Chapter 5

The potential of potato, *Solanum tuberosum* L. as one of the most efficient food crop is an accepted fact. Since, this crop enjoys the first place among cash crops in NE Hills, it is therefore essential to improve its production efficiency by raising quality seed crop by identifying suitable sites with low vector pressure and least degeneration of seed stocks. In the present studies work was carried out to monitor vector population in potato growing season and correlating its population with the meteorological factors. Studies was also conducted to see the degeneration rate of popular varieties at two ideal locations and prevalence of various virus strains in potato crop raised in the farmers fields with their own seed stocks. Besides, with the help of remote mapping identified other similar locations in entire NE states where successful quality seed production can be suggested.

5.0 Virus potential

The present studies are in conformity to the studies conducted by other workers that on the virus potential the variation in aphid transmission ability of the aphid clones are because of the original host effect or the prevailing environmental condition and factors (Swenson, 1960; Miyamoto and Miyamoto, 1966). Such clonal variations have also been observed by the Simons, 1958; Sohi and Swenson, 1964, in the transmission of the stylet-borne plant viruses. It has also been observed that the clones which are efficient in transmitting potato leaf roll virus are essentially not efficient in transmitting potato virus Y and vice versa as reported by (Upreti and Nagaich, 1971 a, b). Some differences observed in efficiency of transmission in the case of different clones for PVY and PLRV can be attributed to the different environmental conditions that the PVY is non-persistently transmitted whereas PLRV is persistently transmitted.

In the literature it is reported that in border crops near to that of potato crops were found more effective in early aphid build-up in the crop where in the crops grown isolated places or near to the maize or other non-solanaceous crops, the population were recorded very low due to the fact that the viruliferous winged aphids searching for a host plant must have alighted in the border crop, and after probing it loses its infectivity before entering the area of susceptible primary crop (DiFonzo *et al.*, 1996) these crops are more effective in reducing the population build up, however the present finding slightly differs from them as in NE Hills due to small holdings most of the farmers practice mixed cropping due to which *M. persicae* (Sulzer) populations were slightly higher in potato crops i.e., the experimental sites at Pedung village, Arunachal Pradesh and Khuzama village in Nagaland.
5.1 Aphid monitoring

In Meghalaya the potato farmers are un-aware of the viruses and viral disease spread by the aphids and do not take any protection measures against them resulting in aphid population build up in un-sprayed crops soon after the crop emergence and remains in the crop till the maturity or crop damaged due to late blight. However it was observed that at lower altitudes the threshold limit 20 aphid/100 leaves crossed earlier than that of the plots at higher altitudes it supports the findings of earlier workers that the aphid population build-up had direct correlation with the abiotic factors like temperature and humidity as reported by Bertels (1976). Further it was critically observed in our studies that if potato crop is sprayed with systemic insecticides soon after the aphid appearance then the aphid population never crosses the critical level. The fungal disease like late blight usually affect the crop by first to second week of May and due to the infestation lowers leaves were affected earlier, which supposed to be the main site for aphid multiplication, resulted in sharp decline in aphid population with the severity of the late blight by the third week of May. The earlier workers have not reported this natural phenomenon and present findings are new in this direction for North Eastern Hilly states. This phenomena have also been reported elsewhere by some workers (Shands et al., 1954; Mack and Smilowitz, 1981; Jansson and Smilowitz, 1985a; Nderitu and Mueke, 1986. Further, the potato crops are almost 100% killed at all the locations due to late blight by middle of June, hence, the aphid build-up in the crop is automatically ceased. The present investigations slightly different from earlier reports made by Pushkarnath, (1976) and Verma, (1977), that aphid population in Shillong and surrounding areas remain very high during July, may be due to prevalence of highly late blight resistance varieties at that time, but in our studies we observed that in the absence of green foliage the congenial environment for aphid colonizing lacking.

