Chapter 1

The Potato (*Solanum tuberosum* L.) popularly known as "The king of vegetables" is the third most important food crop in the world after rice and wheat, provides wholesome food (Rhoades, 1982) and consumed by billions of people worldwide. Global production during 2009-10 was 329.58 million tones from the total area of 18.65 million ha resulting in per capita availability of nearly 50 kg (Vision 2030). Both production and consumption are accelerating in most of the developing countries including India and it is expected that the trend will continue for years to come. The two emerging Asian economies, viz. China and India together contribute nearly 1/3rd of the global potato production today. Potato is preferred in these densely populated countries largely because of its high productivity, flexibility in terms of fitting into many prevailing cropping systems, and stable yields under condition in which other crops may fail. Potato consumption in this region is increasing due to increasing industrialization and participation of women in the job market that created demand for processed, ready-to-eat convenience food, particularly in urban areas. Keeping in view the potential of the potato in the food security of developing nations, FAO has declared it as the "food for future". Unlike developed nations, however, potato has not yet been accepted as staple food in India but it is still being considered as a vegetable supplement. The per capita consumption of potato in India is far below many of the developed countries and even China where per capita consumption is about 50 kg. In fact, China has identified potato as a key crop from which 50% of its extra food demand during next 20 years will be met. (http://www.cipotato.org/press-room/press-releases/feeding-the-future).

Agriculture contributes about 15.7% of the Gross Domestic Product (GDP) of India. Potato contributed around 2.42% of agricultural GDP in 2008 from 1.25% cultivable area. On the contrary, the two principal food crops rice and wheat contributed 14.61% and 8.40% of agricultural GDP, respectively in 2008 from 30.44% and 19.61% cultivable area respectively. Therefore, contribution of...
potato in agricultural GDP from unit area of cultivable land is about 4 times higher than rice and 4.5 times higher than wheat.

In a potato tuber, about 75% is water content and the rest is dry matter. Starch is the major component of the dry matter accounting for approximately 70% of the total solids. The potato can be distinguished from cereals like rice and wheat for its higher capacity to produce dry matter, which is about 47.6 kg/hectare/day. The average composition of the potato tuber per 100g edible portion is as follows, edible portion (85%), protein (1.60g), fat (0.10g), minerals (0.60g), fibres (0.40g), carbohydrates (22.60g), energy (97 kcal), calcium (10mg), phosphorus (40mg), iron (0.70mg), carotene (24mg), thiamine (0.10mg), riboflavin (0.01mg), niacin (1.20mg), vitamin c (17mg) etc. (Gopalan et al, 1972). A potato tuber also contains a number of B-group vitamins and high quality dietary fibres (Swaminathan and Pushkarnath, 1962). The potato produces more edible protein per hectare/day (about 3kg) than rice and wheat and most importantly, the biological value of the potato protein is about 71% that of whole egg, a figure much better than that of wheat (53%), maize (54%), peas (48%) and beans (46%) and even comparable to cow’s milk (75%) (The Potato pp. 3). Equally impressive is the capacity of the potato to produce the minerals, which is about 4-11 times more than that of wheat and rice, respectively. The potato is low energy food (97 kcal/100g fresh weight) because it contains low fat (0-1%) and calorie. Therefore, it is misconception that potato causes obesity. In all, the potato is a high nutritious, easily digestible wholesome food and unique because it can be consumed as boiled, fried or processed all with equal culinary delicacy.

1.0 Surveyed states and potato production systems

1.1 State profile and agro-ecology

1.1.1 Meghalaya

The Meghalaya state is located between 25°1’ and 26°5’ North latitude and 85°4’ and 92°52’ East longitude and has an area of about 19000 ha and production of 175500 tones with 7 districts producing potato crop. The maximum area is
under East Khasi Hills followed by West Khasi Hills and Garo Hills. The potato is grown mainly in two seasons, Kharif (main) and Rabi (15-20% of total Kharif season). Some of the old varieties like President, Great Scot, Royal Kidney and Pimpernel are still cultivated in addition to Kufri Jyoti, K. Megha and K. Giriraj and recently released varieties like K. Girdhari and K. Himalini.

1.1.2 Sikkim

The Sikkim state is located between $27^\circ 5'$ to $20^\circ 9'$ North latitude and $87^\circ 59'$ to $88^\circ 56'$ East longitude and has an area under Kharif season of 5148 ha and a production of 23062 tones and under Rabi 4620 ha and production of 24029 tones. All the four districts of the state produce potato with maximum area under West Sikkim district followed by East Sikkim. K. Jyoti and K. Kanchan are popular among the improved varieties while Beta and Red Pimpernel are the other traditional varieties that are grown in Sikkim. Recently K. Shailja and K. Giriraj have been procured and being multiplied at State Potato Seed farms at Rawangla (South Sikkim) and Hilley (West Sikkim).

1.1.3 Arunachal Pradesh

The Arunachal Pradesh is located between $25^\circ 32'$ and $29^\circ 30'$ North latitude and $91^\circ 51'$ and $97^\circ 31'$ East longitude and has an area of 4000 ha and production of 31700 tones with maximum area in Tawang and Kemeng districts. K. Jyoti and K. Kanchan are the popular varieties cultivated in the state.

1.1.4 Nagaland

The Nagaland state is located between $25^\circ 6'$ to $27^\circ 4'$ North latitude and $93^\circ 20'$ to $95^\circ 15'$ East longitude and has an area of 3500 ha and production of 31,420 tones with the maximum area under Kohima district followed by Dimapur. K. Jyoti, K. Badshah and K. Kanchan are the common and popular varieties grown.

