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THE HOST RANGE OF THE POTATO VIRUS N

Potato virus N (PVN), first isolated from potato seedlings at the Jõgeva Plant Breeding Station (Нурмисте, 1960, 1962) was later found to infect various species of plants. Among the plants susceptible to the virus have been found vegetables (Agur, Villemson, 1970), weeds (Agur, Villemson, 1972; Villemson, Agur, 1973), decorative plants (Agur, Villemson, 1971) as well as various species of indicator plants (Agur, 1967).

This paper summarizes the results of the work done on studying the host range of PVN. Till the publication of the present report, susceptibility of 142 species of plants was studied. Artificial infection by sap-inoculation succeeded in eighty three species. New passages from infected plants (from inoculated leaves and young leaves) to indicator plants (*Nicotiana glutinosa* L.) were done to determine the possibility to isolate the virus and ascertain the species reacting without visible symptoms.

The plants studied could be divided according to the type of reaction into four groups — susceptible plants with systemic reaction, susceptible plants with local reaction, susceptible plants without visible symptoms (symptomless hosts), and insusceptible plants. To the symptomless hosts of the virus may belong systemically as well as locally infected plants. Symptoms induced by PVN on test plants will be described below.

In case of most species, the time necessary for the appearance of systemic symptoms was, under greenhouse conditions, about two weeks. In cases differing from that the time is marked.

The first group — the plants with systemic reaction to PVN infection

AMARANTHACEAE

Amaranthus caudatus L. Chlorotic spots appear on inoculated leaves in about a week after inoculation. The edges of the leaves become brown. The first symptoms on the young leaves appear as chlorotic flecks; later crinkling of leaf lamina and vein banding develop on these leaves. The inflorescence is shortened. The whole plant is stunted (Fig. 1).

CHENOPODIACEAE

Beta vulgaris L. 'Eckendorf'. The inoculated leaves become chlorotic. Chlorotic flecks develop on the young leaves in about 10 days (Fig. 2). It was impossible to transmit the virus from these plants by sap-inoculation.

Spinacia oleracea L. The inoculated leaves become chlorotic. On the young leaves a mottling appears; later a severe mosaic develops, accompanied by a reduction in width of the lamina and by considerable crinkling. The plants are severely stunted (Fig. 3).

COMPOSITAE

Arctium tomentosum Mill. The inoculated leaves are symptomless. The systemic symptoms appear as bright mottling on the young leaves. The virus is transmissible from second-year plants.

Callistephus chinensis L. The inoculated leaves are chlorotic. The systemic symptoms appear as mosaic. The young leaves are distorted, blistered and narrowed. The flowers are misshapen, with irregular and shortened petals. The plants are stunted (Fig. 4).

Cosmos bipinnatus Cavan. The whole plant is mildly chlorotic and lightly stunted. The flowers are smaller than normal.

Zinnia elegans Jacq. The inoculated leaves are symptomless. Mild mottling and slight clearing of the veins occasionally develop on the young leaves. The older leaves curve downwards. The flowers do not appear to be affected. The plants are slightly stunted.

Sonchus arvensis L. The inoculated leaves are slightly chlorotic or symptomless. The chlorotic flecks develop on the young leaves. There is no stunting observed.

Sonchus asper (L.) Hill. The inoculated leaves are chlorotic, the young leaves are mottled. No stunting.

CUCURBITACEAE

Cucumis sativa L. 'Kastekindel'. Chlorotic local lesions develop on the inoculated leaves. The first symptoms on the young leaves are mosaic spots, soon followed by a mottling of yellow and dark green and blistering of leaf lamina (Fig. 5). The plants are severely stunted. The flowers are not affected, but the fruits are mottled and distorted.

LABIATAE

Galeopsis tetrahit L. The inoculated leaves are symptomless. The young leaves develop mild mottling.

Salvia splendens Ker-Gawl. Brown local lesions develop on the inoculated leaves a week after inoculation. Similar brown spots and flecks appear on the young leaves, too. A browning of veins and curving of leaves downwards is noticed (Fig. 6). The inflorescence is smaller, and the number of flowers is less than normal. A transmitting of the virus from these plants by sap-inoculation was not possible.

LEGUMINOSAE

Pisum sativum L., 'Sovershenstvo'. Chlorotic flecks appear of the inoculated leaves and on the young leaves developed after inoculation.

