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**Etiology and biology of viruses affecting Lentil (*Lens esculenta*
Moench.) in Iran (*)**

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Etiology and biology of viruses affecting Lentil (*Lens esculenta* Moench.) in Iran (*)

by WALTER J. KAISER (**)

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Introduction

Lentil (*Lens esculenta* Moench) is one of seven food legumes (pulse crops) grown in Iran under rain-fed or irrigated conditions. Several diseases affect Lentil in various pulse producing regions of the country which contribute to the irregular yields obtained from this crop annually. The most important diseases of Lentil in Iran are caused by root rot fungi and viruses (Kaiser *et al.*, 1968).

Very little information is available in the literature concerning viruses affecting Lentil in nature. This study was undertaken to determine the etiology and study various aspects of the biology of viruses infecting Lentil in Iran.

Materials and methods

Diseased and healthy lentils which were collected in various areas of Iran were assayed for virus infection on different indicator plants. Plant tissues were ground in a mortar and pestle to which had been added 1% K₂HPO₄, pH 7.0 or 0.01 M phosphate

buffer, pH 7.0, and rubbed on carborundum-dusted leaves of test plants with the thumb and forefinger or sterile cotton Q-tips. Test plants utilized in the inoculation studies were Bean (*Phaseolus vulgaris* L. 'Bountiful' and 'Pinto U.I. III'), Chickpea (*Cicer arietinum* L. 'Ghazvin'), Broadbean (*Vicia faba* L. 'Algerian'), Cowpea [*Vigna sinensis* (L.) Savi ex Hassk. 'Early Ramshorn'], 'Ghazvin' Lentil, Cucumber (*Cucumis sativus* L. 'National Pickling'), Tobacco (*Nicotiana glutinosa* L.), *Gomphrena globosa* L. and *Chenopodium amaranticolor* Coste et Reyn.

Fungus isolations were also made from the roots and foliage of diseased lentils by plating surface sterilized (0.5% Clorox for 5 min) pieces of tissue on water agar (WA), potato-dextrose agar (PDA), or acidified potato-dextrose agar, pH 4.0-4.5 (APDA). Cultures were maintained on PDA slants. Inoculation tests were done in the greenhouse by planting surface sterilized lentil seed in pasteurized greenhouse soil infested with macerated PDA cultures or with cornmeal-sand (5-95% v/v) inoculum of each fungus. Lentils were also grown in field soil collected from beneath diseased lentils.

The effects of virus infection on seed yields were studied in replicated field trials at Karaj, Iran, using a large-seeded Lentil line from Ghazvin, Iran. Freshly prepared homogenates of each sap transmissible virus [Alfalfa mosaic (AMV), Bean yellow mosaic (BYMV), and Cucumber mosaic (CMV)] (Kaiser and Danesh, 1971), with carborundum added, were rubbed on leaflets of lentil plants with the thumb and forefinger at two stages of growth: pre-bloom (about 4 weeks after planting), and full bloom (about 9 weeks after planting). Viruliferous aphids were allowed to feed on plants in leaf cages

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TABLE I. - Host range of four viruses affecting Lentil in Iran.
 TABELLA I. - Ospiti dei quattro virus che attaccano la Lenticchia in Iran.

Test plants / Piante di saggio	Virus (a)			
	AMV	BYMV	CMV	PLRV
Amaranthaceae				
<i>Gomphrena globosa</i> L.	LL,S(b)	—	LL	—
Chenopodiaceae				
<i>Chenopodium amaranticolor</i> Coste et Reyn.	LL	LL	LL	—
Cucurbitaceae				
<i>Cucumis sativus</i> L. 'National Pickling'	S	—	S	—
Leguminosae				
<i>Cicer arietinum</i> L. 'Ghazvin'	S	S	S	S
<i>Lens esculenta</i> Moench 'Ghazvin'	S	S	S	S
<i>Phaseolus vulgaris</i> L. 'Bountiful'	LL	S	—	S
<i>P. vulgaris</i> 'Pinto U.I. III'	LL,S	S	—	—
<i>Vicia faba</i> L. 'Algerian'	LL,S	S	—	S
<i>Vigna sinensis</i> L. Savi ex Hassk. 'Early Ramshorn'	LL	—	—	S
Solanaceae				
<i>Nicotiana glutinosa</i> L.	S	—	S	—

(a) Viruses are: AMV (Alfalfa mosaic), BYMV (Bean yellow mosaic), CMV (Cucumber mosaic), PLRV (Pea leaf roll).
 (b) LL = local lesions; S = systemic infection; — = not susceptible



Fig. 1 - Growth and yields of lentils infected with bean yellow mosaic virus (middle) and cucumber mosaic virus (right) are severely reduced when compared to a healthy plant (left) of the same age.