1.2 Climate

The vast area of hills in the NE region is interspersed with fertile valleys with altitudes ranging from 15 m to 2700 m amsl and above. The region is characterized by hot sub-humid (moist) to humid with warm summers and cold winters (Sehgal et al., 1990). The temperature varies with altitudes with the minimum generally ranging between 4-6°C during December-January and the maximum between 27-29°C during June-August. The climatic conditions vary from Alpine in Arunachal Pradesh and Sikkim to sub tropical in Assam and
Tripura. The well distributed precipitation and deep alluvial loamy soils with pH ranging from 4.5-6.5 allows growing of wide variety of agricultural/horticultural crops including potato.

Potato is an important crop in the North Eastern region of India contributes nearly 10% of total potato area of the country but contributes only 4% of total production due to very low productivity. The average potato production of all the NE states during 2001-2004 was recorded 0.95 million tones from 0.12 million hectares with average productivity 7.8 t/ha (Dhiman et al., 2006). The yield however in all the NE states except Tripura (18.5 t/ha) has been all time low (4-8 t/ha) as compared to the national average (19.8 t/ha).

The major limiting factors for low potato yields in the NE states are as follows.

- Inadequate supply of healthy planting material at reasonable prices due to high transportation cost of seed from North India, a distance of more than 2000 km resulting in use of degenerated seed stock
- Adoption of sub-optimal management practices due to farmers and extension workers
- Unawareness of improved agro-techniques for informal quality seed production
- Imbalanced use of fertilizers
- Fast degeneration of tuber seed by viruses due to farmers' ignorance of integrated disease/pests management practices
- Un-organized informal seed producers, such as in North and North West India
- High rainfall during crop season (March-July), resulting in infestation of weeds and making environment congenial for diseases like late blight and brown rot and pests (mainly white-grubs)
- Lack of knowledge of appropriate storage practices
- Shifting (Jhum) cultivation in some areas in which land quality has been degraded by soil erosion and nutrient loss
1.3 Aphid as a virus vector

Aphids are virus vectors *par excellence* of agricultural and horticultural crops. Over 4500 species of aphids have been reported world over, of which, about 675 occurs in India. Among them *Myzus persicae* (Sulzer) and * Macrosiphum euphorbae* (Thomas) are important vectors limiting virus-free potato seed production and often reported as the most important virus vectors that can, respectively transmit over 100 (Kennedy *et al.*, 1962, Blackman and Eastop, 1984) and 45 plant viruses (Fluentes *et al.*, 1996). More than 40 aphid species have been reported to be the vector of different potato viruses, however, only a few species mainly *M. persicae* (Sulzer) and *A. gossypii* (Glover) are important in India. Viruses may be transmitted to originally healthy plants either mechanically through machinery, clothing, neighbouring plants (e.g. PVX and PVS) or by specific vectors, such as aphids (PVA, PVM, PVY and PLRV), nematodes (strain of tobacco rattle virus is transmitted by *Trichodorus and Paratrichodorus* species) and by fungi (e.g. tobacco necrosis virus is transmitted by *Olpidium brassicae* and PMTV is transmitted by the powdery scab organism *Spongospora subterranea*). Important and most devastating viral diseases in potato are Potato Virus Y (PVY), Potato Virus A (PVA), Potato Virus M (PVM), Potato Virus X (PVX) and Potato Virus S (PVS) and Potato Leaf Roll Virus (PLRV) and many more viruses are reported with some impact on yield. Potato can be infected by more than 30 RNA viruses (Salazar, 1996) among which 13 are transmitted by aphids (Brunt and Loebenstein, 2001). They transmit a number of viruses in potato crops in non-persistent manner (e.g. PVA, PVM and PVY) and other ones in persistent manner (PLRV). For growing potatoes the green peach aphid (*M. persicae* Sulzer) is the most important and the most harmful occurs world wide and is by far the most efficient vector of plant viruses.

Viral diseases are very variable and their impacts strongly depend on the cultivars, which they in fact and only condition where these cultivars are grown. The disadvantage of potato, is being host of more than a dozen plant viruses, a viroid and phytoplasma (Khurana and Singh, 1986; Jeffries, 1998) progressively accumulated into the tubers and carried over repeated multiplications resulting in the gradual degeneration and makes seed tuber health an important issue.

Seed tubers also respond to the abiotic conditions during their production and storage but the effects of these conditions are also reflected in the physiological quality of the seed tubers, as expressed in their ability to produce a vigorous crop.
1.4 Objectives

Low productivity of potato in NE regions of India is mainly due to non-availability of healthy planting material. Moreover, being vegetative propagated crop, 25-30 quintals seed is required for a hectare resulting in about 50% of the total cost of cultivation on seed only. For better harvest, healthy seed is a prerequisite for any crop. This region being situated far from the Northern seed producing areas can not afford to procure healthy seed potato therefore, farmers are compelled to use locally available degenerated seed stock year after year which results into low yields. The only answer to this problem is the production of quality seed locally by the growers themselves.

The present study was undertaken to conduct detailed survey on aphid monitoring and their potential to transmit viral diseases (PVY and PLRV) with the following specific objectives.

- Monitoring aphid population dynamics during crop period to understand the virus-vector potential of potato aphids for identifying low aphid or aphid free areas in the selected sites for raising healthy seed potato crop
- Evaluation of degeneration of seed stock due to farmers’ ignorance of integrated disease/pests management practices
- Understanding of the relationship between altitudes and other climatic factors on virus-vector pressure in the surveyed sites