Trifolium incarnatum L. The inoculated leaves are chlorotic. In about three weeks after inoculation, the veins of the young leaves become purple due to an abnormal anthocyanin formation. The plants are stunted.

PAPAVERACEAE

Chelidonium maius L. Chlorotic local lesions develop on the inoculated leaves in about a week after inoculation. Mosaic flecks appear on the

young leaves in about three weeks following inoculation. Sometimes the mosaic flecks have necrotic edges. The virus is transmissible from the second-year plants.

PEDALIACEAE

Sesamum indicum L. The plants are hypersensitive. The whole plant becomes quickly necrotic and usually dies on the second or third day following inoculation.

SOLANACEAE

Atropa belladonna L. The inoculated leaves are symptomless. Later, on about the fifteenth to twentieth day after inoculation, the whole plant becomes chlorotic.

Atropa caucasica L. Symptoms are similar to those on *A. belladonna*.

Capsicum annuum L. Local chlorotic lesions develop on inoculated leaves, followed by systemic symptoms of bright mosaic and curving of leaf stems downwards, on young leaves. The plants are stunted. The fruits are distorted.

Capsicum annuum L. *var. grossum*. The inoculated leaves show a chlorosis. There is a mild mosaic on the young leaves. The plants are somewhat stunted.

Datura metel L. Local chlorotic lesions develop on inoculated leaves. The systemic symptoms appear as mosaic mottling. No stunting.

Datura meteloides DC. Symptoms are similar to those on *D. metel*.

Datura stramonium L. The inoculated leaves are symptomless or mildly chlorotic. The first systemic symptoms appear as a clearing of veins, followed by mosaic appearance which sometimes becomes a chlorotic concentric ring-spotting. The plants are somewhat stunted.

Hyoscyamus albus L. Inoculated leaves show chlorotic lesions. The first systemic symptoms appear as a clearing of veins, followed by bright mosaic. The plants are somewhat stunted.

Hyoscyamus niger L. Inoculated leaves show chlorotic lesions. Symptoms of systemic infection consist of vein-clearing and later of severe mottling, crinkling of leaf lamina and stunting of the whole plant. Sometimes a malformation of the flowers was noticed.

Lycopersicon esculentum Mill. 'Altayets'. The inoculated leaves are chlorotic. The young leaves become mottled and curve downwards or curl up in spirals. The plants are somewhat stunted (Fig. 7). The flowers are normal. The fruits are smaller than normal, but not distorted.

Nicandra physaloides Gaertn. Local chlorotic lesions develop on the inoculated leaves. The systemic symptoms appear as a mild clearing of veins, followed by mosaic. A curving of leaf stems downwards and later a marked narrowing of the leaves are very characteristic of the affected plants (Figs. 8 a and b). The whole plant is severely stunted.

Nicotiana glauca Graham., *N. chinensis* Fisch., *N. goodspeedii* Wheeler, *N. langsdorffii* Weinm., *N. repanda* W., *N. sylvestris* Speg., *N. solanifolia* Walp., *N. suaveolens* Lehm., *N. texana* L., *N. trigonophylla* Dun. The reaction of all these species is similar. Inoculated leaves show chlorotic lesions. The systemic symptoms appear as a clearing of veins, followed by mild mottling. A distortion of flowers or stunting of plants was not noticed.

N. glutinosa L. Slight chlorotic lesions develop on inoculated leaves in about a week after inoculation. The first systemic symptoms appear as

Fig. 7. Systemic symptoms on *Lycopersicon esculentum* Mill., caused by PVN; healthy plant left.

mild mottling on a half of the lamina of the young leaves in about eight to ten days after inoculation. Later the mottling spreads over all the lamina and there are usually dark green blisters on the leaves (Fig. 9). The affected plants are chlorotic and stunted.

N. tabacum L. 'Samsun'. Chlorotic local lesions develop on inoculated leaves in about five days. The young leaves show mosaic mottling, first on one half of the leaf (Fig. 10), and later on the whole leaf lamina. The plants are somewhat stunted. A variation of mosaic symptoms was observed. A disappearance of symptoms on the older plants ("acquired immunity") (Нурмисте, 1962; Agur, 1967) was noticed.

N. tabacum L. 'White Burley'. Local lesions develop on the inoculated leaves. The young leaves show mosaic and sometimes single necrotic rings.

