installation of pheromone traps (5 traps/ha) for monitoring and mass trapping of adult moths and spray of *neem* seed kernel extract @ 4.0% at early crop growth stage are quite effective control measures.

b. Beetles/ Weevils

The species like hadda beetles, flea beetles, blister beetles and weevil damage the potato crop. Deep summer ploughing to kill over wintering population and handpicking of grub infested leaves are good measures apart from chemical means.

SOIL PESTS

Cut worms

These are polyphagous insects and two species *Agrotis ipsilon*, *A. segetum* are widely distributed in plains and hills, respectively. The larvae of cut worms damage crop by cutting young plants at the base and later on by feeding on shoots and leaves. They feed on tubers after tuberisation by making deep and irregular galleries in them, thus reducing the market value of produce. Tuber damage may vary from 12-40 per cent. Cutworms can be managed by deep ploughing of fields during summer season in plains and in autumn in hilly areas. Light traps installation in potato fields is effective for attracting moths for mass collection and destruction. Conservation of natural enemies, spraying crop and ridges with biopesticides (Bt @ 109 spores /ml) or chlorpyrifos 20 EC @ 2.5 lit/ha after noticing 2% plant damage in fields are recommended.

White Grub (*Holotrichia seticollis, Anomala dimidiata* and *Brahmina coriacea*)

Larval stage is found in soil during July-November which initially feed upon roots of living plants and afterward feed upon tubers. Emergence of adults starts with the onset of first monsoon showers in June. Damage the potato crop by feeding on rootlets, roots and tubers. White grubs infested tubers have poor market value. Its damage to tubers is without any symptoms on foliage, so, farmers remain unaware of pest damage until harvest. Its damage is more severe in seasons following high adult activity. In mid-hills, yield losses may be as high as 85%. Removal of alternate/collateral hosts of beetles from the vicinity and within potato crop, spraying of beetle hosts and bunds with contact insecticides and early harvesting of potatoes in areas prone to white grubs is beneficial. Autumn ploughing in hills not only exposes the grubs to low temperatures but exposed grubs also become prey of birds. Use of nitrogenous fertilizers, especially ammonia and urea at higher doses kill the first instar grubs. Light traps may also be used

for collecting the beetles during night. Beetles can also be collected by shaking or jerking host plants during night. Fallen beetles should be collected and destroyed by putting them either in kerosinized water or by burning. Host trees of adults should be lopped or pruned and sprayed with contact insecticides before their emergence in June-July.

STORAGE PEST

Potato tuber moth (*Phthorimaea operculella*)

It is the most obnoxious pest of potato in fields as well as in stores. Prolonged dry and hot weather is quite conducive for its multiplication. Losses to potatoes in country stores may be as high as 70%, in absence of proper control. This problem is quite common in areas where potato crop is raised in heavy soils. PTM larvae damage crop foliage and also stems, exposed tubers in field and stored tubers particularly in country stores. Feeding tunnels are packed with black excretory pellets and larvae are inside these tunnels in infested tubers. Planting healthy seed tubers at a depth of 10 cm reduces its damage to a great extent. Fields should be ridged after 6 to 7 weeks of planting so that the tubers are buried at least 25 cm below soil surface. In areas where PTM population remains quite high and severe tuber damage is expected, ridging should be done twice so that the tubers are not exposed at any time for egg laying and infestation. Timely and adequate irrigations minimize soil cracking and thereby reduces the risk of tuber exposure to PTM attack or their egg laying. Pheromone traps should be placed in the field @ 20 traps/ha for mass trapping. Collect the leftover tubers after harvesting and also remove volunteer plants. All the plant debris including weeds belonging to solanaceae family should be collected and destroyed. Harvested tubers must be removed from the field as early as possible and should not be left overnight in field. Healthy potatoes should be stored in cold stores or traditional stores. Tubers should be covered with 2-3 cm thick layers of chopped dried leaves of either Lantana, soapnut, neem, eucalyptus or eupatorium in country stores. Crops like tomato, tobacco, chillies and brinjal should not be grown in the vicinity of potato fields.

NEMATODES

Root-knot nematode (*Meloidogynae incognita*)

Root-knot nematode infests roots and tubers of potato plants leading to hindrance in normal functions of nutrient and water uptake or translocation. Infested plants are dwarfed, chlorotic and have stunted

foliage and poor root development. The galls on roots are small and often go unnoticed but tubers have warty growth or rough surface that reduces their market value. Management schedule include soil solarization, deep summer ploughing adjusting planting dates, growing trap plants like *Tagetus spp*., rotation with non-host crops like maize, wheat, millets etc, conservation of natural enemies (bacteria, fungi etc.) and need based application of nematicides. Movement of soil and water from infested fields to normal fields should also be avoided. Field should be kept weed free as root- knot nematodes have a wide host range.

Cyst nematode (*Globodera rostochinensis* and *Globodera pallida*)

Potato cyst nematode (PCN) affects total plant growth and marketability. PCN infestation initially appears in patches and then spreads in entire fields within 4-5 years through irrigation water, wind, agricultural implements, humus and movement of seed material grown from the infested fields. Infested plants lose vigour, become sickly in appearance with stunted growth, dull appearance and unhealthy foliage. Infested plants wilt during sunny and bright days and require more water compared to healthy ones. Total photosynthesis is significantly reduced due to reduced leaf area which leads to drastic reduction in yield (65-70%). PCN once established in a region cannot be eradicated completely by using any single control method. These are managed by using chemicals (nematicides), adopting suitable crop rotations and utilizing available sources of resistance in tuber bearing *Solanum* spp. Growing non-host crops and following effective crop rotations at least for a year with any non-solanceous vegetable such as beetroots, cabbage, carrots, cauliflower, French beans, garlic, radish, turnips etc. during autumn brings down the cysts population to a great extent.

Pest infestation symptoms

Myzus persicae

Myzus persicae

Apical leaf curl virus

Stem necrosis

Stem necrosis

Leaf hoppers

Tip burn

Leaf burn

Hopper burn

Mite symptoms

Other pests symptoms

Spilosoma Obliqua caterpiller

Spodoptera litura

Symptoms of nematode in field

Different kind of traps

Water trap

Yellow sticky trap

Water trap

Light trap assembly

13. Disease Management

Potato crop is affected by various diseases during vegetative growth, tuberization, harvesting and storage. Amongst them main diseases are caused by fungi, viruses, bacteria and phytoplasmas. As potato is a vegetative propagated crop, so seed tubers are subjected to large number of seed borne diseases which also persist in soil. A single control method is insufficient for effective disease management; therefore, appropriate integration of cultural, biological and chemical control methods is a sensible strategy. Adoption of integrated disease management helps in managing occurrence and spread of diseases. Specific symptoms of all important potato diseases have been described in Annexure 10-13 for their easy identification. Disease wise control measures have been described below.

Late Blight

Late blight of potato is caused by *Phytophthora infestans*. This is the most important diseases of potato as average annual losses have been estimated to 15% of total production in the country. Specific temperature and humidity is required for initiation and disease build-up. Temperature requirements are different for fungus growth (16-20°C), spore production (18-22°C), spore germination (10-20°C) and for infection and disease development (7.2-26.6°C with optimum 18±1°C). Spore germination and infection requires 100% humidity and spores get killed under low humidity. Normally susceptible cultivars are killed within 8-10 days after disease appearance. Late blight affects all plant parts especially stem, leaves and tubers. It appears on leaves as pale green, irregular spots which enlarge into large water soaked lesions.

Use of disease free healthy seed for planting is very important. Remove infected tubers from seed and field and bury them in soil. Adoption of resistant varieties can control this disease to a good extent. For plains regions the recommended varieties are Kufri (K.) Badshah, K. Jyoti, K. Sutlej, K. Jawahar, K. Anand, K. Garima, K. Mohan, K. Himsona,

K. Chipsona 1, K. Chipsona 3 and K. Pukhraj, whereas for hills good cultivars are K. Girdhari, K. Himalini, K. Giriraj, K. Shailja (HP hills), K. Megha (Khasi hills), K. Swarna (Nilgiri hills) and K. Kanchan (Darjeeling and Sikkim hills). Cultural Practices includes selection of well drained soils, destruction of plant debris, high ridging. Scouting of field to identify primary infection followed by removal of infected plants after drenching them with recommended fungicides. Stopping irrigation when conditions become congenial for occurrence of late blight. Haulm cutting and its destruction at 80% disease severity. Ground keeper/bolter should be rouged out as early as possible. Prophylactic spray with contact fungicides like mancozeb 75% WP (0.2%) or chlorothalonil 75% WP (0.2%) or propineb 70% WP (0.2%) before closure of canopy. On appearance of the disease, spray the crop with fungicides like dimethomorph+ mancozeb or cymoxanil 8%+ mancozeb 64% WP or fenamidone 10%+ mancozeb 50% WG @ 0.3%. Number of spray may be increased or decreased depending upon disease severity and weather conditions. Ensure thorough coverage of plants top to bottom with fungicides. Special attention should be given to lower leaves which need to be covered with fungicides. Do not wait or allow late blight to appear and establish in the field. Always use a sticker @ 0.1% for proper sticking and uniform spread of fungicides on leaf surface.

Forecasting messages from ICAR-CPRI should be followed during crop season. JHULSACAST and INDO BLIGHTCAST software programs are available, which are being used for prediction of late blight appearance.

Early blight and leaf spot

Early blight is caused by *Alternaria solani* (Ell. & Mart.) Jones & Grout whereas leaf spots are caused by *Phoma exigua* Desm., *Phoma sorghina* Doerema, Doren & van Kest., *Alternaria alternate* (Fr.) Keissler, *Cercospora solani-tuberosi* Thir. Early blight occurs in all the potato growing regions of the country but it is common in central India, plateau of Bihar, Madhya Pradesh and Maharashtra. This disease is favoured by moderate temperature (17-25°C) and high humidity (75%). Intermittent dry and wet weather is more conducive for early blight. Pathogens can survive in soil and plant debris particularly in temperate climate. The symptoms of early blight appear on leaves and tubers. Small (1-2 mm), circular to oval, brown spots occur initially on the lower and older leaves. Later these lesions have tendency to become large and angular at later stage. Characteristic 'target board' concentric rings of raised

and depressed necrotic tissue can be observed, often with a chlorotic halo surrounding the lesion. Tuber symptoms comprise brown, circular to irregular and depressed lesions with underneath flesh turning dry, brown and corky. Lesions tend to enlarge during storage and affected tubers later become shrivelled. Symptoms of leaf spots due to *P. exigua* are large (1-2.5 cm) with broad alternate light and dark concentric zones. Affected tubers have grey to greenish black depressed lesions (up to 3 cm) on the surface. Leaf spots due to *P. sorghina* are characterized by pin head size spots, which may be oval, circular or irregular (not exceeding 4 mm). Infected tubers show grey large lesions (up to 1.7 cm).

Disease free seed should be used in planting. Avoid the cultivation of solanaceous crops nearby potato fields. Removal and burning of haulms of the affected potato crop help in reducing spread of inoculums in the field. Balanced doses of fertilizers, especially nitrogen, spray of 1.0% urea at 45 days crop growth and subsequent spray after 8-10 days may easily escape the severe onslaught of early blight and leaf spots. Fungicidal sprays of mancozeb (0.2%) or chlorothalonil 75% WP (0.2%) or propineb 70% WP (0.2%) or hexaconazole (0.04%) are effective in controlling early blight and other leaf spots.

Black scurf

Black scurf is caused by *Rhizoctonia solani* and is prevalent both in plains and hills. Infested tubers look shabby. The pathogen commonly affects the tubers, sprouts, stems and stolons. The fungus attacks young sprouts through epidermis and produces dark brown lesions. Elongated reddish brown lesions develop on stem at or below soil surface that may girdle the stem. When the girdling is complete the foliage curl and turn pinkish to purplish. Often aerial tubers are formed as a result of interference in starch translocation. The pathogen produces numerous hard, small, dark brown to black sclerotia on the surface of mature tubers towards the end of the season. These sclerotia when get deposited continuously, form a black encrustation on tuber surface. Optimum soil temperature for disease development is 18°C and for germination of sclerotia is 23°C. Healthy seed tubers for planting, green manuring with *Sesbania* spp., hot weather cultivation and crop rotation with brassica reduces its inoculum. Seed tubers should be treated with boric acid @ 3.0% for 30 minutes and dried before cold storage. At planting, pencycuron @ 0.25% may be sprayed on seed tubers for its effective control.

Fusarium wilt and dry rot

This disease caused by *Fusarium* spp. and it causes wilt under field condition and dry rot mainly at post-harvest stage. The losses caused by dry rot in plains and hills range between 5-23%. Infected tubers and soils are primary sources of inoculum. This fungus remains viable in soil for 9 to 12 months. *Fusarium spp*. has good saprophytic ability to survive in soil. Pathogen grows well between 15-28°C and high humidity favours infection of tubers. At wilting stage, lower leaves turn yellow and affected plant dries off rapidly. Both, stems and tubers at stolon end show vascular browning. Moreover, internal flecking of stem extended to upper leaves also. Sometimes, damping off seedling type symptoms also observed when temperature is high in early planting. In dry rot, skin of infected tubers first becomes brown, then turns darker and develops wrinkles. These wrinkles are often irregular concentric circles. In later stage of infection, a hole may be observed in centre of ring with whitish or pinkish growth of fungal mycelium. Cutting of affected tubers exhibit whitish or brownish tissues with one or more cavities. Under high relative humidity, secondary organisms like *Erwinia spp*. can invade the infected tubers and cause soft rot. Clean and healthy seed tubers should be used for planting and storage. Tuber damage and injury must be avoided during harvest, grading, transport and storage etc. to avoid adhering of contaminated soil on tubers. Washing of tubers to remove contaminated soil which adhere to the tubers and drying in shade, can reduce the risk of infection. Dip treatment of seed tubers with 3.0 % boric acid for 30 minute before cold storage is quite effective. Cut seed pieces should be treated with mancozeb @ 0.2% for 10 minutes and dried in shade for 24-48 hrs before planting. Crop rotation must be adopted for managing wilt disease.

Charcoal rot (*Macrophomina phaseolina* (Tassi) Goidanich)

Soil and infected tubers serve as source of inoculum. Temperature around 30°C or above are very favourable for infection, the rot is slow at 20-25°C and stops below 10°C. Fungal growth stops in tubers placed in cold stores but it resumes growth after cold storage. This disease causes three types symptoms i.e. stem blight, charcoal tuber rot and dry rot tuber. In stem blight phase, pathogen attacks the stem at or below ground level and a lesion appears on basal part of stem. Subsequently, affected foliage show wilting and yellowing. Charcoal rot affected tubers show black areas around eyes and proliferated lenticels. Initially, a black spot of about 2-3 mm in diameter develops around lenticels

which appears as a whitish speck at the centre. Internal tissues show black patches beneath the spot on surface of tuber. Dry rot affected tubers show black sunken areas on the surface, underneath which a cavity is formed due to destruction of tissues. Planting early maturing cultivars, frequent irrigations to keep down the soil temperature and harvesting before the soil temperature exceeds 28°C can reduce the disease incidence. Rotation with non-host crops and use of seed from disease free area, avoiding cuts and bruises at harvest also reduces disease incidence.

Powdery scab

Causal organism is *Spongospora subterranean* which can survive in soil up to five years. Temperature below 18°C and wet soil favours development of the disease. It is found mainly in cool and wet climates. The disease occurs only on the underground plant parts and does not show any effect on plant growth. It appears as pimple like spots on surface of young tubers. These spots are circular, smooth and light brown which gradually increase in size and later turn to scab like lesions. Unlike common scab, the lesions of powdery scab are round, raised, filled with powdery mass of spores and surrounded by ruptured remains of epidermis. Spore balls of pathogen on tubers as well as in the soil serve as a source of infection. Use of healthy seed for planting, proper drainage facility and crop rotation with non-solanaceous crops reduces the incidence of this disease.

Wart

This disease is caused by *Synchytrium endobioticum* and is both a soil and seed borne disease. The symptoms are cauliflower like warty growth on tubers, stolon and stem bases but not on roots. Infected seed tubers are main source for spread of the disease and hence use disease free healthy seed tubers for planting. Cultivation of wart immune varieties like K. Jyoti, K. Sherpa, K. Kanchan, K. Bahar, K. Chamatkar, K. Khasigaro, K. Muthu, K. Sheetman, K. Himsona, K. Giriraj, K. Pukhraj, K. Anand, K. Sutlej, K. Jawahar, K. Surya and K. Pushkar should be adopted. Practice long term crop rotation (five years or more) with non-solanaceous crops preferably maize, radish, cabbage, peas etc to control this disease. Wart lumps and potato peelings should not be thrown in field or in manure pit and should be destroyed by burning.

Bacterial wilt or brown rot

This disease is prevalent in all potato growing areas except north

western plains, north central plains and north western high hills. Changing temperature is likely to help the spread of this disease in new potato growing areas. Causal organism is *Ralstonia solanacearum* (Smith) Yabuuchi et al., which damage the crop either by premature wilting and death of plant or by rotting the tubers. First symptom is wilting of top branched leaves. Leaves started drooping and in advance stage the basal cut end of stem may show white ooze when squeezed. Bacterial wilt can be distinguished from fungal wilt by placing the stem cut section in clear water. After some time, if a whitish thread like streaming is seen coming out from cut section, then presence of bacterial wilt is confirmed. The same test can be done to see tuber infection. Tubers show two types of symptoms viz., vascular rot and pitted lesion on surface.

Deep ploughing in summer and use of disease free seed controls the disease in non-endemic areas like northern plains. In north-western mid hills (up to 2200 masl), north-eastern hills and Nilgiris, use of disease free seed, ploughing field in September-October and exposing the soil to winter temperature and application of stable bleaching powder @ 12 kg/ha mixed with fertiliser at planting are adequate for disease control. Two year crop rotation with crops like wheat, barley, finger millet, cabbage, cauliflower, knol-khol, carrot, onion, garlic etc. is also beneficial. Early planting and harvesting is also recommended. In winter crop of eastern plains and plateau region, management of disease can be done with practices like use of disease free seed, application of bleaching powder, blind earthing-up and ploughing in March and leaving the soil exposed to summer temperatures during April-May and crop rotations. Clean the field from weeds, root and foliage remnants by burning them.

