

PERFORMANCE OF SIX DIFFERENT POTATO VARIETIES GROWN FROM SEVENTH GENERATION SEED POTATO AGAINST PVY

A. K. M. SHAHED BIN MANNAN¹, A. M. AKANDA², M. K. A. BHUIYAN², AND A. K. M. S. ISLAM³

¹Research Officer, Centre for Innovation and Development Strategy (CIDS), Rampura, Dhaka, ²Professor, Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur and ³Leaf Extension Executive, British American Tobacco Co. Ltd., Kushtia, Bangladesh

Accepted for publication: December 01, 2008

ABSTRACT

Shahed Bin Mannan A. K. M. , Akanda A.M., Bhuiyan M. K. A. Islam A.K.M. S. 2008. Performance of Six Different Potato Varieties Grown from Seventh Generation Seed Potato against PVY. J. Soil. Nature. 2(3): 68-75

An experiment was conducted in the field of Plant Pathology Department of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the cropping season 2006-2007 with the seventh generation seed potato of six different varieties namely Baraka, Remarka, Victoria, Voyager, Bellini and Diamant. The seed potatoes of six varieties were planted in the field to find out the performance of that seed tuber against PVY infection. The incidence of PVY was ranged from 1.67%-81.11% which was higher than healthy plants in all the varieties. The reduction of stem number per plant due to incidence of PVY was estimated to vary from 3.93%-25.81% depending on the varieties as compared to healthy. In case of reduction of number of tuber per plant PVY (23.28%-45.70%) reduced more severely as compared to healthy in all the varieties. Tuber yield reduction for PVY was 44.99%-72.47% as compared to. In tuber grading PVY infected plants produced more number of under graded tubers in all the varieties as compared to healthy. None of the varieties was found to be resistant against the virus. However, seventh generation of the six varieties responded no significance difference in respect of growth and yield due to infection of PVY.

Keywords: Seed potato, incidence of PVY, yield, tuber grade

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a staple food next to rice and wheat grown almost all over the world. Not only a staple food, but also popular as vegetables as well as a main item of preparing various food and confectionary. The yield potential and food value compared to rice and wheat, potato is considered as a promising food crop against world hunger including Bangladesh where food storage is a chronic feature (Anonymus, 1992). In 2004-05, approximately 60 lakh tons of potato was produced from 4 lakh hectares of land. The national average yield of potato is around 15.0 t/ha, which is remarkably low as compared to many other potato growing countries (Anonymous, 2006). The per hectare yield of potato is about 18.38 t/ha in India, 32.65 t/ha in Japan, 33.16 t/ha in Israel, 34.62 t/ha in Australia, 45.28 t/ha in New Zealand, 41.82 t/ha in USA, 28.06 t/ha in Canada, 39.71 t/ha in Denmark, 40.67 t/ha in Germany and 73.57 t/ha in Netherlands (Anonymous, 2007). So, there is an ample scope of increasing potato production in Bangladesh where land scarcity is an acute problem to accommodate diversified crop cultivation. The non availability of quality seed is the major constraint for such low yield of Potato in Bangladesh. Drastic yield reduction of Potato is attributed by various diseases all over the world of which virus diseases are regarded as most important ones. At least 37 viruses naturally infect cultivated potatoes (Brunt, 2001). But the entire viruses do not occur and cause yield loss in all potato growing countries all over the world. Among these, potato virus Y (PVY) is of immense importance causing tremendous yield loss of potato crop (Ali and Khan, 1991) reported the occurrence of seven different viruses (PVY, PLRV, PVX, PVS, PVM, PVA and TMV) on potato in Bangladesh and among them PVY is of most important. PVY is the RNA virus belonging to the Potyvirus group. The virus is transmitted by aphid species in the field. *Myzus persicae* and *Aphis gossypii* are the two important vectors of the virus (Foreres *et al.*, 1993, Ver Zola *et al.*, 1993). The virus persists in the tubers of the infected plants which is the major menace of potato cultivation. Among the viruses PVY have been found to be the most important aphid-vectored virus occurring in almost all potato growing countries of the world affecting the yield and quality of potatoes (Hossain *et al.*, 1994). PVY is the second most important virus disease, which occur worldwide after PLRV (Anonymous, 2006). As PVY is aphid transmitted (Sing *et al.*, 1984) they can be controlled by controlling the vector which is mainly responsible for transmitting and spreading the virus. But it is very difficult to control them through spraying of insecticides (Hemphill *et al.*, 1989). The field epidemiology of these diseases is highly complex and tenacious as insect vectors are involved. The gradual loss of yield potential of potato referred to Degeneration has been recognized as one of the major constraints of Potato cultivation in all Potato growing countries of the world (Bhandal and Naik, 1991, Sawicka, 1994). Yield loss due to PVY rose up to 95% with severe infection in Bangladesh (Hossain and Ali, 1992). PVY have been reported to be major virus occurring in almost all potato growing countries. In Bangladesh a major portion of the potato growers kept their seed tubers by themselves from their own field which they use for the successive crops. This is reasonably believed to be the main cause of poor yield due to use of degenerated seed