The aphid population build-up trends in potato crop in all selected states and locations in NE-region were recorded similar. The chances of virus dissemination through aphids are diluted in NE-mountains because of high rainfall between May to July restricting free movement of aphids in potato fields. Our results are similar to those of Hille Ris Lambers (1972) who reported that rains temporally dislodge aphids from plants and does not affects its population, but in our findings it was observed that in the absence of lower leaves aphids unable to climb back on upper foliage. Secondly, the crop foliage very base on which aphids could multiply and disseminate virus infection is killed by late blight. The crop is about 90-100 days old by May/June before it is killed by the late blight.
The monitoring during autumn crop in Meghalaya revealed that the aphid build-up trend during autumn crop in East Khasi Hills district are dependent on the combined effect of the meteorological parameters which are not similar in different years of our study. Overall, the aphid population build-up trends in potato crop, at almost all the sites, were somewhat similar but their population was on slightly higher. The aphid population increases to 20/100 leaves just after two weeks of crop emergence and remained above till crop maturity (Figures 8, 9 & 10) due to the fact that the farmers' lack knowledge of disease free seed production technologies and appropriate storage practices. Our studies suggests that “successful quality potato seeds” can be raised in autumn season provided potato growers taught the basics of “Seed Plot Techniques” for raising their crop suggested by Pushkarnath (1976) It supports our studies that in the insecticidal sprayed crops at the CPRS, farms aphid population remained much below than that of critical level till the crop maturity (Fig. 7).

The planting of potato in NE- Hills normally starts in early February and continue by first week of March depending on altitudes of the sites and prevailing favourable temperatures. The present study concludes that healthy potato seed can be produced successfully if field crop if examined regularly and virus-infected plants are rouged out from the stocks, the chances of virus infection can be tremendously reduced. Secondly regularly spraying the crop with systemic insecticides based on the traps catches data. Our studies confirm the findings of earlier reports by Das et al., 1996; Basky, 2003 and Biswas et al., 2005 that yellow sticky traps are more efficient than the yellow water pan traps for recording first appearance of aphids in the crop.

5.2 Degeneration

The results indicated that the yields recorded from the fresh breeder seed following the seed plot technique was recorded 2-3 folds higher than the yield obtained in the crop raised with farmers own seed. The reduction in the crop yields raised with farmers own seeds was 18.85 % and 29.00% in cv. K.Jyoti and 30.41 % and 38.55% in cv. K.Giriraj in Meghalaya and Nagaland respectively. High reduction in yields in cv. K. Giriraj might being more susceptible to potato viruses than K. Jyoti. The present study revealed that the crop productivity can be raised to 2-3 folds higher, if good quality seed socks made available to the farmers for raising their own seed crop. Our findings on degeneration studied in Meghalaya and Nagaland are in accordance with the earlier finding of Khurana and Singh, (1988) that in Shimla hills the degeneration in variety K. Jyoti due to PVX alone was 15.36 and 52% in the 1st, 2nd and 3rd year. On the other hand, infection of PVY alone was only 3.6 and 11% in the seed exposed for 1st, 2nd and 3rd year. Further, it was also observed that the losses in the three varieties including K. Jyoti,
due to current year infection of PVX and PVY varied between 11 to 17% and 36 to 48% respectively. In the second year PVX and PVY infected plants yielded 17 to 24% and 40 to 58% less than control (ware crop). The results lend support to earlier recommendations where hills have been said to be suitable for producing healthy seed potatoes (Pushkarnath, 1976 and Verma, 1977). As the main crop gets enough time to tuberize and bulk before the aphid population crosses the critical level.

There was significant difference in yields at both the locations between crops raised with quality seeds and with ware potato crop after four years of field exposure, which clearly indicated that crop productivity under present conditions of both the varieties can be maintained only for three to four years if the essentials of Seed Plot Technique are adopted. Based on our finding we agree with Verma et al., 1998, who also recommended that replacement of potato seed stock once in three to five years. Similar findings are also reported by Pushkarnath (1976); Nagaich et al., 1969; Singh et al., 1977; Khurana and Singh, 1988; Khurana and Singh, 1997 for North Western plains of Uttar Pradesh. Nagaich et al., 1974, reported that 30% yield loss due to mild mosaic viruses in Shimla hills and 50% less yield in four years under high aphid population. Khurana, 1999 reported that a lower incidence up to 5-10% of virus does not cause a marked yield reduction, but a higher incidence results in serious depression. Garg (1987) also observed quick degeneration of potato varieties in 3-4 years in Maharasra conditions. Vashisth et al., (1981) based on his studies from Punjab reported that slight increase in virus incidence and reduction in yield in exposed crop to natural vector pressure from 4th year onward in potato cultivars and advocated replacement of the seed every 3’rd to 4’th year. In our studies we also observed that the rate of degeneration is lower in cv. K. Jyoti compared to K. Giriraj but the seed stock of K. Giriraj in Nagaland were more susceptible and higher degeneration rate was recorded compared to the seed stock in Shillong, this may be due to the presence of high virus inoculums in nearby farmers potato crop due to their ignorance or inability to recognize virus infected plants.