Common scab

Common scab is caused by several *Streptomyces* species. The scab causes superficial lesions on tuber surface. The developing underground parts of stem, stolon and tubers are susceptible to this pathogen. Scab lesions on tubers may be shallow, raised or sunken. Lesions on mature tubers may be abrasions; star shaped with corky depositions; concentric wrinkled layers of cork around a central black core; raised and rough corky pustules or 3-4 mm deep. It's surrounded by hard corky tissues.

The pathogen is both soil and seed borne and is difficult to eradicate because of its long survival. Therefore, practices that minimize the inoculum and creating adverse condition for pathogen its spread are recommended. Disease free seed tubers used in planting significantly

check its spread. Boric acid (3% for 30 minutes) treatment of seed tubers before cold storage is quite effective. Irrigate the crop frequently to keep moisture near to field capacity right from tuber initiation until the tubers are of 1 cm size. Follow crop rotation with wheat, pea, oats, barley, lupin, soybean, sorghum, bajra and adopt green manuring to keep the disease under control. Hot weather cultivation during May- June in northern plains is effective in checking this disease.

Blackleg and soft rot

Bacterial soft rot can cause significant loss of potato tubers at harvest, in transit and storage. The bacteria usually infect potato tubers which have been damaged by mechanical injury or in the presence of other tuber borne pathogens. Bacterial soft rot develops much faster under warm and humid conditions. The pathogen also causes in blackleg of foliage during the crop growing season. *Pectobacterium atrosepticum* (syn. *Erwinia carotovora* sub sp. *atroseptica*), *Pectobacterium carotovorum* sub sp. *carotovorum* (Jones) (syn. *Erwinia carotovora* subsp. *carotovora*) and *Dickeya* spp. (syn. *Erwinia chrysanthemi*), are the major species. Initially a small area of tuber tissue around lenticels or stolon attachment point becomes water soaked and soft. Under low humidity, the initial soft rot lesions may become dry and sunken. Under high humidity, the lesions may enlarge and spread to larger area. Tuber skin remains intact and sometimes rotten tubers are swollen due to gas formation. At harvest, many small rotten tubers with intact skin can be seen. Infected seed tubers rot before emergence resulting in poor stand of the crop. In another kind of symptoms called black leg phase, which develops from soft rot infected seed tubers in cooler regions, affected haulms become black at collar region just above the ground. Infected plants develop yellowing, start wilting and die early without producing any tubers. Stem and petiole rot has been also observed in some locations. Water soaked lesions develop on succulent stems, petioles and leaves. On stem and petioles, the lesions first enlarge into stripes, turn black and then invade the affected parts causing soft rot and toppling of the stem and leaves.

Pathogen is present in soil, water and tubers. Soft rot bacteria are carried deep inside the tuber, in lenticels and surface wounds making it difficult to eradicate. These quiescent bacteria proliferate in high moisture condition and require water film that cause anaerobic conditions leading to disease development. Surface injury predisposes the tubers to soft rot infection. In field, avoid excess irrigation, provide proper drainage and restrict nitrogen dose to a moderate level. Adjust

planting time to avoid hot weather during plant emergence. Harvest the crop before soil temperature rises above 28 °C and tuber skin is fully cured. Avoid injury to tubers and sort out bruised or injured tubers. Treat seed tubers before storage with 3% boric acid for 30 minutes and dry under shade. Store the produce either in well-ventilated cool structures or cold stores.

Management of soil and tuber borne diseases

Soil and tuber borne diseases primarily perpetuate through infected seed tubers and soil. Therefore, management of these diseases requires elimination or lowering down of the inoculum load on the tubers as well as in soil. Management strategies therefore, have to be many fold for combating these diseases. Cultural practices include crop rotations, intercropping and green manuring. It has been found that, long-term rotation of maize or sunhemp with potato significantly reduced black scurf and charcoal rot incidence. *Sesbania*, sunhemp and pearl millet are also effective against black scurf. Some of the soil and tuber borne diseases are temperature sensitive and can be effectively managed by altering the planting and harvesting dates. By advancing the harvest in cool temperatures, incidence of black scurf can be brought down significantly. Harvesting of potatoes before soil temperature crosses 28°C reduces charcoal rot incidence. By delaying the planting from first week of October to last week reduces fusarium wilt markedly. Sanitation approaches includes use of disease free seed, weed control and removal of diseased plants/debris from field to reduce soil and tuber borne inoculum. Soil solarization by the use of transparent polyethylene sheet is an effective, simple and eco-friendly way of managing soil borne diseases. This method could be useful in tropical and sub-tropical plains where summer temperatures are very high and is practiced during the hottest period of the year. Use of *Bacillus subtilis* (B-5) has been found effective against black scurf, common scab, fusarium wilt and bacterial wilt. Combination of soil solarization and seed treatment with boric acid or *Trichoderma viride* is very effective in controlling black scurf. In host resistance, resistant or immune varieties are the best methods to check soil and tuber borne diseases, however, such varieties are available only against few diseases. The early maturing variety like K. Chandarmukhi is less prone to charcoal rot and may be cultivated in plains.

POTATO VIRUSES

Important potato virus with their respective symptoms and their mode

of transmission is described in Annexure 10 and 11 respectively.

Apical leaf curl disease

Incidence of apical leaf curl disease has been observed higher in early planted crop when the temperatures are high in October. It has positive correlation with whitefly population and whitefly infestation period. It is caused by a strain of tomato leaf curl New Delhi virus (ToLCNDV). Infected plant show curling of apical leaves, crinkling and a clear mosaic symptom, later entire plant appears bushy and stunted due to reduced internodal distance. Under field conditions the virus is transmitted by whitefly (*Bemisia tabaci*) in a persistent manner. It is also transmitted through seed tubers from one generation to the next generation.

Potato leaf roll

It is one of the most prevalent viral diseases of potato in India. Generally, all Indian potato varieties are susceptible to this virus. Infected plants produce only a few small to medium tubers. It is caused by Potato leaf roll virus (PLRV) (Syn. phloem necrosis virus). Infected plants show two type of symptoms viz., primary or secondary. Primary symptoms are confined to top young leaves, which usually stand upright, roll and turn slightly pale in certain cultivars. Most varieties, however, develop reddish/pink colour in top leaves starting at the margins, sometimes accompanied with slight rolling of the leaflets. Secondary symptoms develop when the plants are grown from infected seed tubers. Such symptoms are rather prominent in older leaves, i.e. absent or less pronounced on younger top leaves. Infected plants have characteristic pale, dwarfed and upright appearance with rolling of lower leaves that turn yellow, brittle and are leathery in texture. In some cultivars, a reddish or purple discolouration develops on the margins and underside of the leaves. The virus is tuber borne and transmitted efficiently by aphid in a persistent manner.

Potato mosaic

In general majority of the potato viruses like PVY, PVX, PVA, PVM, PVS, PAMV and PSTVd (viroid) causes mosaics, mottling/crinkle, necrosis, etc., either individually or in different combinations. Mosaics are the most common symptoms expressed by plant viruses infecting potato plants.

Management of viruses

Disease free healthy seed tubers from certified source should be used at planting. Combined thermo and chemo-therapy is followed in apical meristem culture for eliminating the viruses from seed tubers to produce pre-nucleus/mother seed stocks. In fields, roguing is done in seed crop to remove diseased and off-type plants which harbour different types of viruses. Roguing of diseased plants should be done as soon as the symptoms are visible in order to remove the source of infection and to prevent the spread of viruses. Rogue out the diseased plants carefully along with their tubers and dispose them. Dehaulm the seed crop before the aphids cross critical level to enforce rigid control of the insect vector. Strict sanitation in the field and also in stores, right from harvest to planting should be followed. Place the yellow traps (15 × 30 cm) just above the canopy height at the rate of 60 traps/ha, equidistant from each other. Treat the seeds with imidacloprid (200 SL) @ 0.04% (4 ml/10 litres) for 10 minutes before planting. First spray the crop with imidacloprid (200 SL) @ 0.03% (3 ml/10 litres) at the time of emergence of crop followed by second spray of thiamethoxam (25 WG) @ 0.05% after 15 days of crop emergence.

14. Harvest and Post-harvest Management

Harvest of potato should be done when tubers become mature and skin is properly set. Discontinue irrigation 8-10 days prior to haulm cutting (dehaulming) so that soil has enough moisture at the time of harvest and there is no formation of soil clods. Cut the haulms when crop is fully mature and after 10-15 days start digging of tubers, so that tuber skin becomes totally mature at the time of harvest and heap making. For seed or ware purpose potato meant for cold storage, harvesting can be done as per the time of haulm cutting. For processing varieties, harvest the crop at appropriate physiological maturity. For seed potatoes, start digging 10-15 days after dehaulming when peel is firm to withstand handling operations.

Harvesting Methods: Potato tubers can be harvested by two popular methods viz., manual and mechanical harvesting.

Manual harvesting: In manual harvesting hand tools like spade and *khurpa* are used for digging of potato tubers. For harvesting 30-40 tonnes of potato per hectare from soil mass of around 1000 tonnes about 600-700 man-hours are required. Animal drawn plow is another option for manual harvesting. This method is faster in comparison to manual one, but harvesting is delayed and fields become dry in case of bigger farms.

Mechanical harvesting: Tractor operated diggers or multipurpose diggers are used for digging of potatoes. They are fast, economical and cause least damage to the tubers and are popular for mechanical harvesting of potatoes. Adjust digger blade 4-5 cm below the tuber zone so that they do not cause any damage to potato tubers. Adjust forward speed of potato digger to have good soil separation and minimum direct impact of tubers on elevator web to avoid surface bruising.

GAP after harvesting of potato tubers

Perform variety wise harvest, handling and transport of potato tubers.

Take adequate care to avoid bruising of tubers during harvesting, handling and transportation. Use plastic trays or any other suitable aids for tuber handling to avoid bruising of potato tubers. After harvesting, keep potato tubers in heaps for about 15 days for hardening of peel and shedding of adhered soil from tubers surface. Cushion the surface with 10 cm straw (paddy or locally available material) or 15 mm thick soft perforated rubber and build potato heap on such soft surface. While making heap drop height should never be more than 15-20 cm on hard surface and 60 cm on cushioned surface. It is better to use belt conveyor for heaping of dug potatoes. Don't allow labour to drop tubers form head height while loading/unloading/heap making of tubers. Before tuber transport to processing plant or cold storage, they should be cured at least for 8-10 days in heaps. Cut/crack/bruised/damaged and diseased tubers should be removed to stop the spread of any disease or pest. Use padding materials between potatoes and metallic surfaces (floor and side walls) during transport. Do not perform tuber handling and transport when tuber temperature is less than 10°C. Take special care of material which is just taken out of cold storage as the inside temp was 2-3°C. Careless handling of material will result into numerous hair cracks in tuber which can increase peeling losses and hence lessen its market value. All the machines used for various operations should be devoid of sharp points to prevent bruising/ cutting of tubers.

Potato tuber grade specifications for domestic market

Marketing of potato crop is regulated by AGMARK specifications under the Agricultural Produce (Grading and Marking) Act, 1937 having Table Potato Grading and Marking Rules 1950 in the domestic market. Therefore, grading is essential process of marketing for potato crop in internal market. It also helps potato growers in selling the produce and fetching better price. Buyers also get liberty in choosing the specific product at appropriate price as per the utility in making various types of dishes for the final consumption. Potato grading can be done both by manual means and by mechanical graders.

Quality attributes like size of tubers, conformity to the variety, tolerance limits for under-sized and over-sized tubers, percentage of diseased and damaged tubers and dust and extraneous matters, etc. are taken into consideration. Similarly, dull, skin blemishes, cut, crack, sprouted, black scars and green tubers are not preferred and have strict limits. Tubers should be firm and skin should be mature and thick. The word 'Round or Oval or Long' should be marked following the grade name on AGMARK label. Thus tubers of different shape, size

and varieties shall be packed separately. Presence of any disease, pest or defect which may be established by cutting the tuber shall be taken into account and tubers having cuts worm and slug holes reaching into flesh shall be regarded as damaged. Potatoes affected by greenness superficial disease or damage shall not be regarded as diseased or damaged unless more than 10% of surface is affected. A potato shall only be regarded as affected by soft rot, if at the time of inspection, it is squashy or the surface is at some part distinctly broken or wet owing to disease. The Agmark grade standards of table potato are furnished in Annexure 17 and 18.

Potato storage

Pack the well cured and graded tubers in bags. Two kinds of bags are prevalent in India i.e. jute bags and synthetic leno bags. The recommended capacity for these bags is 40 kg. The potatoes meant for processing are stored at 10-12°C with the use of CIPC (isopropyl N-(3-chlorophenyl) carbamate) where there is minimum accumulation of reducing sugars and light coloured chips/French fries can be prepared. In case of seed potatoes, the treated tubers should be stored in gunny bags during their storage. In hills, store the seed tubers in country store while in plains in cold storage at 3- 4°C. After every two months, turn the bag once.

In the Indo-Gangetic plains, most of the potatoes are harvested in February-March when the temperatures begin to rise and thus, they have to be stored during the hot summer months. The storage method depends on the required duration of storage and destined use of potatoes which is broadly divided into two categories viz., refrigerated storage and non-refrigerated storage

Refrigerated storage: Refrigerated storages are generally used for long-term storage of seed and table potatoes. This is essentially done in commercial cold storages since potatoes harvested in February-March have to be stored until October or so for around 6-8 months.

Storage at 2-4°C: Low temperature storage is effective as 4°C temperature control sprouting and reduces physiological losses. The storage of seed potatoes at 2-4°C in cold store is ideal. Storage of ware potatoes at 2-4°C is not desirable; besides, the cold stored potatoes are unfit for processing. It is recommended that 2-4°C storage be used for potato seed only and the potatoes meant for table and processing should be stored at higher temperatures either under elevated temperatures of 10-12°C for long-term (6-8 months) or under non-refrigerated conditions for short-term (3-4 months).

Non-refrigerated storage of potatoes: Potatoes can be store for 3-4 months (up to June) after harvest in February/March under non-refrigerated storage. Sometimes, indigenous storage practices like pits, heaps, trenches and basements are used for storage. Improved heaps help to reduce the daily range of variation in temperatures while maintaining a high relative humidity (RH). While the day time variation in ambient temperature and relative humidity is considerable, the atmosphere inside the heap is quite stable. Weight loss and rottage are significantly reduced (<10%) in potatoes stored in heaps as compared to those stored at room temperature. Heaps may be protected from unseasonal rains by proper covering. However, after the onset of monsoon, potatoes can't be stored in a non-refrigerated store because it works only under dry conditions. Short-term storage of potatoes for 3-4 months is good enough as it helps avoid distress sale immediately after harvest and the farmer can get better returns by selling the potatoes in May or June, when potato prices start rising. Treatment of potatoes with sprout suppressants is useful and it is relatively easy to store potatoes under non-refrigerated conditions when they are dormant. Indian potato varieties have a dormancy period of 6-8 weeks. Once the dormancy period is over, sprouting begins. Weight loss in potatoes during storage is mainly due to water loss from the tubers and the weight loss is much more in sprouted tubers. The extent of rotting is high under non-refrigerated storage systems as the temperature and humidity conditions are favourable for aggravating the infection. Appropriate pre and post-harvest measures/ precautions needs to be followed. Potatoes stored in heaps are highly suitable for processing due to low reducing sugar content and preferred as table potatoes too.

MISCELLANEOUS

Physiological disorders

Potatoes are susceptible to several types of non-infectious disorders that affect the shape, function and appearance of plants or tubers (Annexure 16). These are either abnormal growth pattern or external and internal conditions due to adverse environmental conditions viz., moisture, temperature, light, nutrient, harmful gases and inadequate supply of growth regulators. Physiological disorders changes growth and appearances in tubers which contribute to economic losses as tubers may not meet the set standards. Cultivars vary in their susceptibilities to these disorders. Most physiological disorders develop slowly, may not be observed till very late in the crops growth cycle and are difficult to identify. Some common disorders include growth cracks, star cracking, russeting, feathering, an extension of rose end, development of knob-like structure from eyes and tuber greening. Alternate wet and dry growing conditions, fluctuation in temperatures and extended harvest can lead to physiological disorders in tubers. In tubers, these are associated with size which may vary rapidly when a rainy period follows a drought, improper placement of fertilizer or lower plant population. Optimum plant population, balanced nutrient and proper water management and timely haulm killing helps in controlling these disorders.