tubers by the farmers due to ignorance (Khurana *et al.*, 1998). When a plant is affected with PVY, all the tubers of the plants may not be infected. Tuber infection depends upon the size of the tubers (Sangar *et al.*, 1994). The immense importance of healthy seed potato tuber production against PVY in the country needs not to be over emphasized to boost up potato production in Bangladesh. The methods so far available to produce healthy seed potato against PVY needs to be critically evaluated which might be highly beneficial for potato production in Bangladesh. In this context evaluation of seed potato tubers of different generations developed and maintained by BADC might be under the priority of study. It is also highly important to maintain proper certification.

Viewing the facts described earlier the research program was undertaken with the following objectives.

1. To find out the performance of seventh generation seed tubers of six different potato varieties in respect to PVY infection
2. To find out the effect of PVY infection on plant growth and yield

MATERIALS AND METHODS

Experiments conducted

The experiment was conducted in the field at the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), gazipur-1706 during potato growing season 2006-2007. The materials used and methods in the experiments are described below. In experimental field the soil belongs to Salna series under the Agro Ecological Zone (AEZ)-28: Madhupur Tract. The texture of the soil was silty clay in surface layer and silty clay loam in subsurface layer (Rahman *et al.*, 1998). The pH of the soil was 6 to 6.5. The climate of the area is characterized by heavy precipitation during April to September and scanty or no rainfall during October to March 2006-2007.

Collection of potato seed tubers

Seventh generation seed potato of six different varieties namely Baraka, Remarka, Victoria, Voyager, Bellini and Diamond were used in the experiment to evaluate their, disease incidence, growth and yield performance against PVY. Seed tubers were collected from plant pathology laboratory, department of plant pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur.

Land preparation and fertilizer application

The experimental field was mechanically ploughed and leveled to have a good tilth at late November 2006. Before preparation of the land, cow dung @ 10 t/ha was applied. The crop was fertilized with 350, 250, 270, 120, 120, 10, 6 kg/ha of Urea, TSP, MP, Gypsum, Magnesium sulphate, Zinc sulphate and Borax, respectively as recommended by Tuber Crop Research Centre (Anonymous, 2005). One half of the Urea and full dose of all other fertilizers were applied prior to planting. The rest half of the Urea was applied 25 days after planting when first earthing up was done.

Planting and intercultural practices

The seventh generation of all the varieties of seed tubers were planted maintaining 60 m x 30 cm spacing. The unit plot size was 3 m x 1.8 m. The experiments were set up in Randomize Complete Block Design (RCBD) with three replications. The crop was raised following usual cultural practices such as irrigation, weeding, earthing-up etc. were done as and when necessary.

Haulm killing and harvesting

Haulm killing was done ten days before harvesting with a view to avoid the spread of viruses and for hardening of tuber skin. The crop was harvested 95 days after planting and the healthy and PVY infected tubers of each plant was kept separately in net bags separately for further study.

Grading of tubers

The grading of tubers were into four different groups following the standard of BADC as < 28 mm, 28 - 40 mm, 41-55mm and >55 mm which was designated as Under, A, B and Over respectively.

Aphid counting by yellow water trap

Two yellow water traps ('Moericke' yellow trap) were placed in two different locations of the experimental field to catch the aphid vectors as described by Moericke (1957). The trapping initiated from the first week of January,

2007. Half of the yellow trap was filled with tap water where few drops of liquid trix soap were added so that the aphids could not fly after falling on the traps. The number of aphids were counted one day interval at 5 pm. up to the date of haulm killing. The water of the traps was changed every time after aphid counting.

Counting of Healthy plants, PVY infected plants in the field

To observe the symptoms of PVY the plants of the plots were checked visually from the date of emergence to record the number of plants infected with PVY.