The infected leaf samples randomly collected from farmers’ fields from surveyed sites were processed in laboratory by adopting ELISA technique and PCR to ascertain the aphid transmitted viruses like PVY and PLRV. It was observed that these viruses more prevalent at lower altitudes in the states of Meghalaya and Nagaland (< 1650 m amsl) while contact viruses i.e., PVX & PVS were in abundance at all the sites, mainly because farmers use same seed stocks year after year (Table.4). The present studies found more relevance for identifying locations with low aphid pressure for minimum degeneration of seed stocks for multiplying seed potato crops in the respective NE states.
Based on the present findings on the aphid monitoring & population build-up trends an extrapolated geographical map of NE Hills was drawn with the help of Digital Elevation Model (DEM, GIS) and it gave us clear picture of the possible ideal locations for raising potato seed crops in the places located at the altitudes between 2000 to 2700 m amsl. The sites can be further divided in two categories based on their altitudes (Fig.23)

I) Ideal sites (2000-2700 m): Shillong Peak in Meghalaya, Hilley Potato Farm, Rawangla Upper Farm, Okhrey and Ribidi in Sikkim, Upper Wanghoo, Warjung Village in Arunachal Pradesh and Upper Ukule Kigwema in Nagaland.


5.3 Transmission

The transmission studies are in accordance with the studies of earlier workers (Singh, 1981; Verma, 1977, 85, 93, 98; Verma and Chandla, 1999; Santanu and Konar, 2003) who reported that aphid, *M. Periscae* (Sulzer) transmit the important potato virus and play a vital role in limiting seed potato production. Aphid species identified on potato crops in all the surveyed states and sites were *M. persicae* (Sulzer) and *Aphis gossypii* (Glover) but it was observed that *M. persicae* (Sulzer) has the potential to transmit the viral diseases being the most polyphagous and efficient vector species as reported by various workers (Blackman and Eastop, 2000; Bernhard and Dixon, 2005). In addition to the virus disease transmission high population of aphids in the crop can cause considerable injury through sucking of plant sap and plants depicted different virus like symptoms (Kabira *et al*., 2006, Townsend, 2007). Among the important potato viruses PVY was found more common affecting potatoes in our studies because it is easily transmitted and cause yield losses and also reported by (Beemster and De Bokx, 1987; Singh *et al*., 1982; Ward and Shukla, 1991). Our study revealed the presence of PLRV which is most efficient vector at almost all the locations in abundance which primarily causes heavy yield loss as suggested by previous workers (Botjes, 1920; Schultz and Folson, 1921; Cottier, 1931; Williams and Ross, 1957; Close, 1965; Claridge, 1972; Lowe, 1973; Miln, 1978; Sylvester, 1980; Raman, 1985; Webby, 1988; Jayasinghe, 1988; Halbert *et al*., 1995; Woodford *et al*., 1995; Suranyi, 1999).

The infected samples were brought from all the surveyed locations in NE region to ascertain the prevalence of various potato viruses. The electron microscopy results of these samples showed the presence of PVY and PLRV and their morphological characters were similar to that of reported by earlier workers (Garg *et al*., 1989; Garg and
Khurana, 1991; Khurana and Garg, 1993 and Khurana and Garg, 1995), it may be due to the seed stock grown in NE hills are procured long back from the North Western hills and other states of North Western plains where above reported viruses are quite prevalent. Since the farmers of NE hills use their own seed stocks year after year for raising their potato crop, hence all our findings showed similar results as reported by earlier workers from North Western states. The isolated viral RNA and PCR results showed the band size typical of ~320 bp (PVY) and ~492 bp (PLRV) already reported from North Western plains and hills by various workers.