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CODEX Alimentarius International Food Standards: http://www.fao.org/fao-who-codexalimentarius/en

Directorate of Marketing and Inspection: http://dmi.gov.in

Directorate of Plant Protection, Quarantine and Storage: http://ppqs.gov.in

Food and Agriculture Organization: www.fao.org

Food Safety and Standards Authority of India: https://www.fssai.gov.in

ICAR- Central Potato Research Institute, Shimla: www.cpri.icar.gov.in

Indian Council of Agricultural Research, New Delhi: www.icar.gov.in

International Potato Center, Lima, Peru: www.cipotato.org

Ministry of Agriculture and Farmers Welfare: http://agriculture.gov.in/

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Glossary of terms

- **Annual crop:** When the time period between end of propagation stage to first harvest date is less than 12 months.
- **Certification body:** An organization that has been approved to grant IndGAP certificate under the Scheme.
- **Certification:** All those actions leading to the issuing of an IndGAP certificate.
- **Crop rotation:** The practice of growing different crops in recurring succession on the same land. It also includes crops on certain plot are following other crops according to pre-defined plan.
- **Crop year:** Generally, the 12-month period from the beginning of harvest of a particular crop rotation.
- **Crop:** The plants, which produce the produce.
- **Customer:** A customer is anyone who purchases products or services from a supplier.
- **Environment:** Water, air, land, wild species of fauna & flora and any inter relationship between them, as well as relationship with living organisms.
- **Farm:** A farm is an agricultural production unit or group of agricultural production units; covered by same operational procedures, farm management and IndGAP decision-making activities.
- **Food safety:** An assurance that food will not cause harm to the consumer when it is prepared and consumed according to its intended use.
- **Harvesting containers:** Containers used for the transporting produce during harvest
- **Hazard:** A biological, chemical, physical or any other property that may cause a product to be unsafe for human consumption.
- **Individual grower:** An organization or person legally responsible for on farm production, who retains ownership of all the produce covered in this IndGAP certificate.
- **In-organic fertilizer:** Commercial chemical fertilizer.
- **Inspection:** An examination of systems for control of food, raw materials, processing and distribution including in process and finished product testing in order to verify compliance to requirements.
- **Integrated pest management:** In agriculture, integrated pest management (IPM) is a pest control strategy that uses a variety of complementary strategies including mechanical devices, physical devices, genetic, biological, cultural management and chemical management. IPM is a sustainable approach to managing pests by combining biological, cultural, mechanical and chemical tools in a way that minimizes economic, health and environmental risks.
- **Inter-crop:** The crops raised in an orchard or other widely spaced crops for increasing income from the same piece of land e.g. short duration vegetables, pulses, oilseeds etc.
- **Inter-cropping:** Refers to growing of two or more generally dissimilar crops simultaneously on the same piece of land, base crop necessarily in distinct row arrangement. The recommended optimum plant population of the base crop is suitably combined with appropriate additional plant density of the associated crop and there is crop intensification in both time and space dimensions.

- **Irrigation water:** Water which is artificially applied in the process of irrigation. It does not include precipitation.
- **Irrigation:** The application of water to soil to assist in the production of crops especially during stress period.
- **Organic fertilizers:** Organic fertilizers recommended as per standards of national standards for organic production (NSOP)
- **Pesticide:** Plant protection product.
- **Ploughing:** Operations carried out with the help of tractor drawn or bullock drawn implements known as plough, before the crops are sown.
- **Post–harvest chemicals:** Includes post-harvest plant protection products, detergents and lubricants
- **Potable water:** Water which needs the quality standards of drinking water such as those described in the WHO published guidelines for the safe use of waste water and excreta in agriculture and aquaculture.
- **Primary produce:** Produce at a stage before processing.
- **Processed product:** When the structure of the product is altered in appearance or form.
- **Produce:** The harvested product of the crop before it is sold.
- **Product:** The produce sold to the customers.
- **Record:** Document showing objective evidence of the tasks performed and results achieved.
- **Registered product crop:** The crop that produces the product that has been registered by the grower with the certification body under IndGAP.
- **Registered product produce:** The produce that is the result of the registered product crop.
- **Registration number:** The number given to grower or grower group when he has completed the registration.
- **Rouging:** To remove weeds or off-type or diseased plants from a standing field crop.
- **Seed potato:** Potato tubers that are used are seed for raising next generation of the crop.
- **Seedling:** The juvenile stage of a plant grown from seed. Usually indicates plants which have up to and including about 4 true leaves.
- **Tillage:** The use of implements for mechanical manipulation to prepare seed beds conducive for field crop production
- **Trace back:** The ability to trace the history, use or location of a product (i.e., the origin of materials and parts, processes applied to the product, or its distribution and placement after delivery) by means of a record.
- **Worker:** Any person on the farm that has been contracted to carry out a task. This includes farm owners and managers.

Annexure

Annexure 1: General chemical composition of potato tuber (per 100 g of edible portion)

Content	Value
Energy	87 kcal
Protein	2.1 g
Fat	0.1 g
Carbohydrate	18.5 g
Fibres	2 g
Dry matter (raw)	310 kcal
Dry matter (boiled)	67 kcal
Calcium	10 mg
Phosphorus	61 mg
Iron	0.3-0.5 mg
Potassium	455 mg
Magnesium	22 mg
Thiamine (B_1)	0.10 mg
Riboflavin (B_2)	0.01 mg
Nicotinic acid (B_3)	1.2 mg
Pantothenic acid (B_5)	0.3 mg
Folic acid (B_9)	14 mg
Vitamin C	20 mg

(Source: www.cpri.icar.gov.in)

Annexure 2: Package of practices for potato cultivation in different regions

A. Table Potato

Zone	Major States	Planting time	Seed size (g)	Spacing (cm)	Nutrients FYM (t/ha) N-P-K (kg/ha)	Harvesting Time
North-western hills	Jammu & Kashmir, HP and Uttarakhand	Higher hills (1800- <2000 m): March-June Lower hills (650-1800 m): June & February Foothills (<650 m): October-November	40-60	60 X 20	FYM: 20-25 HP: 120: 100:100; Jammu: 120:60:120 Kashmir: 90:75:100 UK: Irrigated: 120:100:100 Un Irrigated-100:80:80	Higher hills: September-October Lower hills: May- June Foothills: January-February
North-eastern hills	Assam, Meghalaya, Arunachal Pradesh, Manipur, Nagaland, Mizoram and Tripura	Main crop: February Autumn crop: July-August	40-50	50- 60 X 20-25	FYM: 10-15 125:120:60	Main: June-July Autumn: Nov-Dec
Southern hills	Nilgiris in Tamil Nadu	Summer crop: April- May Autumn crop: August-September Irrigated: January-February Plains/ Low hills: October/ November	Summer: 50-60 Autumn: 25-40	Summer: 60 X 20 Autumn: 45 X 20	FYM: 20 90:135:90	Summer: August-September Autumn: December-January Irrigated: April-May Plains/Low hills: January-February
North-western plains	Punjab	Early crop: September Main crop: October Spring crop: mid-January	40-60	60 X 20	FYM: 15 180-240: 80: 120	Early: November Main: February-March Spring: March-April
	Haryana	Main crop: October Spring crop: mid-January	40-60	60 X 20	FYM: 25 125-150: 50-60:100	Main: February-March Spring: March-April

	Parts of Jammu	January-February	35-45	60 X 20	FYM: 30 160:100: 100	April-May
	Rajasthan	Main crop: October	25-50	60 X 20	FYM: 25-30 180:125:125	January-February
Central Indo-gangetic plains	Western and central UP, Uttarakhand, MP, Chhattisgarh and Rajasthan	Second-third week of October	40-60	60 X 20	FYM: 15-30 180:80:100	January-March
North-eastern plains	Eastern UP, Jharkand, West Bengal and Orissa	Early crop: September Main crop: October Late crop: February	30-40	60 X 20	FYM: 15-30 180:60:120	Early: November Main: February-March Spring: March-April (temperature below 25-28oC)
	Bihar	Early crop: First fortnight of October Main crop: Last week of October to first week of November Late crop: last week of November to first week of December	30-40	60 X 20	FYM: 15-30 180:60:120	Early: Nov-Dec Main: January-March Spring: March
Plateau region	Karnataka	*Kharif*: June *Rabi*: October	25-40	Rain fed: 60 X 20 Irrigated: 45 X 20	Rain fed: FYM: 20-25 75-120:75: 100 Irrigated: FYM: 20-25 125-150: 100:125	Kharif: August-September Rabi: January-February
	Maharashtra	*Kharif*: June *Rabi*: October	25-40	60 X 20	FYM: 20-25 150:60:120	Kharib: August-September Rabi: Feb- March
	Gujarat	First fortnight of November	25-40	50-60 X 20	FYM: 25 200-275:100-140:200-275	February-March

B. Processing purpose potato

Variety	Major growing zone	Planting time	Seed size (g)	Spacing (cm)	Nutrients FYM (t/ha) N-P-K (kg/ ha)	Harvesting Time
Kufri Chipsona-1, 2, 3, 4 and Kufri Frysona	North Indian plains	15th October - 10th November	30-40	Chips: 67.5 x 20 French fry: 67.5 x 25	FYM: 15-30 270:80: 150	February
Kufri Himsona	Indian hills	Summer: Mid-March-May Spring: January-February Autumn: October	30-60	60 x 20-30	FYM: 20-25 240:100:100-120	Summer: September-October Spring: May-June Autumn: February
Kufri Chipsona-4	Plateau region	Kharif: May-June *Rabi:* October-November	25-40	60 x 20	FYM: 25-30 150:80:100	*Kharif:* September-October *Rabi:* January-March

C. Seed potato

Major growing zone	Planting time	Seed size (g)	Spacing (cm)	Nutrients FYM (t/ha) N-P-K (kg/ha)	Haulms cutting	Harvesting Time
North Indian plains	October	25-125	60 x 15-30	FYM: 15-20 150- 175: 80:100	January	February
*North-western hills	Mid-March-April	25-150	60 x 15-25	FYM: 20-25 120:100:100	15-20 August	September-October
North-eastern hills	March-April	25-150	50-60 x 15-25	FYM: 20-25 100:120:60	15-20 August	September

*** To be utilized within state only and not for outside states/ export (Ref: The Gazette of India, Registered No. DL 33004/99, 15 October 2018)**

Annexure 3: Micronutrient deficiency symptoms in potato

Nutrient	Deficient symptom
Zinc (Zn)	Deficient plants show severe stunting and bronzing or yellowing of the foliage, usually around leaf margins, starting from tips. Zn deficiency in potato, often known as fern leaf or little leaf, first appears on young leaves. Youngest leaves are cupped upwards and rolled to such an extent that the terminal growth resembles ferns. Leaves of affected plants are smaller and their upper inter-nodes shorter.
Iron (Fe)	Its deficiency appears initially as yellowing of top young leaves. With time, the leaves become light yellow to nearly white. During Fe deficiency, blade tips remain green for a longer time. Netted green veination is seen when traces of iron are absorbed and translocated along the veins for chlorophyll formation. Green veination is actually a sign of iron recovery.
Manganese (Mn)	First sign of its deficiency is yellowing and slight cupping of younger leaves. Pinkish colour develops at the base of younger chlorotic leaves while relatively old leaves show dark to black spots. With increased deficiency, dark to black spotting develops between the veins with increased spotting, appearing along larger veins and the mid rib. The symptoms of darkening and cupping of leaves, increase in severity with time. Upon mild deficiency, upper parts of the plants become somewhat chlorotic but do not develop dead spots.
Copper (Cu)	An early sign of its deficiency is the development of a uniform, light green colour of young, immature leaf blades similar to those of molybdenum, manganese and iron deficiencies. Thereafter, it is primarily seen as pronounced upward cupping and inward rolling of the young, relatively large, leaf blades. This is in sharp contrast to the small, narrow leaf blades of zinc deficiency.
Boron (Bo)	Its deficiency causes the formation of a bushy plant with droopy leaves. Blades crinkle, cup upwards and are bordered by light brown tissue. Its deficiency, like calcium, affects the growing points. Immature centre leaves become deformed and growing point dies. In case of mild boron deficiency, slight upward curling of margins of older leaves is visible.
Molybdenum (Mo)	Symptoms of its deficiency are marked chlorosis, associated with reduction in growth and yield.

Annexure 4: Doses of micronutrient application for their deficiency correction in potato

Micro-nutrient	Soil application (kg/ha)	Spray application (g/100 l water)	Tuber soaking treatment (g/100 l water)
Zinc sulphate	25	200	50
Ferrous sulphate	50	300	75
Manganese sulphate	25	200	50
Copper sulphate	25	200	50
Ammonium molybdate	2	100	20
Sodium borate	2	100	20

Annexure 5: Recommended maximum concentration of trace elements in irrigation water[1]

Element	Maximum concentration[2] (mg/l)	Remarks
Aluminium (Al)	5.00	Can cause non-productivity in acid soils (pH<5.5). In alkaline soils (pH>7.0) ion will precipitate and toxicity will be eliminated.
Arsenic (As)	0.10	Toxicity to plants varies widely, ranging from 12 mg/l for Sudan grass to less than 0.05 mg/l for rice.
Beryllium (Be)	0.10	Toxicity to plants varies widely, ranging from 5 mg/l for kale to 0.5 mg/l for bush beans.
Cadmium (Cd)	0.01	Toxic to beans, beets and turnips at concentrations as low as 0.1 mg/l in nutrient solution. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Cobalt (Co)	0.05	Toxic to tomato plants at 0.1 mg/l in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Chromium (Cr)	0.10	Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on its toxicity to plants.
Copper (Cu)	0.20	Toxic to a number of plants at 0.1 to 1.0 mg/l in nutrient solution.
Fluoride (F)	1.00	Inactivated by neutral and alkaline soils.

Iron (Fe)	5.00	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings.
Lithium (Li)	2.50	Tolerated by most crops up to 5 mg/l and mobile in soil. Toxic to citrus at low concentrations (<0.075 mg/l). Acts similarly to boron
Manganese (Mn)	0.20	Toxic to a number of crops at a few-tenths to a few mg/l, but usually only in acid soils.
Molybdenum (Mo)	0.01	Not toxic to plants at normal concentrations in soil and water. Can be toxic to livestock, if forage is grown in soils with high concentrations of available molybdenum.
Nickel (Ni)	0.20	Toxic to a number of plants at 0.5 mg/l to 1.0 mg/l; reduced toxicity at neutral or alkaline pH.
Lead (Pb)	5.00	Can inhibit plant cell growth at very high concentrations.
Selenium (Se)	0.02	Toxic to plants at concentrations as low as 0.025 mg/l and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. An essential element to animals but in very low concentrations.
Titanium (Ti)	----	Effectively excluded by plants; specific tolerance unknown.
Vanadium (V)	0.10	Toxic to many plants at relatively low concentrations
Zinc (Zn)	2.00	Toxic to many plants at widely varying concentrations; reduced toxicity at pH > 6.0 and in fine textured or organic soils.

1 Adapted from National Academy of Sciences (1972) and Pratt (1972).

2 The maximum concentration is based on a water application rate which is consistent with good irrigation practices (10 000 m^3 per hectare per year). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates less than 10 000 m^3 per hectare per year. The values given are for water used on a continuous basis at one site.

Annexure 6: Laboratory determinations needed to be evaluated for common irrigation water quality problems (FAO, 1985)

Water parameter	Symbol	Unit[1]	Usual range in irrigation water
Salinity			
Electrical conductivity	ECw	dS/m	0- 3
Total dissolved solids	TDS	mg/1	0- 2000
Cations and anions			
Calcium	Ca^{++}	me/l	0- 20
Magnesium	Mg^{++}	me/l	0- 5
Sodium	Na^{+}	me/l	0- 40
Carbonate	CO_3^{--}	me/l	0- 1
Bicarbonate	HCO_3^{-}	me/l	0- 10
Chloride	Cl^{-}	me/l	0- 30
Sulphate	SO_4^{-}	me/l	0- 20
Nutrients [2]			
Nitrate-nitrogen	$NO_3^{-}N$	mg/l	0- 10
Ammonium-nitrogen	NH_4^{+} -N	mg/l	0- 5
Phosphate-phosphorus	PO_4^{--} - P	mg/l	0- 2
Potassium	K^{+}	mg/l	0- 2
Miscellaneous			
Boron	B	mg/l	0- 2
Acid/basicity	pH	1-14	6.0- 8.5
Sodium absorption ratio	SAR	$me(l)^{1/2}$	0- 15

1 dS/m= deci Siemen/metre in SI units (equivalent to 1 mmho/cm= 1 milli mho/ centimetre); mg/l= milligram per litre or parts per million (ppm); me/l= milli equivalent per litre (mg/l÷ equivalent weight= me/l) in SI units; 1 me/l= 1 milli mol/ litre adjusted for electron charge.

2 NO-N means the laboratory will analyse for NO but will report NO in terms of chemically equivalent nitrogen. Similarly, for NH- N, laboratory will analyse for NH, but report in terms of chemically equivalent elemental nitrogen. Total nitrogen available to plant will be the sum of equivalent elemental nitrogen. The same reporting method is used for phosphorus; SAR is calculated from Na, Ca and Mg reported in me/l.