Identification of PVY infected plants

PVY incidence was identified based on symptomatological study, mechanical inoculation test (Brunt *et al.*, 1990) and Double Antibody Sandwich Enzyme-Linked Immunosorbent Assay (DAS-ELISA).

Symptomatological study

The identification of PVY infected plants was done mainly through visual observation of typical symptoms. Plant showing rugosity (mosaic plus all kinds of deformation of leaves), weak to severe necrosis, dwarf and brittle with leaves wrinkled and bunched together and finally death of the plants was identified as PVY infection (Beemster and Rozendal, 1972). Some varieties showed both rolling and severe necrosis at the margins of the older leaves. Later on healthy and PVY infected potato plants were confirmed by indicator plant inoculation test and DAS-ELISA using the kit prepared by Agdia Incorporated, USA. The protocol was followed as written in the manual supplied by the manufacturing company. Asymptomatic plants are considered as healthy which was also confirmed by DAS-ELISA.

Double Antibody Sandwich Enzyme-Linked Immunosorbent Assay (DAS-ELISA)

The fundamental protocol outlined by Clark and Adams (1977) for DAS-ELISA and modified by Akanda *et al.*, (1991) was applied in the study. The plants grown in the experimental field were tested using DAS-ELISA (Pathoscreen Kit, supplied by Agdia Incorporated, USA) to reconfirm the identification of PVY infection and healthy plants noted based on symptomatology and indicator plant test. The wells of microtiter plate were examined by eye as well as measured by Immuno-Reader NJ2000 at 405 nm to find out the absorbance value. Wells in which yellow colour develops indicated positive results. Wells which remained colourless indicated negative results. The validity of colour development was confirmed comparing with the results of the positive and negative control.

Data Collection

The data were collected on the following parameters.

- I) Plant height
- II) Numbers of stem/plant
- III) Number of tuber/plant
- IV) Number of tubers / plant under different grades according to following the description of *International Potato Center (CIP)*.
- V) Yield / plant on the basis of tuber weight

Design of experiment and statistical analysis

Randomized Complete Block Design (RCBD) was followed with 3 replications. Analysis of variance (ANOVA) was performed using MSTAT-C software. Data were transformed as and when necessary. Mean separation was done through Duncan's Multiple Range Test (DMRT).

Meteorological data

Meteorological data such as temperature, relative humidity and rainfall were collected from the weather station of Bangladesh Meteorological Department, Agromet Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

RESULTS AND DISCUSSION

Incidence of PVY

The field symptoms, mechanical inoculation test and Double Antibody Sandwich Enzyme-Linked Immunosorbent Assay (DAS-ELISA) were used to identify the typical symptoms induced by Potato Virus Y (PVY) in six different seed potato varieties. As shown in Figure 1 the incidence of PVY was 64.44% and 22.22% was found to be healthy in case of Baraka. The incidence of PVY was 81.11% and 1.11% was found to be healthy in case of Remarka. In

case of Victoria, the incidence of PVY was 39.33% and 2.25% was found to be healthy. In case of Voyager the incidence of PVY was 78.89% and 1.11% was found to be healthy. The incidence of PVY was 1.67% and 1.67% was found to be healthy in case of Bellini. And the incidence of PVY was 50.56% and 3.37% was found to be healthy in case of Diamant.