N. rustica L. Chlorotic local lesions develop on the inoculated leaves. In about a week to ten days after inoculation a vein-clearing and later a mottling appear on young leaves. A malformation of flowers is noticed (Fig. 11), being a mark of infection with the strain N_R of the virus (Agur, 1966).

Physalis floridana L. Slight chlorotic lesions appear on the inoculated leaves. Systemic symptoms appear as a mild mottling. Later the whole plant becomes chlorotic and stunted (Fig. 12).

Ph. ixocarpa Brot., *Ph. peruviana* L. The inoculated leaves are symptomless. The young leaves of both species are mottled. The reaction appears during three weeks following inoculation.

Solanum acaule Bitt. The inoculated leaves show chlorotic flecks. A mild mosaic develops on young leaves.

S. demissum Lindl. Slight chlorotic lesions develop on inoculated leaves. Symptoms of systemic infection consist of mosaic mottling and a slight crinkling of leaf lamina. It is not easy to infect this plant with PVN by sap-inoculation.

S. melongena L. Chlorotic local lesions develop on inoculated leaves. A slight mosaic appears on young leaves, the edges of the leaf-lamina roll

up. A transmitting of the virus from these plants by sap-inoculation was not possible.

S. nigrum L., *S. nodiflorum* Jacq. Local chlorotic lesions develop on inoculated leaves. Systemic symptoms on young leaves appear as mosaic, that on *S. nigrum* is more severe than on *S. nodiflorum*. The young leaves of *S. nigrum* become somewhat blistered.

S. persicum L., *S. villosum* L. The inoculated leaves show chlorotic flecks. A mild mottling and chlorotic flecks develop on the young leaves of *S. persicum* and *S. villosum*, respectively, in about three weeks after inoculation. A transmitting of the virus from these plants by sap inoculation was not possible.

S. tuberosum L. The affected plants show a mild mosaic and faint crinkling of leaf lamina (Fig. 13). There are difficulties in infecting potato with PVN by sap-inoculation.

RANUNCULACEAE

Ranunculus arvensis L. The inoculated leaves are symptomless. The oak-leaf type of line pattern appears on the young leaves in three weeks after inoculation.

In all cases, except in *Salvia splendens, Solanum melongena, S. persicum, S. villosum* and *Beta vulgaris*, it was possible to transmit the virus from the infected plants (from inoculated and young leaves as well) to the indicator plants by sap-inoculation.

The second group — the plants with local reaction to PVN infection

AMARANTHACEAE

Amaranthus retroflexus L. The inoculated leaves show brown necrotic spots or specks of three to five millimetres in diameter, in about ten days after inoculation.

Gomphrena globosa L. Red necrosis appear on the inoculated leaves in about three weeks after inoculation. Later a central light spot of two to three millimetres in diameter develops (Fig. 14).

CHENOPODIACEAE

Chenopodium amaranticolor L. Light necrotic spots, of not more than a millimetre in diameter, appear on the inoculated leaves in about a week after inoculation (Fig. 15).

Ch. quinoa Willd. Necrotic specks of four to six millimetres in diameter appear on the inoculated leaves in about a week to ten days after inoculation.

CUCURBITACEAE

Cucurbita pepo L. Chlorotic local lesions develop in about a week after inoculation on the inoculated leaves.

LEGUMINOSAE

Lupinus barkeri L., *L. coerulens* L. Brown necrotic spots develop in about ten to fifteen days after inoculation on the inoculated leaves of both species.

Vicia faba L. The inoculated leaves show single brown necrotic spots of two to three millimetres in diameter, in a week after inoculation (Fig. 16).

Vigna sinensis Endl. Bright brown necrotic spots of two to three millimetres in diameter appear in three to five days after inoculation (Fig. 17).

MALVACEAE

Lavatera trimestris L. Local chlorotic lesions appear on the inoculated leaves in ten to twelve days after inoculation.

SOLANACEAE

Lycium chinense Mill., *L. ruthenicum* L. A faint chlorosis develops on the inoculated leaves of both species.

Vigna sinensis Endl. and *Chenopodium amaranticolor* L., usually reacting with a great number of bright necrotic spots, are suggested for use as local lesion differential hosts for PVN and may be used for the determination of the relative concentration of the virus (Agur, 1974).

The third group — the symptomless hosts of PVN

1. Systemically infected plants without visible symptoms

CAMPANULACEAE

Campanula medium L.

CARYOPHYLLACEAE

Stellaria media (L.) Cyr.