Annexure 7: Drinking water quality as prescribed by Bureau of Indian Standards (BIS 105000, 2004-05)

Constituent	Maximum count	Unit
pH	6.5-8.5	
Total dissolved solids	500	mg/l
Electrical conductivity at 25 °C	-	micro mho/cm
Alkalinity as $CaCO_3$	200	mg/l
Total hardness as $CaCO_3$	300	mg/l
Calcium (Ca)	75	mg/l
Magnesium (Mg)	30	mg/l
Iron (Fe)	0.30	mg/l
Free Ammonia (NH_4)	-	mg/l
Chloride (Cl)	250	mg/l
Fluoride (F)	1	mg/l
Sulphate (SO_4)	200	mg/l
Nitrate (NO_3)	45	mg/l
Dissolved oxygen (DO)	6	mg/l
Biochemical oxygen demand (BOD)	2	mg/l
Arsenic (As)	0.01	mg/l
Boron (B)	0.30	mg/l
Cadmium (Cd)	0.003	mg/l
Chromium (Cr)	0.05	mg/l
Copper (Cu)	0.05	mg/l
Cyanide	0.05	mg/l
Lead (Pb)	0.01	mg/l
Manganese (Mn)	0.05	mg/l
Mercury (Hg)	0.001	mg/l
Zinc (Zn)	5	mg/l
Phenolic compounds (C_6H_5OH)	0.001	mg/l
Total hardness ($CaCO_3$)	300	mg/l
Sodium percentage	-	-
Sodium absorption ratio (SAR)	-	-

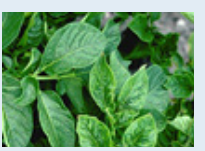
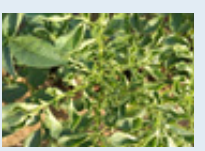
Annexure 8: Common weeds of potato

Scientific name	Common name	Local name
Weed flora of plains		
Amaranthis viridis L.	Pigweed	Jangali chaulai
Anagallis arvensis L.	Pimpernel	Krishn neel
Asphodelus tenuifolius Cavan	Wild onion	Piazi
Avena fatua L.	Wild oat	Jangali Jai
Chenopodium album L.	Lambs quarters	Bathua
Chenopodium murale L.	Goose foot	Kharthua
Cirsium arvense L. Scop.	Canada thistle	Kantaila
Convolvulus arvensis L.	Field bindweed	Hirankhuri
Coronopus didymus (L.) Sm.	Swine cress	Jangali halon
Cynodon dactylon (L.) Pers.	Bermuda grass	Dub
Cyperus iria L.	Yellow nutsedge	Motha
Cyperus rotundus L.	Purple nutsedge	Motha
Melilotus alba Desr.	White sweet clover	Safed senji
Melilotus indica L. All	Yellow sweet clover	Pilli senji
Oxalis corniculata L.	Indian sorrel	Khati-buti
Oxalis latifolia HBK	Wood sorrel	Khati-mithi ghas
Phalaris minor Retz.	Canary grass	Gulli-danda
Poa annua L.	Blue grass	Buin
Solanum nigrum L.	Black night shade	Makho
Sonchus oleraeeus L.	Sow thistle	Sow thistle
Setaria glauca L.Beauv.	Foxtails	Banra, Banari
Trianthema monogyna L.	Carpet weed	Patharchatta/Its chit
Vicia sativa L.	Common vetch	Ruari, Ankari
Weed flora of hills		
Amaranthus viridis L.	Pig weed	Jangali chaulai
Bindens pilosa L.	Begger's sticks	Dipmal
Chenopodium album L.	Common Lamb's quarters	Bathua
Chenopodium murale L.	Common Lamb's quarters	Kharthua
Commelina benghalensis L.	Tropical spider wort	Kanchara/Kanakaua
Cynodon dactylon L.Pers.	Bermuda grass	Dub
Digitaria sanguinalis L. Scop.	Crab grass	-
Echinochloa crusgalli (L.) Beauv	Bamyardgrass/ Watergrass	Savank
Melilotus indica L. All.	Annual yellow sweet Clover	Pili senji
Oxalis corniculata L.	Wood sorrel	Khati-buti
Pennisetum clandestinun	Kikuya grass	Kikuya grass
Polygonum species	Black bird weed	-
Rumex species		Jangali palak
Setaria glauca (L.) Beauv.	Foxtails	-
Spergula arvensis L.	Com spurry	Bundhania/Matkan

Annexure 9: Major herbicides recommended for potato weed management

Name of herbicide	Dose (kg or l a.i./ha)	Type of weed flora controlled	Characteristics /mode of action
Pre-planting			
Fluchloralin	0.70-1.00	Annual grasses and broad leaf weeds	Systemic, selective, soil applied, absorbed by roots
Pendimethalin	1.00	Annual grasses and broad leaf weeds	Systemic, selective, soil applied, absorbed by roots
Pre-emergence			
Atrazine	0.50	Annual grasses and broad leaf weeds	Systemic, selective, soil applied, absorbed by roots
Isoproturon	0.50	Broad leaf weeds	Systemic, selective, soil active
Methabenzthiazuron	1.00	Annual grasses and broad leaf weeds	Selective, absorbed by roots, persists throughout potato crop growth
Metribuzin	0.75-1.00	Annual grasses and broad leaf weeds	Selective, root and shoot mobile, soil residual activity upto 6-12 months
Oxyfluorfen	0.10-0.20	Annual grasses and broad leaf weeds	Selective, absorbed by roots and shoots but translocation is very limited
2, 4-D	0.50	Broad leaf weeds	Selective, translocated, absorbed by roots and shoots
Post-emergence			
Paraquat	0.40-0.60	Annual grasses and broad leaf weeds	Contact, non-selective, absorption by leaves

Annexure 10: Potato viruses and their symptoms

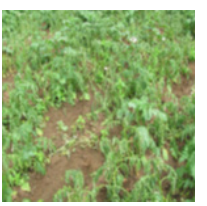
Name of virus	Symptoms	Depiction of symptoms
Potato virus X (PVX) Mechanical/contact	Mild to moderately severe perceptible mottling of leaves with light to dark green patches interspersed with normal green colour; sometime stunted plant growth with chlorosis; latent in many varieties	
Potato virus S (PVS) (Contact as well as non-persistently by aphids)	Mild imperceptible mottling of leaves with light green patches interspersed with veinal green colour, usually latent	
Potato virus M (PVM) (Contact as well as non-persistently by aphids)	Mild mosaic/mottling of young leaves and upward rolling of upper leaves with wavy margins, slight leaf chlorosis.	
Potato virus A (PVA) (Non- persistently by aphids)	Mosaic faint mottling, sometimes leaf distortions, top necrosis in some varieties, rarely rugosity, shiny leaves	
Potato virus Y (PVY) (Non- persistently by aphids)	Mottling of leaves with light to dark green patches interspersed with normal green colour and severe mosaic; production of necrotic spots and veinal necrosis followed by leaf drop streaks. rugosity, twisting of leaves with slight inter-veinal cuppings	
Potato apical leaf curl virus (PALCV) (White-fly transmitted)	Potato plant shows curling of apical leaves, crinkling and a clear mosaic symptom; later entire plant appears bushy and stunted due to reduced inter-nodal distance	
Potato acuba mosaic virus (Aphid transmitted)	Symptoms are observed in old varieties, bright yellow spots/ patches on old leaves; stunting of the plants	

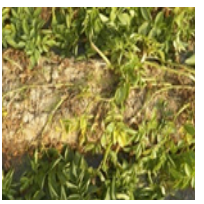
Rugose mosaic (X+Y)	It is due to combined infection of viruses X and Y; plants show severe mosaic and rugosity of leaves and stunted plant growth; leaves curl upward while lower leaves show yellowness and necrosis	
Crinkle (X+A)	Caused by combined infection of viruses X and A with heavy blotching of infected leaves which get distorted with wavy margins and the leave lamina shows complete crinkling	
Potato leaf roll virus (Persistently by aphids)	Varying degree of rolling is observed; lower leaves roll first followed by upper ones; lower leaves become leathery with bronze margins and on pressing, between fingers they give rustling sound, stiffness of older leaves	
Potato stem necrosis virus (PSNV) (transmitted by thrips)	Necrosis of petiole, veins and stems at high temperatures; stem losses turgidity and becomes brittle; apical necrosis progress downward as browning and drying of foliage; later on juvenile plants wither and wilt	
Potato spindle tuber viroid (PSTVd) (transmitted by TPS/ aphids/contact)	Shortening of petioles which are sub tended at 45° angle, chlorotic with stunted growth, leaflets twisted and tubers become spindle shaped with prominent eye brows	

Annexure 11: Transmission of potato viruses

Virus	Transmission
Potato Virus S (PVS)	Contact
Potato Virus X (PVX)	Contact
Potato Virus A (PVA)	Aphids/Mechanical
Potato Virus M (PVM)	Contact/Aphids
Potato Virus Y (PVY)	Aphids
Potato Leaf Roll Virus (PLRV)	Aphids
Potato Apical Leaf Curl Virus	Whiteflies
Stem Necrosis	Thrips

Annexure 12: Common diseases in potato with their symptoms

Diseases	Symptoms	Depiction of symptoms
Foliar Diseases		
Late blight (*Phytophthora infestans*)	The water soaked patches with whitish cottony growth along the lesion margins on the underside of leaflets in the early morning hours; surface of the tubers has hard depressions with purplish ting on the sides; rusty brown discolouration of the flesh is main symptom	
Early blight (*Alternaria solani*)	Brown to black, oval, large and circular spots with concentric rings	
Phoma leaf spot (*Phoma exigua*)	Small spots are brown to black, oval to irregular with variable size	
Cercospora leaf spot (*Cercospora solani tuberosi*)	Small chlorotic spots on the upper surface of leaves and a violet mildew on lower surface	
Wilts		
Fusarium wilt (*Fusarium* spp.)	Yellowing of margins of lower leaves followed by entire foliage, wilting of few stems followed by entire plant	
Bacterial wilt and brown rot (*Ralstonia solanacearum*)	Dropping and rolling of leaves before wilting, succulent portion of plant becomes flaccid and droops; wilting becomes permanent; a distinct brown discoloration in the vascular rings of cut tuber with slimy bacterial ooze	

Sclerotium wilt (*Sclerotium rolfsii*)	Light yellowing, dropping and stunting of juvenile plants; collar region of the stem infected with white mycelium which later on converted into brown mustard like sclerotia; entire plants wilted and topple	
Sclerotinia wilt (*Sclerotinia sclerotiorum*)	At initial stage water soaked lesions are formed on stem base/junction of leaf petiole, which later showed as bleached symptom at the base of the stems and subsequently symptoms spread on whole stem leading to stem rot.	
Tuber borne diseases		
Charcoal rot (*Macrophomina phaseolina*)	A high temperature disease at harvest; tubers show black areas around the eyes and lenticels, flesh show black patches	
Wart (*Synchytricum endobioticum*)	Prominent wart like outgrowth on the tubers which resemble cauliflower	
Common scab (*Streptomyces* spp)	Small radish or brownish spots on tuber surface, spots enlarge into circular or irregular lesions with sunken corky spot or pitted lesions having deep star shaped cracks or russetting of tuber surface	
Powdery scab (*Spongospora subterranea*)	Small coloured blisters like pimples on tuber surface, pustules become dark and epidermis ruptures releasing brown powdery spore mass	

Black scurf (*Rhizoctonia solani*)	Chocolate coloured, crusty scurf like irregular sclerotial mass on the surface of the tubers	
Dry rot (*Fusarium* spp)	Small sunken circular, oval or irregular brown lesions, flesh shows light brown discolouration and white cottony fungal growth	
Soft rot (*Pectobacterium spp (Earlier Erwinia spp*)	Water socked lesions on tuber, tissue turns soft and pulpy/slimy, surface discolours with wrinkles and depressions	
Pink rot (*Phytophthora erythroseptica*)	Blackening around lenticels and eyes, discolouration of flesh when cut and turns pink after exposure to air within few minutes and later on turns black	

Annexure 13: Phytoplasma diseases and their symptoms in potato

Phytoplasma Diseases	Symptoms
Marginal flavescence (Transmitted by leaf hopper)	Marginal chlorosis of the top leaflets, puckering and slightly rough and thick stunted growth, profuse rooting few tubers at the base of the stem
Purple top roll (Transmitted by leaf hopper)	Rolling of the basal part of the top leaflets accompanied by purple pigmentation, short internodes and swelling of nodes, numerous auxiliary branches
Witch's broom (Transmitted by leaf hopper)	Numerous thin stems with simple leaves giving an appearance of 'broom'
Potato phyllody (Transmitted by leaf hopper)	Petals become green giving a phyllody appearance

Annexure 14: Biological and chemical control measures for major potato pests

Pest	Season of occurrence	Distribution	Host range	Biological control	Chemical control
SAP FEEDERS OR SUCKING PESTS					
Aphids	Northern Plain: November - April	Punjab, UP and Potato growing regions of India	Peach (primary host), asparagus, cotton, cabbage, cauliflower, mustard, solanaceous, cruciferous crops and some weed	Predators: *Allograpta favana* (Wiedemnn), *Episyerphus balteatus* (De Geer), *Ischiodon scutellaris* (Fabricius), *S. Scripta* (Linnaeus) , *Sphaerophoria indiana* Bigot; *Leucopis fumidilarva* Tanas, *Menochilus sexmaculatus* (Fabricus) Parasitoids: *Aphelinus* sp. and *Aphidius colemani* Viereck Parasitize: *Aphelinus* sp (under glass houses conditions at Shimla)	Hills: Oxy- demeton methyl 25EC 1.2 ml/l, (Avoid granular insecticide) Plains: Oxy- demeton methyl 25EC 1.2 ml/l, imidacloprid 200 SL @ 0.03 % and mineral oil @ 1-3 %
White flies	General: Sept-October & March Plaine: Nov-December	All potato growing regions of India	Solanaceous, okra, cotton, tobacco, cucurbits and some weed	Parasitoids: Big-eyed bug (*Geocoris* sp.), minute pirate bug (*Oriussp.*), *Eretmocerus massi* and *Encarsia* sp. Predator: *Chysoperla carnea.*	Seed treatment: Imidacloprid 200 SL @ 0.04% 10 minute before planting Foliar spray Imidacloprid 200 SL @ 0.03% at crop emergence, 2nd spray with thiamethoxam (25WG) @ 0.05% after 15 days of first spray; or spiromesifen 240SC @ 96g a.i. ha at emergence, 2nd spray with thiamethoxam (25WG) @ (100g ai) after 15 days of first spray
Leaf hoppers	September to March	Karnataka, Maharashtra, Gujarat, Punjab, Haryana and UP	Solanaceous, cowpea, celery, okra peanuts, woody ornamental, apples, grape, castor and alfalfa	-	Table purpose may be protected with higher dose of N 200 kg/ha followed by 1 spray of azadirechtin @ 0.4%, oxy-dementon methyl 25 EC @ 1 ml/l or foliar spray Imidacloprid 200 SL @ 0.03%
Mites	Plains: Sept - October Spring crop: December Kharif: Early August Rabi: February -March	*Kharif*: Karnataka, MP (Gwalior) & Maharashtra *Rabi*: Western UP & Punjab Hills: Kangra valley (HP)	Solanaceous, cotton, sesame, beans, mango, tea, apple, citrus, coffee, grapes, guava, jute, papaya & pear		Table purpose may be protected with higher dose of N 200 kg/ha followed by 1 spray of azadirechtin @ 0.4%, dicofol 18.5 EC or quinophos 25EC @ 2 lit/ha or wettable sulphur @ 2.5 kg/ha. mancozeb (80 WP) or micronized wettable sulphur (80 WP) @ 2.0 kg and 2.5 kg/ha

FOLIAGE FEEDERS OR DEFOLIATORS					
Lepidop-terans	Plains: Last week of Nov to mid of December. Hills: June-July (In polyhouse & glasshouse)	Jalandhar, Modipuram and Shimla	Cotton, groundnut, castor, chillies, tomato, potato, sweet potato, pigeon pea, maize, millets, pulses & other vegetables.	Egg parasitoid: *Trichogramma brasiliensis* @ 250000 /ha	Cypermethrin 25EC @ 0.30 ml or deltamethrin 2.8EC @ 0.1ml/l of water, chlorpyrifos 20 EC is recommended @ 2 ml/l
Beetles/ Weevils and their young ones	September-October	-	-	Egg parasitoid: *Tetrastichus ovulorum* Chalcid parasitoid: *Ugnamenoni Kerrich* and *Pediobius foveolatus* The parasitisation of *H. vigintioctopunctata* in the field by *P. foveolatus* Crawford has been reported to be as high as 77%	Chlorpyrifos 20 EC is recommended @ 2 ml/l at earthing upfollowed by one spray each with azadirechtin @ 0.4% and imidacloprid 200 SL @ 0.03%
SOIL PESTS					
Cut worms	Plains: October - April Hills: April (During summer) More damage during May	More serious in northern region than in south	Pulses, vegetables, cereals, oilseeds and some weeds (Polyphagous)	Parasitises: *Broscus punctatus* Dist and *Liogryllus bimaculatus* Linn (for cutworms' larvae) Parasitise: *Macrocentrus collaris* (Spin), *Netelia ocellaris* (Thomson), *Coelichneumon* sp. Nrtruncatulus Thomson , *Periscepsia carbonaria* Panzer and *Turanogonia chinensis* Wiedemann	Chlorpyrifos 20 EC is recommended at 2 ml/l
White grub	Plains & Hills: May - June (1st shower of rain) Peck activity of grubs: September-October	All potato growing regions of India	Polyphagous, damage almost all the vegetable crops, pulses, oilseeds, cereals, millets, potato, tobacco, sorghum, groundnut, maize, soybean, chillies, ornamental plants, forest nurseries etc.	Bio-control agents: Scoliids, *Campsomeris collaris* F, *Scoliaureipennis lepeletier* and *S. pustulata* Magr. pathogen:*Bacillus papillae* Dutky, *Metarrhizium anisopliae* (Metch.), *Beauveria brongniartii* (Sacc.) Petch, Isyr. and *B. tenella* (Del.)	Carbofuran 3G 25-30 kg/ha at earhing up or spray of chlorpyrifos 20 EC or quinalphos 25 EC@ 2-2.5 ml/l at after earthing up

STORAGE PEST					
Potato tuber moth (PTM)	September - March	Maharashtra (Pune), Bihar, MP (Chhindwara), HP (Kangra Valley), UK (Kumaon Hills), JH (Ranchi), WB, TN (Nilgiris) North Eastern hills, Plateau region and Karnataka	Solanaceous plants like, brinjal, tobacco, tomato, potato & datura	Bioagents: Parasitoids: *Chelonus curvimaculatus* Cameron, *Bracon gelechiae* Asheamd, *Apanteles* sp., *Orgilus jennieae* , *Apanteles subandinus*, *Pristomerus vulnerator* Panzer Egg/larval parasitoid: *Copidosoma koehleri* Blanchard	In stores use 2-2.5 cm thick layer of dried lantana or eucalyptus or neem leaves below and at top of the potato heaps, spraying the crop with Bt (109cfu/ml) @ 3ml or GV @ 4 LE/l of water, quinalphos @ 0.375 kg or acephate @ 0.5 kg a.i./ha, CIPC (Isopropyl N- (3-chlorophenyl) carbamate) @ 40-60 ml/t, seed potatoes dusting with cypermethrin dust @500 g/ton & fenvalerate 2%, malathion 5% or quinalphos 1.5% dusts @ 125 g dust/100kg potato
NEMATODES					
Root knot nema todes (RKN's)	-	*Meloidogyne arenaria*- Plains (UP); *M. hapla* – Hills (UP, HP, J&K & TN); *M. incognita*- Certain pockets in hills and plains; *M. javanica*- Mid hills and plains of India	Polyphagous	Biotic agents: Such as fungi, bacteria, predacious nematodes, protozoan	Two equal splits *i.e.* half at planting and remaining half at earthing time: Carbofuran @ 3 kg a.i./ha or aldicarb @ 2 kg a.i./ha or ethoprop @ 10 kg/ha
Potato cyst nema tode (PCN)	-	Nillgiris hills and Kodaikanal hills	Solanaceous plants, e.g. potato, tomato, eggplant and solanaceous weeds such as bittersweet (*Solanum dulcamar*)	Bio-agent: *P. lilacinus* *In vitro* parasitization of eggs by these fungi: *Dactylaria* sp. (82.4%) followed by *Penicilium* sp. (80.6%) , Aspergillus sp. (68%) and *Humicolagrisea* (60%)	Two equal splits *i.e.* half at planting and remaining half at earthing time: Furadan 3G @75 kg/ha
Snail (Helix species) and slugs (*Anadenus altivagus*)					
Snail and slugs					Metaldehyde 5% pellets (bait) in the field. It can be broadcasted on ridges@15 kg/ha once or twice