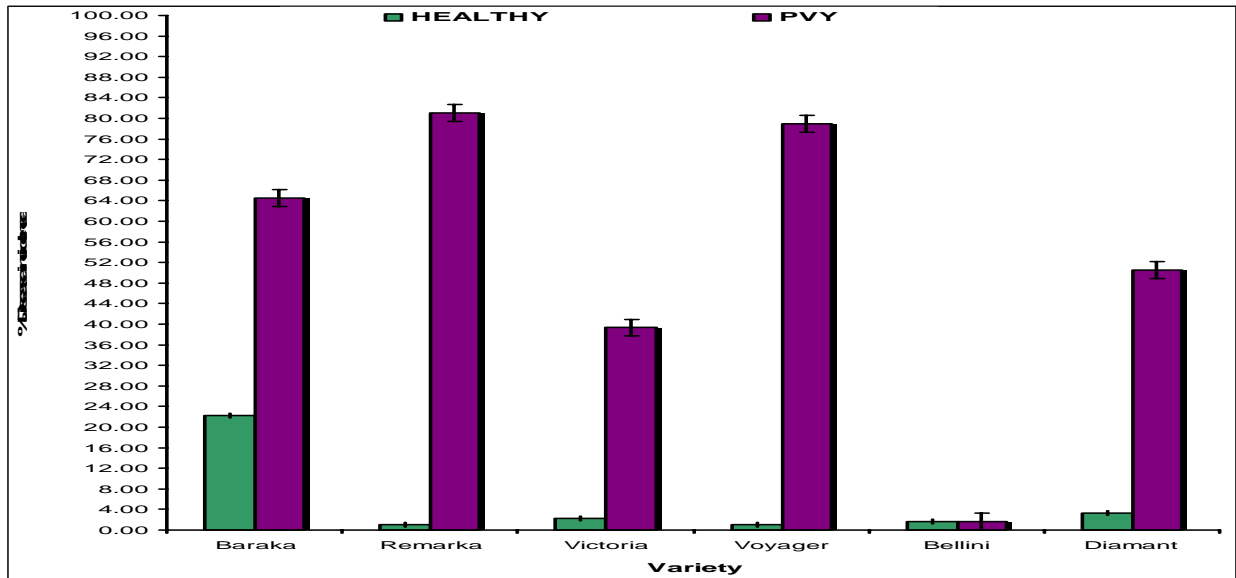


Figure 1. Percent disease incidence of PVY in contrast of healthy plants

Effect of PVY and PLRV on plant height of six potato varieties

Table 1. Effect of PVY on plant height of six potato varieties

Varieties	Plant height (cm)	
	Healthy	PVY
Baraka	71.26 a	56.61 b-e
Remarka	52.53 c-h	46.32 e-i
Victoria	67.39 ab	55.55 b-f
Voyager	73.92 a	62.97 a-d
Bellini	64.49 abc	54.3 b-g
Diamant	66.77 ab	50.06 d-i

* Same letters are not statistically different at 5% level of significance by DMRT.

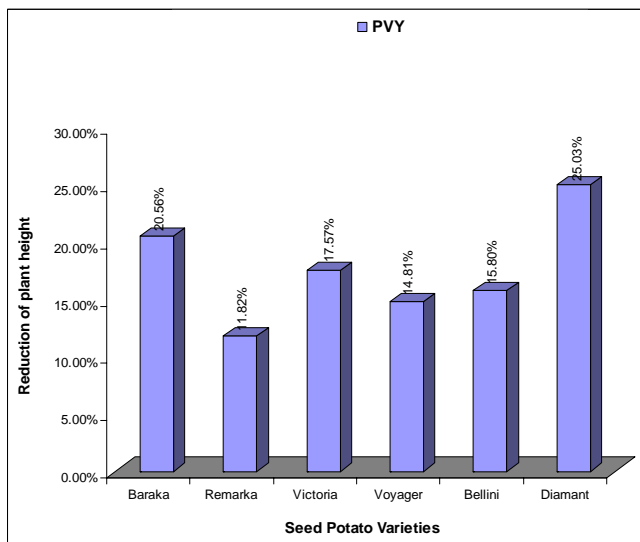


Figure 2. Plant height reduction due to PVY infection in six potato varieties

The results of the plant height of the six different potato varieties namely Baraka, Remarka, Victoria, voyager, Bellini and Diamant raised from healthy and PVY infected seed potato are summarized in Table In all the cases, plant height was found to be the highest in healthy plants as compared to PVY infected plants. In case of variety Baraka, plant height of healthy plants was significantly ($P=0.05$) differed with PVY infected plants in respect of plant height. In Remarka there was no statistical difference among healthy and PVY in respect of plant height. Plant height of healthy plants in Victoria was statistically similar with PVY infected plants and the similar phenomenon was also observed in Voyager and Bellini. However, in Diamant plant height of healthy plants was statistically differed with PVY infected plants. In respect of plant height of healthy plants, none of the varieties was statistically differed with one another except Remarka. However the highest plant height was observed in Voyager followed by Baraka, Victoria, Diamant, beloini and Remarka. In case of PVY infected plants none of the varieties statistically differed among themselves in respect of plant height excluding Remarka where the highest plant height was observed in Voyager followed by Baraka, Victoria, Bellini, Diamant and Remarka. As shown in figure 2, in all the varieties

the percent reduction of plant height was higher due to PVY infection as compared to healthy plants. The reduction of plant height was found to be varied from 11.82- 25.03% due to PVY infection. The results of the present study suggested that the percent reduction of plant height varied depending on six different potato varieties.