COMPOSITAE

Anthemis tinctoria L., *Calendula officinalis* L., *Chrysanthemum carinatum* Schousboe, *Dimorphoteca pluvialis* Moench., *Tagetes patula* L., *Taraxacum sp.* L.

CRUCIFERAE

Brassica rapa L. 'Eesti', *Erysimum cheiranthoides* L., *Matthiola incana* (L.) R. Brown, *Sinapis alba* L.

PAPAVERACEAE

Papaver somniferum L.

RANUNCULACEAE

Aquilegia vulgaris L. *var nivea*

SOLANACEAE

Petunia × *hybrida hort.*

UMBELLIFERAE

Apium graveolens L.

It was possible to transmit the virus to indicator plants *(N. glutinosa)* from the inoculated as well as from the young leaves of all the species

named. In the case of biennial or perennial species *Anthemis tinctoria*, *Taraxacum sp.*, *Apium graveolens*, *Campanula medium* and *Aquilegia vulgaris var. nivea* the virus was transmissible from the second-year plants, too.

2. Locally infected plants without visible symptoms

CARYOPHYLLACEAE

Silene armeria L.

POLYGONACEAE

Rumex acetosella L.

It was possible to transmit the virus from the inoculated leaves of both the species named, but not from the young leaves.

The fourth group — the insusceptible plants to PVN infection

ARACEAE

Calla aethiopica L.

BEGONIACEAE

Begonia tuberhybrida hort.

CAMPANULACEAE

Jasione montana L.

CARYOPHYLLACEAE

Agrostemma githago L., *Melandrium album* (Mill.) Garcke, *Spergula arvensis* L.

CHENOPODIACEAE

Beta vulgaris L. 'Bordoo'.

COMPOSITAE

Achillea lanulosa L., *Aster alpinus* L., *Carduus acanthoides* L., *C. crispus* L., *C. nutans* L., *Centaurea scabiosa* L., *Cirsium arvense* (L.) Scop., *C. vulgare* (Savi) Ten., *Coreopsis grandiflora* Nutt., *C. tinctoria carmin* Nutt., *Doronicum caucasicum* Marsch.-Bieb., *Gaillardia aristata* Pursh., *Lactuca sativa* L., *Sonchus oleraceus* L.

CRUCIFERAE

Brassica napus var. *napobrassica* (L.) Reikhenb., *B. oleracea* var. *botrytis* L., *B. oleracea* var. *capitata* L., *B. rapa* L. 'Petrovi', *Bunias orientalis* L., *Capsella bursa-pastoris* (L.) Med., *Raphanus sativus* var. *sativus* L., *Sinapis arvensis* L.

CUCURBITACEAE

Luffa operculata Cogn.

FICOIDACEAE

Tetragonia expansa Thunb.

GRAMINEAE

Triticum aestivum L. 'Norröna'

LEGUMINOSAE

Lupinus albus L., *L. elegans* L., *L. pubescens* Benth., *L. subcarnosus* Hook., *Phaseolus vulgaris* L., *Trifolium repens* L.

LILIACEAE

Allium cepa L.

PAPAVERACEAE

Eschscholtzia californica Cham., *Papaver orientale* L.

PLANTAGINACEAE

Plantago lanceolata L., *P. major* L., *P. media* L.

POLYGONACEAE

Rheum rhaponticum L., *Rumex acetosa* L.

PRIMULACEAE

Cyclamen sp. L., *Primula obconica* Hanke.

RANUNCULACEAE

Aquilegia vulgaris L., *Delphinium grandiflorum* L.

RESEDACEAE

Reseda odorata L.

SCROPHULARIACEAE

Antirrhinum majus L.

SOLANACEAE

Solanum capsicastrum Link.

TROPAEOLACEAE

Tropaeolum majus L.

UMBELLIFERAE

Aegopodium podagraria L., *Daucus carota* L., *D. sativus* (Hoffm.) Rochl.

URTICACEAE

Urtica dioica L.

VIOLACEAE

Viola cornuta L.