Annexure 15: Economic threshold level (ETL) of different potato pest

Insect species	Initiation of control measures	ETL
Aphid	2 aphids/100 leaves	20 aphids/ 100 compound leaves
Whiteflies	2-3/plant	9-11 adults/plant
Leafhopper	1-2 adult	5-10 adults/plant
Defoliators (lepidopterans)	2 larvae/ 10 plant	1-2 larvae/ plant
Cutworms	2% plant damage	1-2 larvae/ 10 plants
White grub	With the appearance of 2 or more beetles in light traps or with the emergence of beetles with the onset of monsoon	2 grubs per square feet
Pototo tuber moth	1 larvae/ 2 plants (in field)	10-20 adults/trap/day and 2 or more holes/ tuber in stores
	1 hole per tuber (in stores)	
Root knot nematode	At the time of planting	More than 20 larva/ 200 ml of soil

Annexure 16: Common physiological disorders in potato

Disorder	Pictorial view	Cause	Control / management
Tuber surface disorders			
Growth cracks		Usually associated with irregular moisture levels and rapid water uptake. Such conditions occur when irrigation follows a long dry period or during short periods of heat stress	Ensure proper irrigation, avoid over fertilization
Star cracking		Caused by internal pressure during tuber enlargement but the cracking is limited to surface end. The use of fertilizers can also cause cracks because of excessively rapid growth induced in tubers	Avoid over fertilization, ensure optimum irrigation for an even development of tubers
Russeting		Influenced by soil type and conditions Generally, in coarse-textured soils and dry soil conditions	Ensure proper irrigation, avoid susceptible varieties in coarse textured soil

Feathering		Loose skin hang in shreds due to harvesting of immature tubers, rough handling during harvest or post-harvest	Optimizing irrigation and allowing a sufficient interval from haulm destruction to harvest; Careful harvesting and handling to minimize surface damage; A good tuber skin set will ensure that tubers resist damage
Secondary growth			
Extension of rose end/ Dumbbell		Result of irregular growth, particularly if a period of warm, dry weather is followed by rainfall; Re-growth of the meristematic tissue at the rose end to produce an elongated, dumbbell shaped tuber; Starchy food reserves for new growth are drawn from original tissue	Adequate supply of water throughout crop growth period; Adoption of modern methods of irrigation
Develop-ment of knob- like structures from eyes		Result of irregular growth, particularly if a period of warm, dry weather is followed by rainfall. Genotypic response and variability	Can be controlled by an adequate supply of water throughout crop growth period; Selection of suitable genotype for such conditions
Secondary metabolites			
Tuber greening		When tubers are exposed to light due to cracks in soil or fast tuber growth, Glycoalkaloids (solanine and chaconine) under skin accumulates depending upon duration and intensity of light exposure, environmental conditions, cultivar and physiological age of tuber	Keep soil moist to prevent formation of soil cracks; Mulching prevents soil cracks and reduce evaporation from soil, thus preventing extensive crack development

Annexure 17: Grade designation and definition of quality of table potatoes (oval or long varieties*)

(Reference: https://dmi.gov.in/ComProfiles.aspx (Directorate of Marketing and Inspection, Ministry of Agriculture and Farmer's Welfare, Government of India, New Delhi)

Grade designation	General	Applicable to single tuber's size (min. diameter in mm)	Definition of quality applicable to quantities				
			Conformity to variety etc.	Tolerance			
				Under size or over-size	Disease and damage etc.	Earth and extraneous matter	Maximum aggregate of all defects
Extra special	Reasonably clean, healthy potatoes, free from serious defects and suitable for human consumption	41	At least 95% by weight must conform to the variety	Not more than 2% of total weight may pass through sieve having circular holes with a diameter of minimum specified size specified for grade included in this not more that 0.5% of total weight may pass through 25 mm mesh	Not more than 2% of total weight may consist of appreciably diseased, damaged or unsightly potatoes	Not more than 2% may be total present (percentage to be calculated on net weight of screened potatoes)	4% of total weight
Special	Reasonably clean, healthy potatoes, free from serious defects and suitable for human consumption	29	At least 95% by weight must conform to the variety	Not more than 2% of total weight may pass through sieve having circular holes with a diameter of the minimum specified size specified for the grade included in this not more that 0.5% of total weight may pass through a 25 mm mesh	Not more than 2% of total weight may consist of appreciably diseased, damage or unsightly potatoes	Not more than 2% may be total present (percentage to be calculated on net weight of screened potatoes)	4% of total weight

*When tubers passed over a riddle of greater mesh than 41 mm the minimum size may at the seller's discretion be appended to grade name e.g. 'Extra Special (51, 57, 64 mm etc.)' but potatoes which exceed 89 mm in their smallest diameter shall be excluded from grading.

Annexure 18: Grade designations and definition of quality of table potatoes (round varieties*)

(Reference: https://dmi.gov.in/ComProfiles.aspx (Directorate of Marketing and Inspection, Ministry of Agriculture and Farmer's Welfare, Government of India, New Delhi)

Grade designation	General	Applicable to single tuber's size (Min. diameter in mm)	Definition of quality applicable to quantities				
			Conformity to variety etc.	Tolerance			
				Under size or over-size	Disease and damage etc.	Earth and extraneous matter	Maximum aggregate of all defects
Extra special	Reasonably clean, healthy potatoes, free from serious defects and suitable for human consumption	45	At least 95% by weight must conform to the variety	Not more than 2% of total weight may pass through sieve having circular holes with a diameter of the minimum specified size for grade included in this not more that 0.5% of total weight may pass through a 25 mm mesh	Not more than 2% of total weight may consist of appreciably disease, damaged or unsightly potatoes	Not more than 2% may be total present (percentage to be calculated on net weight of screened potatoes)	4% of total weight
Special	Reasonably clean, healthy potatoes, free from serious defects and suitable for human consumption	32	At least 95% by weight must conform to the variety	Not more than 2% of total weight may pass through sieve having circular holes with a diameter of the minimum specified size specified for the grade included in this not more that 0.5% of total weight may pass through a 25 mm mesh	Not more than 2% of total weight may consist of appreciably diseased, damage or unsightly potatoes	Not more than 2% may be total present (percentage to be calculated on net weight of screened potatoes)	4% of total weight

*When tubers passed over a riddle of greater mesh than 45 mm the minimum size may at the seller's discretion be appended to the grade name, e.g. 'Extra Special (51, 57, 64 mm etc.)' but potatoes which exceed 83 mm in their smallest diameter shall be excluded from grading.

Annexure 19: Maximum residue limit (MRL) for potato

(Source: Food safety and standards (contaminants, toxins and residues) amendment regulations, 2017, Ministry of Health and Family Welfare)

S. No.	Chemical	MRL in mg/kg	Codex (mg/kg)
1	2,4-Dichlorophenoxy acetic acid	0.2	
2	Ametroctradin	0.05	
3	Azoxystrobin	7.0	7.0
5	Carbendazim	0.01*	
6	Chlormequat chloride	0.1	
7	Chlorothalonil	0.1	0.3
8	Chlorpropham	30	
9	Chlorpyriphos	2.0	2.0
10	Copper hydroxide	0.1*	
11	Copper oxychloride (determined as Copper)	1.0	
12	Cuprous oxide	0.01**	
13	Cyazofamid	0.02*	
14	Cymoxanil	0.01	
15	Dimethomorph	0.05	0.05
16	Dithiocarbamates (Residue tolerance limit are determined and expressed as mg/CS_2/kg and refer separately to the residues arising from any or each group of dithiocarbamates)	0.2	0.2
	a. metiram as CS_2	0.2	0.2
17	Famoxadone	0.05	
18	Fenamidone	0.01	0.02
19	Fluchloralin	0.01**	
20	Hexaconazole	0.02	
21	Imidacloprid	-	0.5
24	Mandipropamid	0.05*	
25	Mepiquat chloride	0.1	
26	Metalaxyl-M	0.05*	0.05
27	Metribuzin	0.05*	
28	Oxyfluorfen	0.01	
29	Oxymentho methyl	-	0.01
30	Paraquat dichloride (determined as Paraquatcations)		
31	Phosalone	0.1	

32	Propineb	0.5	
33	Pyraclostrobin	0.05*	
34	Qninalphos	0.01**	
35	Thiamethoxam	0.01	0.3

* Maximum residue limit fixed at limit of quantification (LOQ)

** Insecticides are registered under the Insecticide Act, 1968 (46 of 1968) but label claim for the said commodity are not fixed hence maximum residue limit fixed at LOQ

Note- All these maximum residue limit/tolerance limit values are provisional for a period of five years and not fixed on the basis of actual data in the Indian context. They may be reviewed after five years or as and when the relevant scientific data is made available to Food Safety and Standard Authority of India, whichever is earlier.

Annexure 20: List of notified referral laboratories for chemical residue estimation in India

(Source:https://www.fssai.gov.in/home/food-testing/Food-Laboratories/Notified-Laboratories.html)

Table 1: State level laboratory		
S. No.	**Name of referral food laboratory**	**Local areas or states or union territories**
1	Director, Central Food Laboratory, 3 Kyd Street, Kolkata - 700016	West Bengal, Orissa, Bihar, Jharkhand, Assam, Arunachal Pradesh, Chhattisgarh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Union Territories of Andaman and Nicobar Island
	Director, Food Research and Standardization Laboratory, Ahinsa Khand-II, Indirapuram, Ghaziabad-201014.	
2	Director, Food Safety and Analytical Quality Control Laboratory, C/o. Central Food Technological Research Institute, Mysore-570013.	Andhra Pradesh, Karnataka, Kerala Tamil Nadu, Telangana, Puducherry and Lakshadweep
	Director, State Public Health Laboratory, Stavely Road, Cantonment Water Works Compound, Pune-411 001.	
3	Director, State Public Health Laboratory, Stavely Road, Cantonment Water Works Compound, Pune-411 001.	Gujarat, Maharashtra, Madhya Pradesh, Rajasthan, Dadar and Nagar Haveli, , Goa and Daman and Diu
	Director, Food Safety and Analytical Quality Control Laboratory, C/o. Central Food Technological Research Institute, Mysore-570013	

4	Director, Food Research and Standardization Laboratory, Ahinsa Khand-II, Indirapuram, Ghaziabad-201014.	Delhi, Haryana, Himachal Pradesh, Punjab, Union Territory of Chandigarh, Uttar Pradesh, Uttarakhand and Jammu
	Director, & Kashmir Central Food Laboratory, 3 Kyd Street, Kolkata 700016.	
Table 2: Commodity wise		
S. No.	**Name of referral food laboratory**	**All over India as per scope of testing defined hereunder**
5	Director, Indian Institute of Horticultural Research, Hessaraghatta lake post, Bengaluru - 560 089.	Pesticide residue analysis of fruits and vegetables, cereals and pulses, water, spices (curry leaves), nutritional, proximate and microbiological analysis of fresh and processed food products
6	Director, Indian Institute of Vegetable Research, Post Bag No. 01; P.O. Jakhini, (Shahanshahpur), Varanasi- 221 305.	Analysis of pesticide residue, heavy metals, microbial contaminations, mycotoxins, antibiotics, disinfectants, colouring agents, adulterants, food additives, phytohaemagglutinin, allergens etc. in vegetables
7	Director, Quality Evaluation Laboratory, Spices Board, Palarivattom P.O., Kochi – 682025.	Analysis of chemical contaminants (pesticide residues, heavy metals, illegal dyes and any other chemical contaminant), mycotoxins (aflatoxins, ochratoxin etc.), microbial contaminants, physical contaminants and adulterants in spices
8	Director, Quality Evaluation Laboratory, Spices Board, Chuttugunta Center, GT Road, Guntur- 522004.	-do -
9	Director, Quality Evaluation Laboratory, Spices Board, Plot No. R-11, Sipcot Industrial Complex, Gummidipoondi, Thiruvallur District, Chennai – 601201.	-do-
10	Director, Quality Evaluation Laboratory, Spices Board, First Floor, Banking Complex II, Sector 19A, Vashi, Navi Mumbai – 400703.	-do-

11	Director, Council of Scientific and Industrial Research - Indian Institute of Chemical Technology, Uppal Road, Tarnaka, Hyderabad – 500007.	Analysis of moisture, hexane insoluble matter, acid value, unsaponifiable matter, iodine value, saponification value, allyl isothiocyanate, Reichert Meissl value, peroxide value, fatty acid composition, presence of animal body fat in the vegetable fat, cold test, test for physical properties, nickel in vanaspati, phosphorous in soybean oil, presence rancidity, soluble colors, presence of beef fat, phospholipids, tocopherol, trans fatty acid determination, pesticide residues, heavy metal analysis in fats and oils.
12	Director, Indian Institute of Crop Processing Technology, Food Safety and Quality Testing Laboratory, Pudukkottai Road, Thanjavur – 613005, Tamil Nadu.	Nutritional, proximate and microbiological analysis of fresh and processed food products; packaged drinking water analysis; Analysis of pesticide residues, heavy metals and microbiological analysis of cereals and cereal products and spices
13	Director, Indian Institute of Integrative Medicine, Council of Scientific & Industrial Research, Canal Road, Jammu-Tawi-180001.	Analysis of aflatoxins, free fatty acids, peroxide value, iodine value, pesticide residues, metals & other soluble residues in nuts; Presence of moisture content, specific gravity, reducing sugar, fructose-glucose ratio, acidity, ash content, analysis of heavy metals, pesticide residues in honey; Analysis of aflatoxins, energy organics, vitamins, total fatty acids, total saturated fatty & unsaturated fatty acids, pesticide residues & heavy metals in nutraceuticals.

Note: Apart from this list, APEDA, Bureau of Indian Standards (BIS), FSSAI, CIB has approved various laboratory for chemical residue estimation. Visit respective website for most recent list of approved labs for residue estimation.

Annexure 21: Soil and water quality testing laboratories

S. No.	Laboratory
1.	State and district wise soil testing laboratories can be located from website: https://soilhealth.dac.gov.in/PublicReports/STL
2.	ICAR institutes
3.	State agricultural universities
4.	*Krishi Vigyan Kendras*
5.	Soil and water quality testing laboratories situated at district levels

Annexure 22: List of certification agencies for IndGAP

Agency	Contact details
APPROVED CERTIFICATION BODIES	
TQ cert Services Private Limited (Formerly Food cert of India)	Mr. P S Naidu 6th Floor, Splendid Towers, H. No:1-8- 364,438,445, SP Road, Begumpet, Hyderabad-50016, Telangana, India. psnaidu@tqcert.in www.foodcert.in +040 67258825 / 9246276352
PROVISIONALLY APPROVED CERTIFICATION BODIES	
Indian Council of Food and Agriculture	Mr. Sudhanshu Arya, 214-217, B - Block, Naurang House, K G Marg, New Delhi - 110001 certification@icfa.org.in http://www.icfa.org.in 011-41501465 / +91 8860853531
Weltweit Certification Pvt Ltd	Mr. Dinesh K Menon, Flat no. 1, Sanskruti Apartment SR no. 106, Kalanagar, Indira Nagar, Nashik 422009 info@weltweit.co.in www.weltweit.co.in +91 9539065116

(Source: https://www.qcin.org/india-good-agriculture-practices.php dated on 27 MArch,2019)

Annexure 23 : BasicGAP: CHECKLIST FOR SELF-ASSESSMENT

Critical- 95% compliance of all applicable critical control points
Major - 85% compliance of all major control points is compulsory
Minor - 70% compliance of all applicable minor control points is compulsory

Cl. No.	Item	Parameter/control point	Level	Compliance		Remarks
				Yes	No	
1	**SITE SELECTION**					
1.1	Risk assessment for new site	Is the farm free from toxic elements such as industrial wastes and effluents?	Major			
1.2	Water availability	Is the farm having access to reliable source of irrigation water, if irrigation is required?	Major			
1.3	Risk management plan	Has a management plan been developed for setting out strategies to minimize all identified risks? Are the results of this analysis recorded and used to justify that the site in question is suitable?	Major			
1.4	Meteorological data collection	Has the meteorological data collated for preceding three years taken into account while judging the suitability of the farm ?	Minor			
2	**SOIL CONDITIONS/MANAGEMENT**					
2.1	Mapping of soil	Has the soil map prepared for the farm?	Major			
2.2	Soil health	Is the soil optimal for the potato cultivation with reference to its water holding capacity and fertility?	Major			
2.3	Soil test and nutrition profile	Are the soils with low fertility levels use soil amendments as per the specific site and requirement of species? Are the latest soil test report on physico-chemical parameters and nutrient profile to decide the nature and quantity of soil amendments available?	Major			
2.4	Water suitability	Has the quality of irrigation water been adequately understood and classified in the context of both soil type and potato crop in terms of total salt concentration, sodium absorption ratio, bicarbonate and boron concentration etc.?	Major			