Effect of PVY on number of stem/plant of six potato varieties

Table 2. Effect of PVY on number of stem/plant of six potato varieties

Varieties	No. of branches/plant	
	Healthy	PVY
Baraka	3.67 b-f	3.34 c-f
Remarka	3.35 c-f	3.11 c-f
Victoria	4.30 abc	3.19 b-f
Voyager	4.64 c-f	3.90 b-f
Bellini	5.13 a	3.97 a-d
Diamant	3.18 c-f	3.31 c-f

* Same letters are not statistically different at 5% level of significance by DMRT.

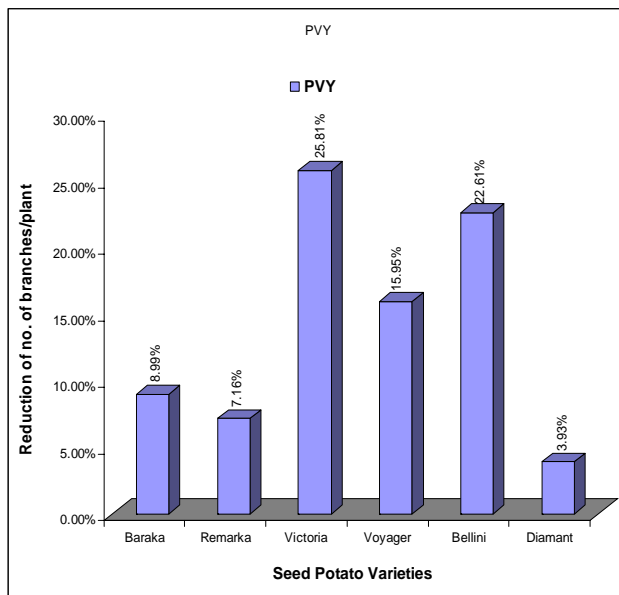


Figure 3. Percent reduction of number of branches per plant due to PVY infection in six potato varieties

Effect of PVY on total number of tuber/plant of six potato varieties

Table 3. Effect of PVY on total number of tuber/plant of six potato varieties

Varieties	No. of tuber/plant	
	Healthy	PVY
Baraka	8.89 c-f	6.82 def
Remarka	10.57 be	5.94 f
Victoria	11.55 bc	7.70 c-f
Voyager	11.18 bcd	8.19 c-f
Bellini	13.93 ab	7.63 c-f
Diamant	17.57 a	9.54 c-f

* Same letters are not statistically different at 5% level of significance by DMRT.

of tuber/plant of healthy and PVY infected plants statistically did not differ among themselves. But in Remarka, Bellini and Diamant healthy plants was statistically differed with PVY infected plants. In case of healthy plants, Diamant and Bellini statistically did not differ with each other however, Bellini, Remarka, Victoria and Voyager also statistically similar with one another except Baraka in respect of number of tuber/plant. The total number of

Table 2 represents the results of number of stem/plant grown from healthy and PVY infected plants of the six different potato varieties. The total number of stem/plant was found to be the highest in healthy plants as compared to PVY infected plants in all the varieties. In Baraka and Victoria it was lowest in PVY infected plants as compared to healthy plants. In case of Baraka, number of stem/plant of healthy plants was significantly (P=0.05) differed with PVY infected plants and the same phenomenon was also observed in Remarka, Victoria and Diamant. In Voyager and Bellini, healthy plants were statistically similar with PVY infected plants. And the PVY infected plants did not differ statistically among each other in respect of number of stem/plant. Among six different potato varieties, healthy plants of Bellini were statistically similar with Victoria but differed with the rest four varieties. However, all the varieties excluding Bellini did not differ statistically with one another in respect of number of stem/plant. The reduction percentage of number of stem/plant was found to be ranged from 3.93- 25.81 due to PVY infection (Figure 3). The present study indicates that the percent reduction of plant height varied depending on six different potato varieties and the virus.