Eighty-three species belonging to sixteen genera were susceptible to PVN. Fifty-three species from them, most belonging to Solanaceae, react with visible systemic symptoms. The appearance of a mosaic of different

severity was typical of PVN infection. Most plant species infected systemically show this type of symptoms. In most cases the mosaic was asymmetric in regard to the leaf-halves. Growth reduction (in most of the species reacting systemically) and deviation in the morphology of leaves (crimpling — *Callistephus chinensis, Cucumis sativus, Nicotiana goodspeeaii*; leaf narrowing — *Nicandra physaloides, Spinacia oleracea*; curving of the leaves downwards — *Zinnia elegans* etc.) were noticed. A malformation of flowers (*Hyoscyamus niger, Nicotiana rustica, Amaranthus caudatus*) was not exceptional when the plants were affected by PVN.

Twelve plant species, mainly from the *Papilionaceae* and *Chenopodiaceae*, reacted with local symptoms. Necrosis as well as chlorotic lesions were noticed. The species reacting with quickly appearing necrosis (*Vigna sinensis* — brown necrosis, *Chenopodium amaranticolor* — light necrosis) were recommended as differential hosts for the virus.

Eighteen species being susceptible did not show visible symptoms.

Fifty-nine species were insusceptible to PVN infection.

It was possible to reisolate the virus from the plants reacting with visible symptoms (plants with systemic reaction and plants with local reaction) and from the plants without visible symptoms (symptomless hosts of the virus). In all the cases named, the synthesis of the virus must have been normal, i. e. the particles formed are complete. It is hard to explain the impossibility to reisolate PVN from the species *Beta vulgaris, Solanum melongena, S. persicum, S. villosum* and *Salvia splendens* reacting with symptoms of systemic reaction. It may be that the virus exists in these species in a defective form. Perhaps in the species that are considered to be insusceptible ones the virus also exists in a defective form, and we have no methods to determine it.

The investigations show that PVN has a very wide host range. The virus infects many species of plants occurring in the natural flora of Estonia. The weeds, decorative plants as well as vegetables susceptible to PVN might be the essential reservoir plants of the virus. The biennial and perennial natural hosts of the virus (*Sonchus arvensis, Taraxacum sp., Arctium tomentosum, Campanula medium,* etc.) are considered to be the overwintering sources of the virus.

No direct methods for the control of virus diseases are yet available. The main procedure is the removal and elimination of the affected plants. In practice, it is possible to remove only plants showing visible symptoms. It is usually difficult to recognize affected plants that react with faint symptoms, and it is quite impossible to recognize the symptomless diseased plants. It is very difficult to control PVN that infects many species without any visible symptoms (about one fifth of the susceptible plants studied) and a great number of species reacting with faint symptoms. Many of the weeds, vegetables and decorative plants susceptible to PVN belong to this group. To prepare an antiserum to PVN has proved impossible, as yet (Agur, 1967).

A comparison of the host range, the disease symptoms and physical properties of PVN with other viruses affecting the potato has shown that this virus differs from them, but it has been suggested that PVN belongs to the group of cucumber mosaic virus (CMV-1) (Agur, 1968; Виллемсон, Aryp, 1971). Confirmation of this view is derived from studies on the biophysical and biochemical properties of the virus (Хёдреярв, Олсперт, 1971) and from the electron micrographs of the N-virus preparations (30 nm in diameter when stained with uranyl acetate and about 37 nm

when shadowed with nickelchromium) (Хёдреярв, Олсперт, Тарасова, 1968).

PVN as CMV may be very widespread in nature, causing losses in the yield of agricultural crops and reducing their quality.

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KARTULI-N-VIIRUSE PEREMEESTAIMEDE RING

Resümee

Uuriti 27 sugukonnast pärineva 142 taimeliigi vastuvõtlikkust kartuli-N-viiruse (KNV) nakkusele. Viirus oli mahlinokulatsioonil ülekantav 83 taimeliigile. Neist 53 reageeris KNV nakkusele süsteemilise infektsiooni tunnustega ja 12 lokaalse infektsiooni tunnustega. 18 vastuvõtlikul taimeliigil haigustunnuseid ei avaldunud. 59 taimeliiki osutus KNV nakkusele mittevastuvõtlikuks. Kirjeldatakse vastuvõtlikel taimeliikidel avaldunud haigustunnuseid. KNV-le vastuvõtlikuks on osutunud rida umbrohtusid, dekoratiivtaimi ja köögivilju, nii ühe-, kahe- kui ka mitmeaastasi liike, kusjuures viimaseid (*Arctium tomentosum, Campanula medium, Sonchus arvensis* jt.) tuleks arvestada kui KNV võimalikke looduslikke reservaatoreid, milles viirus säilib ületalve.