2.5	Water quality	Irrigation water is required to conform to standards of heavy metals and residual pesticides?	Major			
3	**SEED AND PROPAGATION MATERIAL**					
3.1	Planting material identification	Do the potato seed tubers accompany with the following information? name, variety, purity etc.?	Critical			
3.2	Sowing record keeping	Does the producer keep records on sowing methods, seed rate, sowing date?	Major			
3.3	**Seed**					
3.3.1	Seed purity	Does the seeds chosen for cultivation purposes meet the botanical and varietal purity?	Critical			
3.3.2	Seed quality	Are the seeds chosen for cultivation purposes physically free from pests, diseases, weeds, and foreign and inert matter?	Critical			
3.3.3	Seed producing record	Does the producer keep records on sowing/ planting methods, seed/planting rate, sowing /planting date?	Major			
3.3.4	Seed treatment protocol	Are prescribed seed treatment protocols for the potato crop, completed well in advance to match the planting season?	Major			
4.	**POTATO CROP MANAGEMENT FOR CULTIVATION**					
4.1	**Field preparation**					
4.1.1	Soil tilth	Is soil brought to the desired tilth to facilitate favorable environment for growing potatoes?	Major			
4.1.2	Soil preparation	Do field operations performed provide better environment, soil structure and texture for potato cultivation and keep it free from weeds for initial 20-30 days?	Major			
4.2	**Planting**					
4.2.1	Seed rate	Are recommended rate of seed tubers per unit of land area adhered to?	Minor			
4.2.2	Seed planting depth	Is placement of seed tubers taking place at the appropriate depth in the moist zone of the soil?	Major			
4.2.3	Spacing	Whether the replenishment of potato plant populations to compensate mortality losses was carried out within a reasonable timeframe and in consideration of the gestation period potato crop ?	Minor			

4.2.5	Plant Population	Is replenishment of plant population carried out within reasonable time frame to compensate mortality losses ?	Minor			
4.2.6	Seed quality document	Is there a document that guarantees potato seed tubers quality (free from injurious pests, diseases, virus, etc.)?	Minor			
4.3	**Manures and fertilizers**					
4.3.1	Sources of manures/fertilizers	Is the source of information/material about manures and fertilizers used is available? Are the parameters used to accept or qualify the manure listed in case source is from outside?	Major			
4.3.2	Organic manures preferences	Is the use of organic manure preferred for growing plants supplemented by mineral nutrition through inorganic source in consideration of the nutritional needs potato crop vis-à-vis the soil characteristics?	Minor			
4.3.3	Manure use	Is the use of compost, vermi-compost, green leafy manure and bio-fertilizers considered desirable?	Minor			
4.3.4	Nutritional care	Are the specialized nutritional care for distinct purposes such as root production or enhancement of leafy bio-mass etc opted for in the light of recommended agronomic practices for potato?	Major			
4.4	**Irrigation**					
4.4.1	Water requirement estimation	How is the total water requirement of the potato crop estimated in the context of available agronomic protocol? Whether the irrigation cycles is planned for and implemented to ensure optimal plant growth?	Major			
4.4.2	Water optimization	Is there a water management plan to optimize water usage and reduce waste in terms of method of irrigation?	Major			
4.4.3	Water harvesting and conservation	How water harvesting and water conservation methods are followed, wherever possible?	Minor			
4.4.4	Water testing	Is the quality of water considered in the context of prevailing soil conditions and soil and water analysis taken into account for this purpose?	Major			
4.4.5	Water drainage	How soils having the problem of drainage are dealt with in specific manner so as to provide outlet for excess water?	Major			

4.5	**Weeding and intercultural operations**					
4.5.1	Control of initial flush of weeds	How initial flush of weeds are controlled effectively to ensure a weed free environment to young potato plants?	Major			
4.5.2	Inter culture operations optimization	Is the recommended schedule of all inter-cultural operations such as weeding, hoeing and earthing up etc followed?	Major			
4.5.3	Rare use of herbicides	Is the use of herbicides avoided as far as possible? In case of their inevitable usage, whether theavailable evidence of safety to the potato crop is considered adequately?	Major			
4.6	**Crop protection**					
4.6.1	Pest management, preventive and control measures	Are there comprehensive preventive and control measures enumerated in the agronomic protocol used for pest management to minimize loss of the final crop and its quality?	Major			
4.6.2	Bio control agents	Is crop protection plans limited to the use of bio-control agents and bio-pesticides?	Major			
4.6.3	Pest management protocols	Integrated pest management protocol shall be in place in absence of the protocols at 4.6.1 and 4.6.2	Critical			
4.6.4	Smallest effective dosage	How under compulsive circumstances care is taken to use smallest effective dosage of pesticides on the basis of crop protection protocols prescribed for potato?	Major			
4.6.5	Residue analysis	When chemical pesticides are used for crop protection, is the residue analysis of final product carried out through appropriate testing agencies following standard procedures?	Critical			
5	**HARVEST AND POST HARVEST MANAGEMENT**					
5.1	**Harvesting**					
5.1.1	Maturity determination	Whether the harvesting season is determined and followed on the basis of qualitative parameters set for the end product of the constituents rather than the total vegetative yield?	Major			
5.1.2	Harvesting devices and careful harvesting	How are cutting devices employed for harvesting selected to minimize the contamination by soil particles? How care is taken to avoid incidental and concurrent harvest of weeds, during harvesting?	Major			

5.1.3	Harvesting containers	How are the containers used for harvested materials kept clean? How care is taken to ensure freedom from the risks of cross contamination by other species, weeds and such other extraneous matter?	Major			
5.2	**Primary processing**					
5.2.1	Washing and cleaning methods	Are the washing and cleaning methods for freshly harvested materials laid down in consideration of the potato tubers?	Major			
5.2.2	Produce drying and handling	Is the freshly harvested produce not be stored as such and the process of skin curing initiated in a continuum? How is the length of storage minimized and handled in a manner to prevent degradation or rotting?	Major			
5.2.3	Processing area conditions	How the processing area or sites are kept clean, well ventilated, and have the facilities for protection against sunlight, dust, rain, rodents, insects and livestock?	Major			
5.2.4	Drying and temperature requirements	Whether sorting procedure is carried out after completion of harvesting phase and before the material is stored and packed?	Critical			
5.2.5	Sorting procedure	Whether sorting procedure is carried out after completion of frying phase and before the material is packed?	Major			
5.3	**Packaging, storage and transportation**					
5.3.1	Packing material	Is the selection of packaging material based on the quality requirements and possible length of storage before consumption/processing and kept clean, dry and undamaged?	Major			
5.3.2	Container filling	While packaging, are mechanical damages and undue compacting of the dried plant material that may result in undesirable quality changes avoided? Is care taken to avoid overfilling of the containers?	Major			
5.3.3	Storage conditions	Is the storage area kept dry and protected from insects and rodents and such other factors that may be detrimental to the quality of the product?	Major			
5.3.4	Separate storage	Are different varieties stored separately to avoid varietal mixing?	Major			
5.3.5	Multiple commodity storage	When multiple commodities/varieties are handled in the same storage area, is care exercised to prevent product mix up and cross contamination?	Minor			

6	**IDENTIFICATION AND TRACEABILITY**					
6.1	**Identification**					
6.1.1	Produce labeling	Are produce legibly labeled inscribing on every pack with the product name, month and year of harvest and the name of farmer/farming agency? If the material was tested before, an appropriate label may be used indicating quality approval?	Major			
6.2	**Traceability**					
6.2.1	Traceability record	Is registered product traceable back to and trackable from the registered farm (and other relevant registered areas) where it has been grown?	Critical			
7	**PERSONNEL AND EQUIPMENT**					
7.1	Trained personnel	Key resource persons engaged at the site (such as farm owner/ supervisor) must be conversant with all aspects related to the potato crop such as, quality requirements of the end product, crop husbandry etc.	Major			
7.2	Safety and hygiene awareness	The personnel should have basic exposure to subject matters like safety and hygiene.	Major			
7.3	Calibrations	The machinery used in fertilizer and pesticide application must be calibrated at prescribed schedules and calibration certificates / records should be maintained.	Major			
7.4	Equipment cleanliness and placement	Equipment must be clean and mounted where applicable, in an easily accessible manner. Scheduled servicing procedures must be adhered to keep them in working order.	Major			
7.5	Specific part cleaning	Additional care should be taken for cleaning those machine parts that get into direct contact with the harvested produce.	Major			
7.6	Safe material equipment	The material used for the equipment, particularly that coming into direct contact, should be safe. Equipment that pose a risk of hazardous metallic contamination of the harvested crop should be avoided.	Critical			
8	**WORKERS HEALTH, SAFETY AND WELFARE**					
8.1	**Risk assessment**					
8.1.1	Risk assessment of working conditions	Does the farm have a written risk assessment for safe and healthy working conditions?	Major			

8.1.2	Safety and hygiene policy	Does the farm have a written health, safety and hygiene policy and procedures?	Major			
8.2	**Training**					
8.2.1	Competence training	Do all workers handling and/or administering plant chemicals, disinfectants, plant protection products, biocides or other hazardous substances and all workers operating dangerous or complex equipment have certificates of competence, and/or details of other such qualifications?	Major			
8.2.2	Health and safety training	Have all workers received adequate health and safety training and are they instructed according to the risk assessment?	Major			
8.2.3	First aid training and deployment of trained person	Is there always an appropriate number of persons (at least one person) trained in first aid present on each farm whenever on-farm activities are being carried out?	Major			
8.3	**Hazards and first aid**					
8.3.1	Emergence procedures, display and communica- tion	Do accident and emergency procedures exist; are they visually displayed and communicated to all persons associated with the farm activities?	Major			
8.3.2	Warning signs	Are potential hazards clearly identified by warning signs and placed where appropriate?	Minor			
8.4	**Protective clothing /equipment**					
8.4.1	Availability of protective clothing	Are the workers (including subcontractors) equipped with suitable protective clothing in accordance with legal requirements and/or label instructions or as authorized by a competent authority?	Major			
9	**RECORD KEEPING AND INTERNAL SELF-ASSESSMENT/ INTERNAL INSPECTION**					
9.1	Duration of record keeping	Are all records requested during the external inspection accessible and kept for a minimum period of time of two years, unless a longer requirement is stated in specific control points?	Major			
9.2	Internal self-assessment	Does the producer take responsibility to undertake a minimum of one internal self-assessment per year against the requirements of this standard?	Major			
9.3	Corrective actions	Are effective corrective actions taken as a result of non-conformances detected during the internal self-assessment?	Major			

10	**WASTE AND POLLUTION MANAGEMENT, RECYCLING AND REUSE**					
10.1	Identification of waste and pollutants	Have all possible waste products and sources of pollution been identified in all areas?	Major			
10.2	Waste and pollution action plan	Is there a farm waste management plan to avoid or reduce wastage and pollution by waste recycling? Are organic wastes composted on the farm and utilized as manure?	Minor			
10.3	Clean premises	Are the farm and premises clear of litter and waste to avoid establishing a breeding ground for pests and diseases which could result in a food safety risk?	Major			
10.4	Designated place for waste storage	Do the premises have adequate provisions for waste disposal?	Minor			
11	**ENVIRONMENT AND CONSERVATION**					
11.1	**Impact of farming on the environment and biodiversity**					
11.1.1	Wildlife conservation plan	Does each farmer have a management of wildlife and conservation plan that acknowledges the impact of farming activities on the environment?	Minor			
11.1.2	Benefit to local community	Has the farmer considered how to enhance the environment for the benefit of the local community and flora and fauna?	Minor			
11.1.3	Avoid damage habitat	Does the plan include action to avoid damage and deterioration of habitats on the farm?	Minor			
11.1.4	Increase biodiversity	Does the plan include activities to enhance habitats and increase biodiversity on the farm?	Minor			
12	**COMPLAINTS**					
12.1	Availability of complaint procedure	Is there a complaint procedure available relating to issues covered by the standard?	Major			
12.2	Record of complaints	Does the complaints procedure ensure that complaints are adequately recorded, studied and followed up including a record of actions taken?	Major			

Annexure 24 : IndGAP: CHECKLIST FOR SELF-ASSESSMENT

Critical - 100% compliance of all the applicable critical control points
Major - 90% compliance of all the major control points is compulsory

Minor - 75% compliance of all the major control points is compulsory

Cl.No.	Item	Control Point	Level	Compliance		Remark
				Yes	No	
AF 1	**RECORD KEEPING AND INTERNAL SELF-ASSESSMENT / INTERNAL INSPECTION**					
AF 1.1	Duration of record keeping	Are all records requested during the external inspection accessible and retained for a minimum period of two years, unless a longer requirement is stated in specific control points?	Major			
AF 1.2	Internal self- assessment	Does the producer or producer group take responsibility to undertake a minimum of one internal self-assessment or producer group internal inspection, respectively, per year against the IndGAP standard?	Critical			
AF 1.3	Corrective actions on non-conformities	Are effective corrective actions taken as a result of non-conformances detected during the internal self-assessment or internal producer group Inspections?	Critical			
AF 2	**SITE HISTORY AND SITE MANAGEMENT**					
AF 2.1	**Site history**					
AF 2.1.1	Recording system	Is a recording system established for each unit of production or other area / location to provide a permanent record of the livestock/aquaculture production and/or agriculture activities undertaken at those locations? Are these records kept in an ordered and up-to-date fashion?	Critical			
AF 2.1.2	Reference system	Is a reference system for each field, orchard, greenhouse, yard, plot, livestock building or other area/location used in production established and referenced on a farm plan or map?	Major			
AF 2.1.3	Vicinity of potential risk	Is the farm in vicinity of brick kilns, chemical or other industries, rivers, canals, other water sources, hill-rocks, forests, pastures and reclaimed land? If yes, then measures in place to check contamination and other potential risk?	Critical			
AF 2.2	**Site management**					
AF 2.2.1	Risk assessment for new farm site	Is there a risk assessment for new agricultural sites/farm or existing one only where risks have changed, which shows the site in question to be suitable for potato production, with regards to food safety, operator health, the environment and animal health where applicable?	Critical			

AF 2.2.2	Management plan to minimize all identified risk	Has a management plan been developed setting out strategies to minimize all identified risks? Are the results of this analysis properly maintained and used to justify the site selection, if questioned?	Major			
AF 3	**WORKERS HEALTH, SAFETY AND WELFARE**					
AF 3.1	**Risk assessment**					
AF 3.1.1	Risk assessment of working conditions	Does the farm have a written risk assessment for safe and healthy working conditions?	Major			
AF 3.1.2	Health, safety and welfare policy	Does the farm have a written health, safety and welfare policy and procedures including issues of the risk assessment of working conditions?	Major			
AF 3.2	**Training**					
AF 3.2.1	Training activities	Is there a record kept for training activities and attendees?	Major			
AF 3.2.2	Certification of competence	Do all workers handling and/or administering veterinary medicines, chemicals, disinfectants, plant protection products, biocides or other hazardous substances and all workers operating dangerous or complex equipment as defined in the risk assessment of working conditions have certificates of competence, and/or details of other such qualifications?	Critical			
AF 3.2.3	Health and safety training	Have all workers received adequate health and safety training and are they instructed according to the risk assessment of working conditions?	Major			
AF 3.2.4	Number of persons trained in first aid	Is there always an appropriate number of persons (at least one person) trained in first aid present on each farm whenever on-farm activities are being carried out?	Major			
AF 3.2.5	Documentation of hygiene conditions	Does the farm have documented hygiene instructions?	Major			
AF 3.2.6	Training of basic hygiene	Have all persons working on the farm received basic hygiene training according to the documentation of hygiene conditions instructions?	Major			
AF 3.2.7	Farm hygiene procedures	Are the farm's hygiene procedures implemented?	Major			
AF 3.2.8	Personal safety and hygiene	Are all subcontractors and visitors aware of the relevant procedures on personal safety and hygiene?	Major			
AF 3.3	**Hazards and first aid**					
AF 3.3.1	Prevention of accidents	Have adequate precautions been taken to prevent on farm accidents during operation of farm equipments/ machinery?	Critical			
AF 3.3.2	Accident and emergency procedures	Do accident and emergency procedures exist; are they visually displayed and communicated to all persons associated with the farm activities?	Major			

AF 3.3.3	Warning signs	Are potential hazards clearly identified by warning signs and placed where appropriate?	Major			
AF 3.3.4	Availability of safety advice	Is safety advice available /accessible for substances hazardous to worker health, when required?	Major			
AF 3.3.5	Availability of first aid kits	Is first aid kits present at all permanent sites and in the vicinity of fieldwork?	Major			
AF 3.4	**Protective clothing/equipment**					
AF 3.4.1	Availability of protective clothing	Are workers (including subcontractors) equipped with suitable protective clothing in accordance with legal requirements and/or label instructions or as authorized by a competent authority?	Major			
AF 3.4.2	Cleaning of protective clothing	Is protective clothing cleaned after use and stored so as to prevent contamination of the clothing or equipment?	Critical			
AF 3.5	**Worker welfare**					
AF 3.5.1	Person responsible for worker welfare	Is a member of management clearly identifiable as responsible for workers health, safety and welfare?	Critical			
AF 3.5.2	Communication between workers and management	Do regular two-way communication meetings take place between management and workers? Are there records from such meetings?	Minor			
AF 3.5.3	Overview information of all workers	Is there information available that provide an accurate overview over all workers of the farm?	Major			
AF 3.5.4	Eating area for workers	Do workers have access to clean food storage areas, designated eating areas, hand washing facilities and drinking water?	Major			
AF 3.5.5	Hygiene in living quarters	Are on site living quarters habitable and have the basic services and facilities?	Major			
AF 3.5.6	On farm electrical installation	Are all electrical installations on the farm and other working areas have adequate safety measures?	Critical			
AF 3.6	**Sub-contractors**					
AF 3.6.1	Information on sub-contractors	When the producer makes use of subcontractors, is all the relevant information about sub-contractors available on farm?	Major			
AF 4	**WASTE AND POLLUTION MANAGEMENT, RECYCLING AND RE-USE**					
AF 4.1	**Identification of waste and pollutants**					
AF 4.1.1	Sources of pollution	Have all possible waste products and sources of pollution been identified in all areas of the business?	Major			