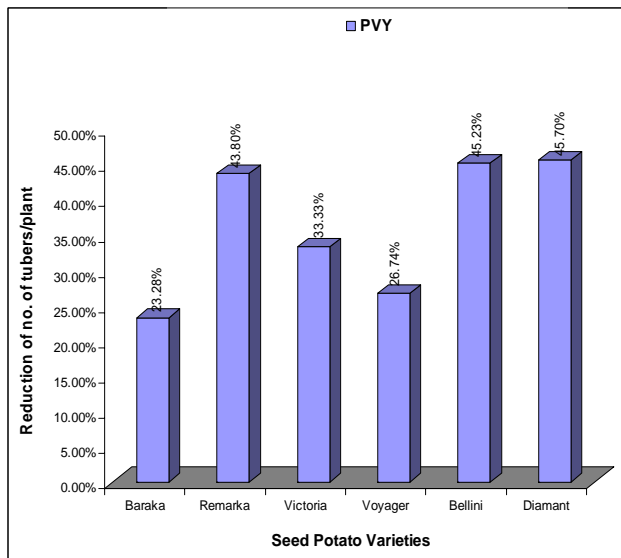


Figure 4. Percent reduction of number of tuber per plant due to PVY infection in six potato varieties.

statistically did not differ among themselves. However, the highest tuber yield was recorded in Diamant followed by Bellini, Remarka, Voyager, Victoria and Baraka. The highest tuber yield in case of PVY infected plants was recorded in Baraka followed by Victoria, Voyager, Remarka, Diamant and Bellini while none of the varieties

Table 4. Effect of PVY on yield of six potato varieties

Varieties	Yield/plant (g)	
	Healthy	PVY
Baraka	473.17 bcd	260.29 e
Remarka	585.67 ab	211.65 e
Victoria	496.67 bc	243.11 e
Voyager	560.17 b	241.12 e
Bellini	668.67 ab	206.78 e
Diamant	767.67 a	211.33 e

Same letters are not statistically different at 5 % level of significance by DMRT

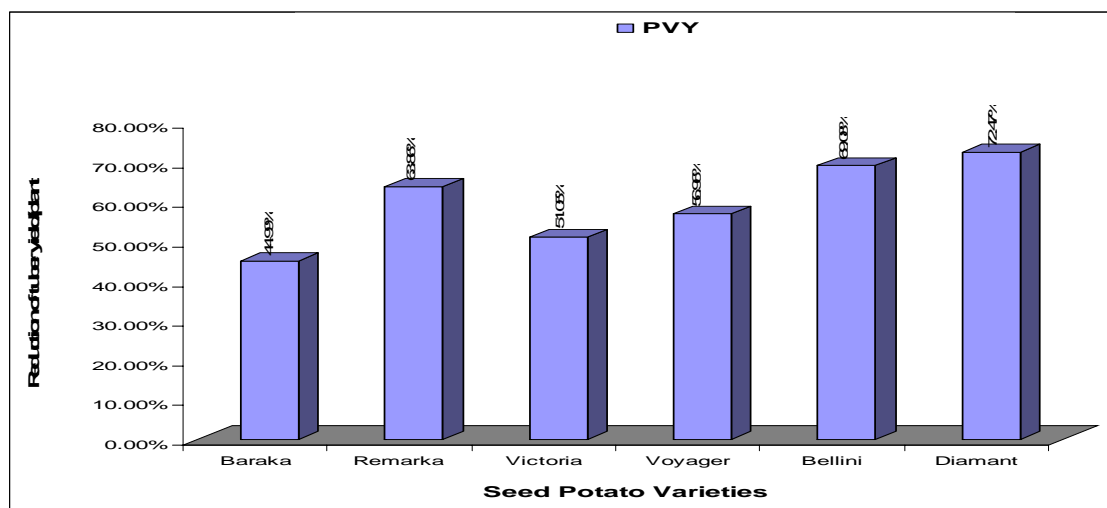


Figure 5. Percent reduction of tuber yield (g) per plant due to PVY infection in six potato varieties

tuber/plant of all the varieties in PVY infected plants statistically did not differ among themselves. The present enquiry indicates that the reduction percent of number of tuber/plant varied depending on the virus and the six seed potato varieties.

Yield of six potato varieties grown from healthy and PVY infected plants

The outlines of tuber yield of the six respective seed potato varieties are sketched in Table 4. The tuber yield was found to be the highest in healthy plants as compared to PVY infected plants in all the varieties. In all the varieties tuber yield of healthy plants was significantly (P=0.05) differed with PVY infected plants. In all the respective varieties, tuber yield of PVY infected plants did not differ with each other. In respect of tuber yield of healthy plants Diamant was statistically similar with Remarka and Bellini but differed with Baraka, Victoria and Voyager. The tuber yield of Baraka, Remarka, Victoria, Voyager and Bellini

statistically differed among one another in respect of tuber yield. As represented in Fig-5, the percent reduction of tuber yield was higher due to PVY infection as compared healthy plants. The percent reduction of tuber yield was found to be ranged from 44.99 - 72.47 due to PVY infection (Figure 5). The outcomes of the present study suggested that the percent reduction of plant height varied depending on six different potato varieties and also on the virus.