Eesti NSV Teaduste Akadeemia
Eksperimentaalbioloogia Instituut

Toimetusse saabunud
4. II 1974

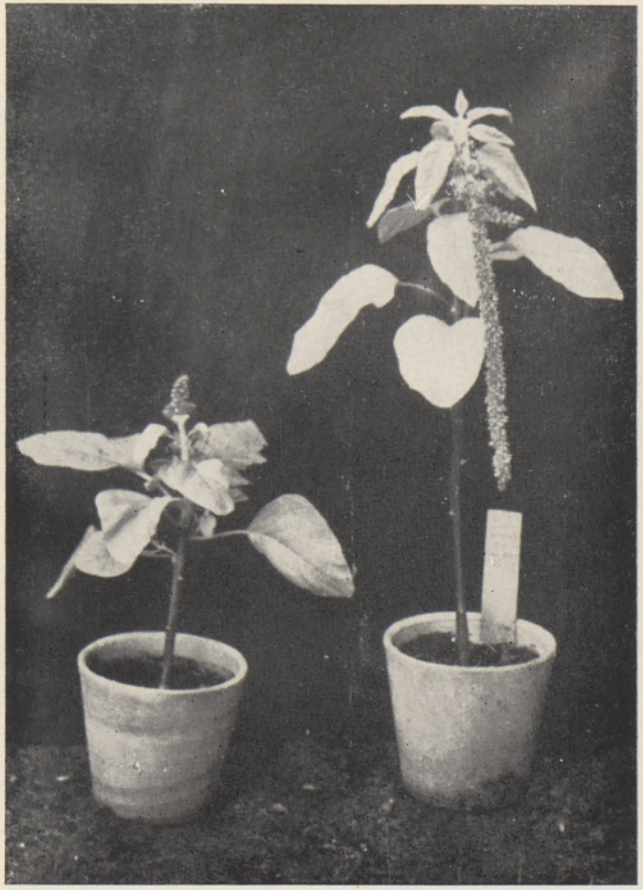

Fig. 1. Systemic symptoms on *Amaranthus caudatus* L., caused by PVN; healthy plant right.

Fig. 2. Chlorotic flecks on leaf of *Beta vulgaris* L. 'Eckendorf', caused by PVN.

Fig. 3. Systemic symptoms on *Spinacia oleracea* L., caused by PVN; healthy plant left.

Fig. 4. Flower distortion on *Callistephus chinensis* L., caused by PVN; healthy plant left.

Fig. 5. Mosaic on *Cucumis sativa* L. 'Kastekindel', caused by PVN.

Fig. 6. Necrotic flecks on *Salvia splendens* Ker-Gawl., caused by PVN.

Fig. 8. Systemic symptoms on *Nicandra physaloides* L., caused by PVN; curving of leaf stems downwards (*a*); narrowing of leaves (*b*); healthy plant right.

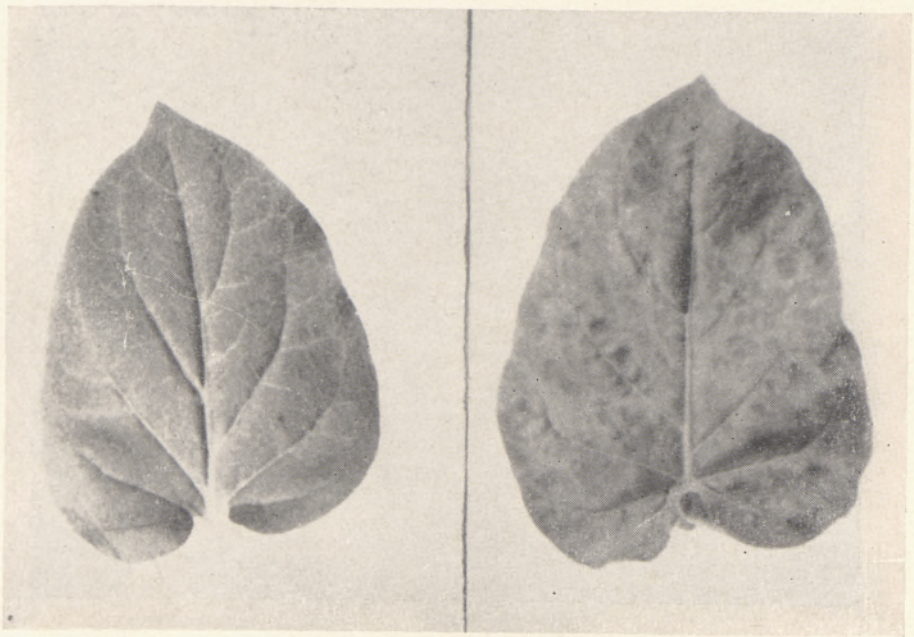

Fig. 9. Mosaic on *Nicoticna glutinosa* L., caused by PVN; healthy leaf left.