AF 4.2	**Waste and pollution action plan**					
AF 4.2.1	Documentation of farm waste management	Is there a documented farm waste management plan to avoid or reduce wastage and pollution and avoid the use of landfill or burning, by waste recycling? Are organic wastes composted on the farm and utilized for soil conditioning, provided there is no risk of disease carry-over?	Minor			
AF 4.2.2	Implementation of farm waste management plan	Has this waste management plan been implemented?	Minor			
AF 4.2.3	Cleaning of litter and waste	Are the farm and premises clear of litter and waste to avoid establishing a breeding ground for pests and diseases, which could result in a food safety risk?	Critical			
AF 4.2.4	Provision for waste disposal	Do the premises have adequate provisions for waste disposal?	Minor			
AF 5	**ENVIRONMENT AND CONSERVATION**					
AF 5.1	**Impact of farming on the environment and biodiversity**					
AF 5.1.1	Conservation of wild life	Does each producer have a conservation of wildlife and conservation plan for the enterprise that acknowledges the impact of farming activities on the environment?	Major			
AF 5.1.2	Improvement of environment	Has the producer considered how to improve the environment for the benefit of the local community and flora and fauna?	Minor			
AF 5.1.3	Compatibility with agricultural production	Is this policy compatible with sustainable commercial agricultural production and does it minimize environmental impact of the agricultural activity?	Minor			
AF 5.1.4	Biodiversity audit plan	Does the plan include a baseline audit to understand existing animal and plant diversity on the farm?	Minor			
AF 5.1.5	Protection of farm habitat	Does the plan include action to avoid damage and deterioration of habitats on the farm?	Minor			
AF 5.1.6	Enhancement of farm habitat	Does the plan include activities to enhance habitats and increase biodiversity on the farm?	Minor			
AF 5.2	**Unproductive site**					
AF 5.2.1	Conversion of unproductive sites	Has consideration been given to the conversion of unproductive sites (e.g. low lying wet areas, woodlands, headland strip or areas of impoverished soil) to conservation areas for the encouragement of natural flora and fauna?	Minor			
AF 5.3	**Energy efficiency**					
AF 5.3.1	Monitoring of energy use	Can the producer show monitoring of energy use on the farm?	Minor			
AF 6	**COMPLAINTS**					

AF 6.1	Complaint procedure	Is there a complaint procedure available relating to issues covered by the IndGAP standard?	Critical			
AF 6.2	Record of action on complaints	Does the complaints procedure ensure that complaints are adequately recorded, studied and followed up including a record of actions taken?	Critical			
AF 7	**TRACEABILITY**					
AF 7.1	Product recall procedure	Do all producers have a documented recall procedure to manage the withdrawal of registered products from the market?	Critical			
AF 8	**VISITORS SAFETY**					
AF 8.1	Instructions on visitors safety	Are there instructions on the safety issues for visitors?	Minor			

CONTROL POINTS AND COMPLIANCE - CROP BASE MODULE [CB]

Cl.No.	Item	Control Point	Level	Compliance		Re-mark
				Yes	No	
CB 1	**TRACEABILITY**					
CB 1.1	Feasibility of traceability	Is IndGAP registered product traceable back to and trackable from the registered farm (and other relevant registered areas) where it has been grown?	Critical			
CB 1.2	Farm location	Survey no./part-survey no., village, tehsildDistrict, state where the farm is located along with total area under cultivation and specify the area under IndGAP certification.	Major			
CB 1.3	Identification of farm infrastructure	Are fields/plots and structures identified on the field map?	Major			
CB 2	**PROPAGATION MATERIAL**					
CB 2.1	**Quality and health**					
CB 2.1.1	Seed quality	Is there a document that guarantees the seed tuber quality in terms of its varietal purity, freedom from diseases, pests and virus, uniformity etc?	Minor			
CB 2.1.2	Quality of propagation material	Is purchased seed potato tubers free of visible signs of pest and diseases?	Minor			
CB 2.1.3	Documentation of propagation material	Are quality guarantees or certified production guarantees documented for purchased seed potato tubers?	Major			

CB 2.1.5	Recommen dation of SAU / NRC/ other govt. approved organization	Is the potato variety for cultivation is selected as per recommendation on type, region, resistance to pest and diseases, quality attributes etc.?	Major			
CB 2.1.5.1	Recommen dation of GEAC	If GM potatoes are used, the GEAC number, permitting its usage, along with evidence of the source of the seeds must be recorded?	Critical			
CB 2.1.6	Pest / disease resistance	Do the potato seed tubers have any special quality with reference to resistance to pests/diseases, quality of the produce, germination percentage, expiry date, physical or any other characteristics?	Major			
CB 2.1.7	Treatment of seeds	Are the seed tubers treated with approved fungicides / pesticides and, if so, are these differentiated by colour to avoid accidental use in food? Whether only approved colours/ dyes have been used for colour coating?	Major			
CB 2.2	**Pest and disease resistance**					
CB 2.2.1	Varietal selection	Does the producer consider pest and disease resistance/tolerance characteristics during variety selection?	Major			
CB 2.4	**Sowing/planting**					
CB 2.4.1	Record of sowing/ planting methods	Does the producer keep record of sowing/planting methods, seed/planting rate, sowing/planting date ?	Major			
CB 2.5	**Genetically modified organisms**					
CB 2.5.1	Legal compliance of GMOs	Does the planting of potato or trials with GMO's comply with all applicable legislation in the India?	Critical			
CB 2.5.2	Documentation of GMOs	Is there documentation available when the producer is growing genetically modified organisms?	Major			
CB 2.5.3	Communication of GMOs	Did the producer inform their direct clients of the GMO status of the product?	Critical			
CB 2.5.4	Handling plan for GMOs	Is there a plan for handling GM material (crops and trials) setting out strategies to minimize contamination risks, such as accidental mixing of adjacent non-GM crops and maintaining product integrity?	Critical			
CB 2.5.5	Segregation of GMO crops	Are GMO crops stored separately from other crops to avoid adventitious mixing?	Critical			
CB 3	**SITE HISTORY AND MANAGEMENT**					
CB 3.1	**Rotations**					

CB 3.1.1	Crop rotations	Is there, where feasible, crop rotation for annual crops?	Minor			
CB 4	**SOIL MANAGEMENT**					
CB 4.1	**Soil mapping**					
CB 4.1.1	Mapping of soil	Has the soil map prepared for the farm?	Minor			
CB 4.1.2	Soil health	Is soil health based on chemical coposition suited for crops?	Major			
CB 4.2	**Cultivation**					
CB 4.2.1	Soil maintenance	Have techniques been used that improve or maintain soil structure, and to avoid soil compaction? Is the preparation of the soil for growing crop according to the standard recommended practices?	Minor			
CB 4.3	**Soil erosion**					
CB 4.3.1	Field cultivation	Are field cultivation techniques used to reduce the possibility of soil erosion?	Major			
CB 5	**PLANT NUTRITION MANAGEMENT/ FERTILIZER USE**					
CB 5.1	**Nutrient requirement**					
CB 5.1.1	Proper application of plant nutrient	Is the application of all plant nutrition products timed to maximize the efficacy and/or uptake by potato?	Major			
CB 5.2	**Advice on quantity and type of fertilizer/nutrients**					
CB 5.2.1	Recommen- dations on use of fertilizers/ nutrients	Are recommendations for application of fertilizers/ nutrients (organic or inorganic) given by competent, qualified advisers holding a recognized national certificate or similar? Do producers who use outside professional help (advisers and consultants) regarding the use of fertilizers/ nutrients satisfy themselves that the people on whom they rely are competent to provide that advice?	Major			
CB 5.2.2	Competence of advice	Are producers able to demonstrate their competence and knowledge, where such advisers are not used?	Major			
CB 5.3	**Records of application**					
CB 5.3.1	Record of nutrient applications	Have all application of soil and foliar fertilizers, both organic and inorganic been recorded?	Major			
CB 5.3.2	Dates of nutrient application	Have all application dates of soil and foliar fertilizers, both organic and inorganic, been recorded?	Major			
CB 5.3.3	Record of applied nutrient types	Have all application of soil and foliar fertilizers, both organic and inorganic been recorded including applied fertilizer types?	Major			

CB 5.3.4	Record of applied quantities	Have all applied quantities of soil and foliar fertilizers, both organic and inorganic, been recorded?	Major			
CB 5.3.5	Record of method of application	Have all applications of soil and foliar fertilizers, both organic and inorganic, been recorded including the method of application?	Major			
CB 5.3.6	Record of operator details	Have all applications of soil and foliar fertilizers, both organic and inorganic, been recorded including the operator details?	Major			
CB 5.4	**Application machinery**					
CB 5.4.1	Condition of application machinery	Is fertilizer application machinery kept in good condition and verified annually to ensure accurate fertilizer application?	Major			
CB 5.5	**Storage of fertilizers/nutrients**					
CB 5.5.1	Inventory of fertilizers	Is there an inorganic fertilizer stock inventory or record of use up to date and available on the farm?	Major			
CB 5.5.2	Segregation of fertilizers from plant protection products	Are inorganic fertilizers stored separately from plant protection products?	Major			
CB 5.5.3	Protection of storage area	Are inorganic fertilizers stored in a covered area?	Major			
CB 5.5.4	Hygiene of storage area	Are inorganic fertilizers stored in a clean area?	Major			
CB 5.5.5	Humidity in storage area	Are inorganic fertilizers stored in a dry area?	Major			
CB 5.5.6	Reduction in risk of contamination of water	Are inorganic fertilizers stored in an appropriate manner, which reduces the risk of contamination of water sources?	Major			
CB 5.5.7	Reduction in risk of contamination of environment	Are organic fertilizers stored in an appropriate manner, which reduces the risk of contamination of the environment?	Major			
CB 5.5.8	Segregation from produce	Are inorganic and organic fertilizers stored separate from farm produce harvested -fresh or dry, as applicable?	Critical			
CB 5.6	**Organic fertilizers**					
CB 5.6.1	Ban on human sewage sludge	Has the use of human sewage sludge been banned on the farm?	Critical			

CB 5.6.2	Risk assessment of organic fertilizers	Has a risk assessment been carried out for organic fertilizer, which considers its source and characteristics, before application?	Major			
CB 5.6.3	Nutrient in organic fertilizer	Has account been taken of the nutrient contribution of organic fertilizer applications?	Minor			
CB 5.6.4	Method of organic manure preparation	Have aerobic and anaerobic methods of preparation been followed?	Minor			
CB 5.6.5	Soil enrichment	Are the soils enriched with adequate organic matter?	Major			
CB 5.6.6	Use of green manure	Are the green manures incorporated into the soil to improve soil health?	Minor			
CB 5.6.7	Use of bio-fertilizers	Are any bio-fertilizers applied to the potato crop? Are they approved by technically competent source?	Major			
CB 5.6.8	Use of sheep/poultry manures	Is sheep & poultry manure applied raw/ripe?	Minor			
CB 5.6.9	Use of municipal/ industrial sludge	Is municipal / industrial sludge applied?	Critical			
CB 5.6.10	Use of other organic manure	Any other organic manure added to the soil in raw or decomposed form?	Major			
CB 5.7	**Inorganic fertilizers**					
CB 5.7.1	Composition of inorganic fertilizers	Are purchased inorganic fertilizers accompanied by documentary evidence of nutrient content (N, P, K)?	Major			
CB 5.7.2	Documentary evidence of chemical content	Are purchased inorganic fertilizers accompanied by documentary evidence of chemical content, which includes heavy metals?	Minor			
CB 5.7.3	Dosage commendations by SAU/NRC / other approved organizations.	Are the doses in tune with the soil test – crop response studies and SAU / NRC/other approved organizations? Recommendations for the potato crop? Do the fertilizers contain desirable/ approved proportion of critical plant nutrients NPK?	Critical			
CB 5.7.4	Micro nutrient content	Are the micronutrients optimally provided?	Minor			
CB 5.7.5	Stages of nutrient applications	Are the critical/major nutrients applied through recommended application practices at appropriate stages of crop growth? Are foliar sprays of nutrients done as per standard recommendations without leaving residues?	Major			

CB 5.7.6	Grower competence on applications	Does the grower demonstrate her/his competence to determine the type and quantity of fertilizers/ nutrients being used and its application?	Major			
CB 5.7.7	Records of application	Have all applications of soil & foliar fertilizers, both inorganic, organic & bio-fertilizers been recorded?	Major			
CB 6	**IRRIGATION AND FERTIGATION**					
CB 6.1	**Predicting irrigation requirement**					
CB 6.1.1	Method of calculation	Have systematic methods of prediction been used to calculate the water requirement of the potato crop?	Minor			
CB 6.2	**Irrigation/fertigation method**					
CB 6.2.1	Method of irrigation/ fertigation	Can the producer justify the method of irrigation/ fertigation used in light of water conservation?	Major			
CB 6.2.2	Water optimization	Is there a water management plan to optimize water usage and reduce waste?	Minor			
CB 6.2.3	Record of irrigation/ fertigation	Are records of irrigation/fertigation water usage maintained?	Minor			
CB 6.3	**Quality of irrigation water**					
CB 6.3.1	Ban on untreated sewage water	Has the use of untreated sewage water for irrigation/fertigation been banned?	Critical			
CB 6.3.2	Annual risk assessment	Has an annual risk assessment for irrigation/fertigation water pollution been completed?	Major			
CB 6.3.3	Frequency of analysis	Is irrigation water analyzed at a frequency in line with the risk assessment?	Major			
CB 6.3.4	Suitability of laboratory	Is the analysis carried out by a suitable laboratory?	Minor			
CB 6.3.5	Action on adverse results	Have any adverse results been acted upon?	Minor			
CB 6.4	**Supply of irrigation/fertigation water**					
CB 6.4.1	Sustainability of water source	To protect the environment, is water abstracted from a sustainable source?	Major			
CB 6.4.2	Advice on abstraction	Has advice on abstraction been sought from water authorities, where required by law?	Major			
CB 6.4.3	Water quality	Is the water potable or free from harmful contaminants?	Critical			

CB 6.4.4	Dependability of water source	Is the source dependable under normal conditions during rain free period? Is the source an approved one?	Major			
CB 6.4.5	Water harvesting	Is water harvesting being practiced by the farmer?	Minor			
CB 6.4.6	Water conservation	Is water conservation being practiced by the farmer?	Minor			
CB 6.4.7	Irrigation equipment	Is the farmer maintaining irrigation equipment as per guidelines provided by the manufacturer?	Major			
CB 6.4.8	Prevention of undesirable water	Has the farmer taken adequate measures to prevent flow of water into the fields from undesirable sources like municipal landfill areas, hospital & industry waste dump areas, etc.?	Critical			
CB 7	**INTEGRATED PEST MANAGEMENT**					
CB 7.1	Assistance for IPM	Has assistance with implementation of IPM systems been obtained through training or advice?	Major			
CB 7.2	Evidence for prevention	Can the producer show evidence of implementation of at least one activity that falls in the category of "Prevention"?	Major			
CB 7.3	Evidence for monitoring	Can the producer show evidence of implementation of at least one activity that falls in the category of "Observation and Monitoring"?	Major			
CB 7.4	Evidence for intervention	Can the producer show evidence of implementation of at least one activity that falls in the category of "Intervention"?	Major			
CB 7.5	Minimum input use	Where plant protection products have been used, has protection been achieved with the appropriate minimum input?	Major			
CB 7.6	Anti-resistance label commendation	Have anti-resistance label recommendations been followed to maintain the effectiveness of available plant protection products?	Major			
CB 7.7	IPM for endemic pests/diseases	Are the IPM practices suggested for endemic pests and diseases are followed?	Critical			
CB 7.8	**Soil treatment**					
CB 7.8.1	Soil treatment recommendations	Is soil treatment, suggested by SAU/NRC or approved by any other govt. agency for endemic pests and diseases followed?	Major			
CB 7.9	**Seed treatment**					
CB 7.9.1	Methods of sowing	Are seed tubers treated using approved methods before sowing?	Minor			
CB 7.10	**Cultural methods**					

CB 7.10.1	Use of cultural practices	Are appropriate cultural practices followed for preventing the build-up of pests and diseases followed?	Major			
CB 7.10.2	Total use of recommendations	Are the recommended IPM practices completely followed?	Critical			
CB 7.10.3	**Mechanical methods**					
	Use of mechanical methods	Are recommended mechanical methods for control of pests and diseases followed?	Major			
CB 7.10.4	**Biological methods**					
	Use of biological methods	Are biological methods and bio control measures followed as recommended by the SAU/NRC or any other govt. agency?	Major			
CB 8	**PLANT PROTECTION PRODUCTS**					
CB 8.1	**Choice of plant protection products**					
CB 8.1.1	Use of label commendations	Is the plant protection product applied appropriate for the potato crop as recommended on the product label?	Critical			
CB 8.1.2	Use of registered plant protection products	Do producers only use plant protection products that are registered in the country of use for the target crop where such official registration scheme exists?	Critical			
CB 8.1.3	Purchase record	Are invoices of registered plant protection products kept?	Major			
CB 8.1.4	List of plant protection products	Is a current list kept of plant protection products that are used and approved for use on crops being grown?	Major			
CB 8.1.5	Awareness of banned chemicals	Is the farmer aware of the banned chemicals and is there a process that prevents chemicals that are banned in the target country from being used on crops destined for sale in that country?	Critical			
CB 8.1.6	Competence of advisors	If the choice of plant protection products is made by advisers, can they demonstrate competence?	Critical			
CB 8.1.7	Competence of producer	If the choice of plant protection products is made by the producer, can competence and knowledge be demonstrated?	Critical			
CB 8.1.8	List of pest / diseases in the area	List out the common pests and diseases endemic to the area and those that occurred on the crop during the past three crop seasons.	Major			
	Approved chemicals targeting the pest and diseases					
CB 8.1.9	Appropriate- ness of chemical	Is the crop protection chemical applied; appropriate for the target pest/disease? Is the current list of approved chemicals for the crop is available with the grower?	Major			