Effect of PVY on tubers grading (by tuber number) of six potato varieties

In all the cases, healthy plants yielded highest percentage of over size tubers as compared to virus infected plants. In case of 'B' size tubers, there was no consistent result. Healthy plants of all varieties yielded higher percentage of such graded tubers as compared to PVY infected plants. Considering the 'A' size tubers, there is certain consistency observed. In all the cases, healthy plants yielded lowest percentage of 'A' size tubers as compared to PVY infected plants. Healthy plants of all the respective varieties yielded the lowest percentage of under size tuber as compared to PVY plants. The results of the present study demonstrated that the virus infection contributed in the production of higher number of small size tubers which ultimately cause low yield in potato production. This under size tuber production acted as the major factor to produce the low yield in virus infected plants. The size of the tubers is an important factor contributing to the total yield of the potato crop. The reduction in size has been reported to be different depending on varieties and viruses.

Table 5. Effect of PVY on tubers grading (by tuber number) of six potato varieties

Variety	Categories of plants	% no. of tuber			
		Over	B	A	Under
Baraka	Healthy	12.39	30.14	39.72	17.75
	PVY	0.00	25.30	53.65	21.05
Remarka	Healthy	17.97	39.49	35.95	6.59
	PVY	0.37	5.54	59.92	34.17
Victoria	Healthy	7.74	32.01	41.98	18.27
	PVY	0.00	10.90	55.44	33.66
Voyager	Healthy	9.89	36.76	42.81	10.55
	PVY	2.49	5.91	64.30	27.30
Bellini	Healthy	16.74	33.07	35.23	14.97
	PVY	0.00	2.81	44.62	52.57
Diamant	Healthy	2.69	35.47	35.92	25.92
	PVY	0.00	0.71	61.14	38.15

SUMMARY

It was observed that, PVY (81.11 %) incidence was highest in the variety Remarka and the lowest was 1.67 % in Bellini. The results indicate that the incidence varied depending on depending on six different potato varieties and also on the virus. In case of PVY infected plants, all the varieties yielded statistically similar plant height except Remarka in respect of Plant height. It was found to be varied from 11.82-25.03 % due to PVY infection. In all the six potato varieties, the healthy plants produced the highest number of stem per plant in comparison with PVY infected plants. The number of stem/plant in PVY infected plants was statistically similar with one another. The reduction percentage of number of stem per plant due to PVY ranged from 3.93-25.81. In healthy plants, the total number of tuber per plant was higher as compared to PVY infected plants. But in respect of plant height, none of the varieties differed statistically among themselves in case of PVY infected plants. The reduction percentage was higher due to PVY infection as compared to healthy plants. The reduction of number of tuber per plant was found to be varied from 23.28- 45.70 % due to PVY infection. The tuber yield was found to be the highest in healthy plants as compared to PVY infected plants in all the varieties. But in Remarka, Victoria, Voyager and Diamant the lowest was recorded due to PVY infection. In Remarak, Victoria, Voyager and Diamant, the reduction percentage of tuber yield was higher due to PVY infection as compared healthy plants. The reduction of tuber yield was found to be varied from 44.99- 72.47 % due to PVY infection. In all the cases, healthy plants yielded highest percentage of over size tubers as compared to virus infected plants. Healthy plants of all varieties yielded higher percentage of 'B' size tubers as compared to PVY infected plants. PVY infected plants yielded higher percentage of 'A' size tubers as compared to healthy plants in all the varieties. In all the varieties, the highest percentage of under size tuber was recorded PVY infected plants as compare to healthy plants. This under size tuber production acted as the major factor to produce the low yield in virus infected plants.

CONCLUSION AND RECOMMENDATION

The results of the present study may be concluded as

- i. The incidence of PVY was recorded to be varied from 1.67% - 81.11% depending on six different potato varieties which exceeded the acceptable limit of seed potato.
- ii. The reduction of growth parameters, yield parameters and yield seemed to be very high in all the six varieties due to PVY incidence.

- iii. Seventh generation seed potato of six different varieties might not be used as seed to grow potato crop.