Fig. 10. Mosaic on one half of *Nicotiana tabacum* L. leaf, caused by PVN.

Fig. 11. Flower distortion on *Nicotiana rustica* L., caused by PVN (strain N_R).

Fig. 12. Systemic symptoms on *Physalis floridana* L., caused by PVN; healthy plant left.

Fig. 13. Mosaic symptoms on potato, caused by PVN.

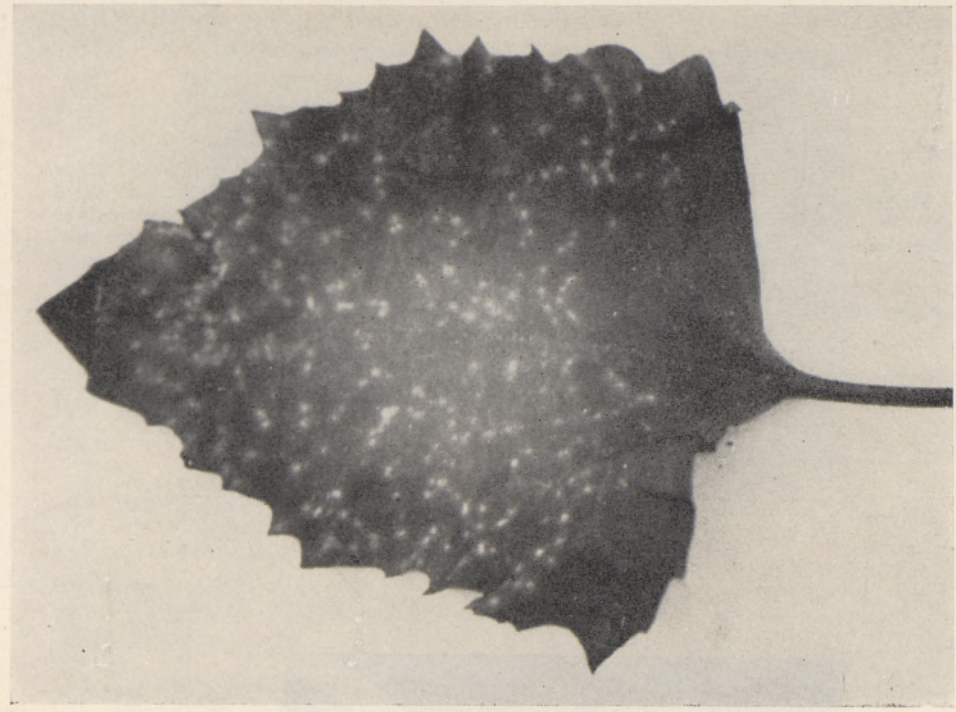

Fig. 15. Local lesions on *Chenopodium amaranticolor* L., caused by PVN.

Fig. 14. Local lesions on *Gomphrena globosa* L., caused by PVN.

Fig. 16. Local lesions on *Vicia faba* L., caused by PVN.
Fig. 17. Local lesions on *Vigna sinensis* Endl., caused by PVN. →

Мильви АГУР

КРУГ РАСТЕНИЙ-ХОЗЯЕВ ВИРУСА N КАРТОФЕЛЯ

Резюме

Методом искусственного заражения (инокуляцией соком) изучалась восприимчивость 142 видов растений (из 27 семейств) к вирусу N картофеля (BNK). Восприимчивыми оказались 83 вида. Из них 53 реагировали симптомами системной инфекции, 12 — симптомами локальной инфекции и 18 видов оказались бессимптомными. Описываются симптомы заболевания у пораженных растений. 59 видов оказались невосприимчивыми. Среди восприимчивых видов наблюдается ряд декоративных, овощных и сорных растений. Показано, что двухлетние и многолетние виды (*Arctium tomentosum, Campanula medium, Sonchus arvensis* и др.) имеют значение как возможные резерваторы вируса в зимний период.

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