CB 8.1.10	Banned chemicals	Are chemicals banned in India or importing countries used for crops destined for internal use or for exports?	Critical			
CB 8.2	**Record of application**					
CB 8.2.1	Record of applications	Have all the plant protection product applications been recorded including the crop name and/or variety?	Critical			
CB 8.2.2	Record of application location	Have all the plant protection product applications been recorded including the application location?	Critical			
CB 8.2.3	Record of application dates	Have all the plant protection product applications been recorded including application date?	Critical			
CB 8.2.4	Record of chemical trade names	Have all the plant protection product applications been recorded including the product trade name?	Critical			
CB 8.2.5	Identification of operator	Has the operator been identified for plant protection product applications?	Major			
CB 8.2.6	Record of justification of application	Have all the plant protection product applications been recorded including justification for application?	Major			
CB 8.2.7	Record of technical authorization	Have all the plant protection product applications been recorded including the technical authorization for application?	Major			
CB 8.2.8	Record of quantity of application	Have all the plant protection product applications been recorded including appropriate information to identify the product quantity applied?	Major			
CB 8.2.9	Record of application machinery	Have all the plant protection product applications been recorded including the application machinery used?	Major			
CB 8.2.10	Record of pre harvest interval	Have all the plant protection product applications been recorded including the pre-harvest interval?	Critical			
CB 8.3	**Pre-harvest interval**					
CB 8.3.1	Observation of pre-harvest interval	Have the registered pre-harvest intervals prescribed by CIB or approved PHIs by relevant govt. agencies been observed?	Critical			
CB 8.4	**Application equipment**					
CB 8.4.1	Condition of application machinery & calibration	Is plant protection product application machinery kept in good condition and verified annually to ensure accurate application?	Major			

CB 8.4.2	Producer's participation in calibration of equipment	Is the producer involved in an independent calibration-certification scheme, where available?	Minor			
CB 8.4.3	Label instructions	When mixing plant protection products, are the correct handling and filling procedures followed as stated on the label?	Major			
CB 8.5	**Disposal of surplus application mix**					
CB 8.5.1	Disposal method	Is surplus application mix or tank washings disposed of according to national or local law, where it exists, or in its absence according to below two points, either of which in this case must be complied with in order to comply with this Major must?	Major			
CB 8.5.2	Record of surplus application mix	Is surplus application mix or tank washings applied over an untreated part of the crop, as long as the recommended dose is not exceeded and records kept?	Minor			
CB 8.5.3	Record of surplus application mix in fallow land	Are surplus application mixes or tank washings applied onto designated fallow land, where legally allowed, and records kept?	Minor			
CB 8.6	**Plant protection product residue analysis**					
CB 8.6.1	Sampling procedure	Are the correct sampling procedures followed?	Major			
CB 8.6.2	Record of residue testing	If the producer or producer's customer able to provide current evidence either of annual (or more frequent) residue testing or of participation in a third party plant protection product residue monitoring system, which is traceable to the production location and that covers the plant protection products applied to the crop/product?	Critical			
CB 8.6.3	Knowledge of MRL of target market	Is the producer (or the producer's customer) able to demonstrate information regarding the market where the producer is intending to trade produce, and the maximum residue level (MRL) of that market?	Critical			
CB 8.6.4	Action taken to comply with MRL	Has action been taken to meet the MRLs of the market the producer is intending to trade his produce in?	Critical			
CB 8.6.5	Action on non-compliances of MRL	Is an action plan in place in the event of an MRL being exceeded, either of the country of production or of the countries where produce is intended to be traded in?	Critical			
CB 8.6.6	Accreditation of laboratory	Is the laboratory used for residue testing accredited by a competent national authority to ISO 17025 or equivalent standard?	Major			
CB 8.7	**Plant protection product storage**					

CB 8.7.1	Compliance with local regulations	Are plant protection products stored in accordance with local regulations?	Critical			
CB 8.7.2	Storage conditions	Are plant protection products stored in a location that is sound?	Major			
CB 8.7.3	Security of location	Are plant protection products stored in a location that is secure?	Critical			
CB 8.7.4	Temperature conditions	Are plant protection products stored in a location that is appropriate to the temperature conditions?	Major			
CB 8.7.5	Fire protection	Are plant protection products stored in a location that is fire-resistant?	Minor			
CB 8.7.6	Ventilation	Are plant protection products stored in a location that is well ventilated (in the case of walk-in storage)?	Major			
CB 8.7.7	Light arrangement	Are plant protection products stored in a location that is well lit?	Major			
CB 8.7.8	Segregation from other materials	Are plant protection products stored in a location that is located away from other materials?	Major			
CB 8.7.9	Conditions of shelves	Is all plant protection product storage shelving made of non-absorbent material?	Minor			
CB 8.7.10	Prevention of spillages	Is the plant protection product store able to retain spillage?	Major			
CB 8.7.11	Measuring equipment	Are there facilities for measuring and mixing plant protection products?	Major			
CB 8.7.12	Facilities to prevent spillage	Are there facilities to deal with spillage?	Major			
CB 8.7.13	Worker restriction	Are keys and access to the plant protection product store limited to workers with formal training in the handling of plant protection products?	Major			
CB 8.7.14	Inventory records	Is the product inventory documented and readily available?	Major			
CB 8.7.15	Packaging	Are all plant protection products stored in their original package?	Critical			
CB 8.7.16	Segregation for crop rotation plant protection products	Are those plant protection products that are approved for use on the crops grown in the crop rotation stored separately within the plant protection product store from those plant protection products used for other purposes?	Major			
CB 8.7.17	Positioning in shelves	Are liquids not stored on shelves above powders?	Major			
CB 8.8	**Plant protection product handling**					
CB 8.8.1	Health check of workers	Are all workers who have contact with plant protection products submitted voluntarily to annual health checks?	Minor			

CB 8.8.2	Procedures for re-entry of persons	Are there procedures dealing with re-entry of persons on the farm after application of plant protection products?	Critical			
CB 8.8.3	Monitoring of re-entry times	Have the recommended re-entry times been monitored?	Major			
CB 8.8.4	Accident procedures	Is the accident procedure evident within 10 meters of the plant protection product/ chemical storage facilities?	Major			
CB 8.8.5	Prevention accidental contamination	Are there facilities to deal with accidental operator contamination?	Major			
CB 8.9	**Empty plant protection product containers**					
CB 8.9.1	Reuse of containers	Is re-use of empty plant protection product containers for purposes other than containing and transporting of the identical product avoided?	Major			
CB 8.9.2	Disposal of containers	Does disposal of empty plant protection product containers occur in a manner that avoids exposure to humans?	Major			
CB 8.9.3	Environmental protection	Does disposal of empty plant protection product containers occur in a manner that avoids contamination of the environment?	Major			
CB 8.9.4	Official disposal system	Are official collection and disposal systems used when available?	Major			
CB 8.9.5	Labeling and handling	If there is a collection system, are the empty containers adequately stored, labelled and handled according to the rules of a collection system?	Major			
CB 8.9.6	Cleaning of empty containers	Are empty containers rinsed either via the use of an integrated pressure rinsing device on the application equipment, or at least three times with water?	Critical			
CB 8.9.7	Rinsing	Is the rinsate from empty containers returned to the application equipment tank?	Major			
CB 8.9.8	Storage of empty containers	Are empty containers kept secure until disposal is possible?	Major			
CB 8.9.9	Compliance with local regulations	Are all local regulations regarding disposal or destruction of containers observed?	Major			
CB 8.10	**Obsolete plant protection products**					
CB 8.10.1	Disposal of obsolete chemicals	Are obsolete plant protection products securely maintained and identified and disposed of by authorized or approved channels?	Major			

CONTROL POINTS AND COMPLAINCE - FRUITS AND VEGETABLES (Applicable to potato production)

Cl.No.	Item	Control Point	Level	Compliance		Remark
				Yes	No	
FV 1	**CHOICE OF VARIETY/ROOTSTOCK**					
FV 1.1	Planting material awareness	Is the producer aware of the importance of effective crop husbandry in relation to the quality of potato seed tubers?	Major			
FV 2	**SOIL AND SUBSTRATE MANAGEMENT**					
FV2.1	**Soil fumigation**					
FV 2.1.1	Justification	Is there a written justification for the use of soil fumigants?	Major			
FV 2.1.2	Pre-planting Interval	Is any pre-planting interval complied with ?	Major			
FV 3	**IRRIGATION/FERTGATION**					
FV 3.1	**Quality of irrigation water**					
FV 3.1.1	Risk analysis	According to risk analysis (CB 6.3.2) , does the analysis consider the microbial contamination?	Major			
FV 3.1.2	Risk management	If the risk analysis so requires, have suitable corrective actions taken to avoid identified risks?	Major			
FV 3.1.3	Quality of fertigation material	Is farmer aware of the quality of fertigation material?	Major			
FV 4	**HARVESTING**					
FV 4.1	**General**					
FV 4.1.1	Hygiene risk analysis	Has a hygiene risk analysis and risk assessment been performed for the harvested crop handling process that covers the hygiene aspects of the produce handling operation?	Critical			
FV 4.1.2	Documen- tation of procedures	Are documented hygiene procedures for the harvesting process implemented?	Critical			
FV 4.1.3	Instruction to workers	Have workers received basic instructions in hygiene before handling produce?	Critical			

FV 4.1.4	Implemen- tation of instructions	Are hygiene instructions and procedures for handling produce, to avoid contamination of the product, implemented?	Critical			
FV 4.1.5	Cleaning of containers	Are the containers and tools used for harvesting cleaned, maintained and protected from contamination?	Critical			
FV 4.1.6	Cleaning of vehicles	Are vehicles used for transport of harvested produce cleaned and maintained?	Critical			
FV 4.1.7	Access to hand washing	Do harvests workers that come into direct contact with the crops have access to clean hand washing equipment?	Critical			
FV 4.1.8	Access to clean toilets	Do harvest workers have access to clean toilets in the vicinity of their work?	Major			
FV 4.1.9	Produce containers	Are produce containers used exclusively for produce?	Critical			
FV 4.1.10	Compliance with maturity standards	Are prescribed maturity standards for the crops followed before harvesting?	Minor			
FV 4.1.11	Compliance with quality parameters	Are the prescribed quality parameters accomplished at the time of harvest?	Major			
FV 2	**Final produce packing at point of harvest**					
FV 4.2.1	Hygiene at harvesting/handling point	Is the hygiene procedure considered while handling of harvested produce and produce packed and handled directly in the field, orchard or greenhouse?	Critical			
FV 4.2.2	Documen- tation of inspection	Is a documented inspection process in place to ensure compliance with defined quality criteria?	Major			
FV 4.2.3	Protection from cont- amination	Are packed produce protected from contamination?	Critical			
FV 4.2.4	Hygiene at handling points	Is collection/ storage /distribution point of field packed produce maintained in clean and hygienic conditions?	Critical			
FV 4.2.5	Storage of packing material	Is packing material used for in-field packing, stored to protect against contamination?	Critical			
FV 4.2.6	Waste disposal	Are bits of packaging material and other non-produce waste removed from the field?	Major			

FV 4.2.7	Climatic conditions at storage	If packed produce are stored on farm, are temperature and humidity documented?	Major			
FV 4.2.8	Source of ice and water	If ice or water is used in produce handling at point of harvest, is it made with potable water and handled under sanitary conditions to prevent produce contamination?	Major			
FV 5	**PRODUCE HANDLING**					
FV 5.1	**Principles of hygiene**					
FV 5.1.1	Documen- tation	Are documented hygiene procedures implemented for the process of harvested crop handling?	Major			
FV 5.2	**Personal hygiene**					
FV 5.2.1	Basic instruction on hygiene	Have workers received basic instructions in hygiene before handling produce?	Critical			
FV 5.2.2	Implemen- tation of instructions	Do the workers implement the hygiene instructions for handling produce?	Critical			
FV 5.2.3	Condition of outer garments	Are all workers wearing outer garments that are clean and fit for purpose for the operation and able to protect products from contamination?	Minor			
FV 5.2.4	Smoking/ eating instructions	Is smoking, eating, chewing and drinking confined to designated areas segregated from products?	Major			
FV 5.2.5	Signages	Are signs clearly displayed in the packing facilities with the main hygiene instructions for workers and visitors?	Major			
FV 5.3	**Sanitary facilities**					
FV 5.3.1	Access to clean toilets	Do workers in the packing facility have access to clean toilets and hand washing facilities in the vicinity of their work?	Critical			
FV 5.3.2	Hand washing instructions	Are signs clearly displayed instructing workers to wash their hands before returning to work?	Critical			
FV 5.3.3	Changing facilities	Are there suitable changing facilities for the workers?	Major			

FV 5.5.5	Secure place to store personal items	Are there secure storage facilities for the workers?	Major			
FV 5.4	**Packing and storage areas**					
FV 5.4.1	Maintenance	Are produce handling, storage facilities and equipment cleaned and maintained so as to prevent contamination?	Major			
FV 5.4.2	Storage of cleaning agents	Are cleaning agents, lubricants, etc. stored to prevent chemical contamination of produce?	Major			
FV 5.4.3	Approval of cleaning agents	Are cleaning agents, lubricants etc. that may come into contact with produce, approved for application in the food industry? Are dose rates followed correctly?	Major			
FV 5.4.4	Maintenance of equipment	Are all forklifts and other driven transport trolleys clean and well maintained and of suitable type to avoid contamination through emissions?	Minor			
FV 5.4.5	Disinfection	Is rejected produce and waste material in the packing environment stored in designated areas, which are routinely cleaned and/or disinfected?	Major			
FV 5.4.6	Lamp protection	Are breakage safe lamps or lamps with a protective cap used above the sorting, weighing and storage area?	Critical			
FV 5.4.7	Handling procedures	Are there written handling procedures in place for glass, clear hard plastic and articles with sharp edges?	Major			
FV 5.4.8	Hygiene of packing material	Are packing materials clean and stored in clean and hygienic conditions?	Major			
FV 5.4.9	Restriction on animals	Is access of animals to the facilities restricted?	Major			
FV 5.4.10	Strength of packaging material	Are packaging materials used in accordance with the recommended specifications, if any, or as per the approved hygiene standards and have adequate holding strength?	Major			
FV 5.4.11	Labeling and track back	Are the packages properly labelled and coded for unique identification and trace-back?	Critical			
FV 5.4.12	Palletization/ stacking	Are the packages suitably palletized/stacked and loaded in the trucks/containers, as applicable? Are the workers trained for proper stacking?	Major			

FV 5.4.13	Temperature stabilization	Are the packages/pallets shifted to the cold store for stabilization of temperature before loading into containers?	Major			
FV 5.4.14	Suitability of pallets/ stacks	Are the palleted packages marked suitably for proper handling & loading into the trucks & containers?	Major			
FV 5.4.15	Ventilation in vehicles	Is the vehicle/truck suitably covered & ventilated for carrying the cargo by road to destination?	Major			
FV 5.5	**Quality control**					
FV 5.5.1	Documen- tation of inspection	Is a documented inspection process in place to ensure compliance with a defined quality standard?	Major			
FV 5.5.2	Documen- tation of temperature and humidity controls	Are temperature and humidity (where applicable) controls maintained and documented where produce is packed and/ or stored?	Critical			
FV 5.5.3	Light sensitive products	For products that are sensitive to light (e.g. potatoes), is daylight ingress controlled in longer term storage facilities?	Critical			
FV 5.5.4	Temperature control equipment	Is there a process for verifying measuring and temperature control equipment?	Major			
FV 5.6	**Rodent and bird control**					
FV 5.6.1	Blockade at entry points	Are all entry points to buildings or equipment that may come into contact with them suitably protected to prevent, whenever practically possible, the ingress of rodents and birds?	Major			
FV 5.6.2	Bait points	Are there site plans with bait points and/or traps?	Major			
FV 5.6.3	Protection of non-target species	Are baits placed in such a manner that non-target species do not have access?	Major			
FV 5.6.4	Record keeping	Are detailed records of pest control inspections and necessary actions taken, kept?	Major			
FV 5.7	**Post-harvest washing**					

FV 5.7.1	Water source	Is the source of water used for final product washing potable or declared suitable by the competent authorities?	Critical			
FV 5.7.2	Re-circulation conditions	If water is re-circulated for final product washing, has this water been filtered and are pH, concentration and exposure levels to disinfectant routinely monitored?	Critical			
FV 5.7.3	Laboratory	Is the laboratory carrying out the water analysis a suitable one?	Minor			
FV 5.8	**Post-harvest treatments**					
FV 5.8.1	Labelling instructions	Are all labeling instructions observed?	Critical			
FV 5.8.2	Registration of biocides	Are all the biocides, waxes and plant protection products used for post-harvest protection of the harvested crop officially registered in the country of use?	Critical			
FV 5.8.3	Selection of biocides	Are any biocides, waxes and plant protection products used on harvested crop destined for sale in the importing countries are banned?	Critical			
FV 5.8.4	Updation of list of post-harvest chemicals	Is an up-to-date list maintained of post-harvest plant protection products that are used, and approved for use, on crops being grown?	Major			
FV 5.8.5	Competence of responsible person	Is the technically responsible person for the harvested crop handling process able to demonstrate competence and knowledge with regard to the application of biocides, waxes and plant protection products?	Critical			
FV 5.8.6	Record of identity of chemicals	Have the post-harvest biocides, waxes and plant protection product applications, including the harvested crops' identity (i.e. lot or batch of produce), been recorded?	Critical			
FV 5.8.7	Record of formulations made on site	Are the ingredients of post-harvest biocides, waxes and plant protection products used in on site formulation preparation approved by the competent authorities?	Critical			
FV 5.8.8	Record of location of chemicals	Has the location of the post-harvest biocides, waxes and plant protection products applications been recorded?	Critical			

FV 5.8.9	Record of application dates	Have the application dates of the post-harvest biocide, wax and plant protection product been recorded?	Critical			
FV 5.8.10	Record of treatment	Has the type of treatment been recorded for the post-harvest biocide, wax and plant protection product applications?	Critical			
FV 5.8.11	Record of chemical trade names	Has the product trade name of the post-harvest biocide, wax and plant protection product applications been recorded?	Critical			
FV 5.8.12	Record of quantity of chemical applied	Has the product quantity applied of the post-harvest biocide, waxes and plant protection product applications been recorded?	Critical			
FV 5.8.13	Record of operators	Has the name of the operator of the post-harvest biocide, wax and plant protection product applications been recorded?	Major			
FV 5.8.14	Record of justifications	Has the justification for application for the post-harvest biocide, wax and plant protection product applications been recorded?	Major			
FV 5.8.15	Completeness of record	Are all of the post-harvest plant protection product applications also considered?	Critical			

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