REFERENCES

- Akanda, A.M., K. Tsuno and S. Wakimoto. 1991. Serological detection of four plant viruses in cucurbitaceous crops from Bangladesh. *Ann. Phytopath. Soc. Japan* 57:499-505.
- Ali, M. S. and A., L. Khan. 1991. Pathological constraints of seed potato production in Bangladesh. Proceedings of the International seminar on seed potato. January 8-10, held at Dhaka, Bangladesh, 24Op.
- Anonymous. 1992. Annual Report, 1990-91. Tuber Crops Research Centre (TCRC), BARI, Joyuebpur, Gazipur.
- Anonymous. 2005. Annual Report, 2004-05. Tuber Crops Research Centre (TCRC), BARI, Joydebpur, Gazipur.
- Anonymous. 2006. Annual Report, 2005-06. Tuber Crops Research Centre (TCRC), BARI, Joydebpur, Gazipur.
- Anonymous. 2007. FAOSTAT, 2007.
- Beemster, A.B.R. and A. Rozendal. 1972. Potato viruses: Properties and ". symptoms. *In: J .A. de Bokx (ed.) viruses of potato and seed-potato production.* Pudoc, Wageningen 115-143.
- Bhandal, M.S. and P.S. Naik. 1991. Degeneration and yield reduction in potato genotypes in Plateau region of Maharashtra J. of Indian Potato Assoc.18(142): 108-109.
- Brunt, A., K. Crabetree and A. Gibbs. 1990. Viruses of tropical plants. C.A.B. International and A.C.I.R. 707 p.
- Brunt, A. A. 2001. The Main Viruses Infecting Potato Crops. Horticulture Research International, Warwicks CV 35 9EF. U.K.
- Clark, M.F. and A.N. Adams. 1977. Characteristics of the microplate method of enzyme-linked immunosorbent assay for the detection of plant viruses. *Journal of General Virology*, 34:475-483.
- Foreres, A., P. Perez, E. Gemeno and F. Ponz. 1993. Transmission of Spanish pepper and potato PVY isolates by aphid vectors. *Environ. Entomol.* 22(6): 1260-1265.
- Hemphill Jr.,D.D., G.L Read, O. Gutbrod and F. Crowe 1989. Row covers reduce aphid vectored virus transmission in seed fields. *Ann. Meet. Potato Assoc. Amer. Corvallis, Oregon (USA), July 30 to August 3, 1989. American Potato J.* 66(8): 525.
- Hossain, M. and M.S. Ali 1992. Effect of *Potato virus Y* severities on virus concentration, dilution end point and potato yield. *Bangladesh .J. of Plant Pathol.* 8:27-29.
- Hossain, M., M.S. Ali and M.M. Rashid. 1994. Effect of inoculum levels of *Potato virus Y* (PVY) on yield and subsequent spread of the disease under insecticide spray and unsprayed condition. *Bangladesh .J. of Bot.* 23: 87.
- Khurana, S.M.P., S.K. Pandey, U. Bhale, R.L. Patel and B.S. Lakra. 1998. Degeneration of potato varieties in northern and central India. *Indian J. of Virol.* 14(2):111-119.
- Moericke, V. 1957. Fine Farvfalle, zur kontrolle Des Fluges ven Blattlausen Insbetsomdere Der Pflirsich-Blattlaus. *In Bangladesh J. Agril. Res.* 9: 64 p.
- Rahman, M. A., Haider, J., Sinha, U. K., Chowdhury, A. R. and Chowdhury, M. M. U. 1998. economically viable rates of fertilizers and manures for maximizing growth and yield of year round tomato. *Bangladesh Journal of Agricultural Research* 23 *Journal of Plant Pathology*, 4: 47p.
- Sangar, R.B.S., H.O. Agrawal and B.B. Nagaich. 1994. Studies on extent of primary infection of PVX and PVY among tubers of potatoes. *Indian J. of Virol.* 10(1):22-32.
- Sawicka, B. 1994. Degeneration of potato varieties in the south West part of Biala podlasua region. *Fragmenta Agronomica II* (2):58-65.
- Singh, M.N., S.M.P. Khurana, B.B. Nagaich and H.O. Agrawal. 1984. Efficiency of *Aphis gossypii* and *Acyrtosiphon pisum* in transmitting potato viruses leafroll and Y. *In: Potato in developing countries* (B.B. Nagaich et al. Eds.) IPA, Simla 189-305.
- Verzola, E.A. and LA. Khayad. 1993. Aphid incidence in selection potato growing areas. *Philippine J. of Crop Sci.* 18: 18 p.