Fig. 1 - Lo sviluppo e la produzione delle piante di Lenticchia infette da BYMV (al centro) e da CMV (a destra) sono molto ridotti rispetto a quelli delle piante sane (a sinistra) della stessa età.

for 3 days with Pea leaf roll virus (PLRV), a circulative virus which is not sap transmitted (Kaiser and Danesh, 1971; 1971a). Plots were sprayed with an insecticide every 10-14 days. Before each inoculation, plots were rogued of all diseased and/or abnormal plants. In the inoculated plots, diseased plants were tagged 15-20 days after inoculation, and harvest time, yields were taken from 25 plants in each plot.

Nonviruliferous aphids (*Aphis craccivora* Koch) were also fed on diseased lentils in the greenhouse and field in leaf cages for 18-72 h before being transferred to healthy test plants for a 72 h inoculation feeding period. Aphids collected from different pulse crops and used in vector transmission studies were *A. craccivora*, *Acyrtosiphon pisum* Harris, and *A. sesbaniae* David. Aphids were reared in cages in the greenhouse on healthy or diseased Broadbean (*V. faba* 'Algerian').

The importance of annual and perennial plants as alternate and overwintering hosts of viruses infecting lentils was investigated. Diseased plants growing in or adjacent to fields or pulse crops were indexed for virus infection.

Various techniques were utilized in virus identification, many of which were recommended by Bos *et al.* (1960) for legume viruses. These included symptomatology, host range studies, physical property tests, vector-virus relationship, serology, and electron microscopy. The procedures and criteria used in identification of lentil viruses were similar to those outlined in an earlier paper dealing with the virus diseases of Chickpea in Iran (Kaiser and Danesh, 1971).

To observe whether viruses affecting *Lens* were seed-borne in this host, seeds from lentil plants infected naturally or inoculated with each virus in field trials were planted in pasteurized soil in the greenhouse. After 4-6 weeks healthy and abnormal appearing plants were back-inoculated to healthy indicator hosts.

Results

Identification of viruses affecting lentils. - Utilizing various techniques (Ball, 1961; Bos *et al.*, 1960; Kaiser and Danesh, 1971), the naturally occurring viruses of Lentil in Iran were identified as AMV, BYMV, CMV, and PLRV. AMV, BYMV, and CMV were sap transmitted, in contrast to PLRV which was not mechanically transmitted. Transmission of PLRV was accomplished only by grafting and with aphids. The host ranges of the four viruses are given in Table I. AMV and CMV infected plants in the *Amaranthaceae*, *Chenopodiaceae*, *Cucurbitaceae*, *Leguminosae*, and *Solanaceae*, whereas the host ranges of BYMV and PLRV were confined to the *Chenopodiaceae* and *Leguminosae*, and *Leguminosae*, respectively (Table I). Serology, utilizing the Ouchterlony agar double-diffusion test (Ball, 1961), was especially useful in confirming the identity of isolates of AMV and CMV from crude sap of naturally infected or greenhouse inoculated plants. Flexuous rods about 750 nm in length which were observed by electron microscopy of negatively stained leaf dip preparations and serology were important criteria utilized in identification of isolates of BYMV. Symptomatology, host range studies, and vector-virus relationship were used to identify PLRV (Kaiser and Danesh, 1971; 1971a), because information was lacking on its morphology and serology.

Symptoms of disease. - Symptoms frequently observed in virus-infected lentils were stunting (Fig. 1 and 3), leaf deformation, dwarfing, and twisting (Fig. 1, 2, 3, and 4), shortening of the internodes (Fig. 1, 2, and 3), proliferation of the axillary buds (Fig. 2), and mottling. Plants infected with CMV (Fig. 1 and 2) and PLRV (Fig. 3) were usually chlorotic. Narrowing and twisting of the leaflets were commonly observed in lentils affected by AMV (Fig. 4) and BYMV (Fig. 1 and 2). Flowering and pod formation in virus-infected plants were usually sparse or lacking, and seeds which developed were often small, discolored, and shrivelled. Virus symptoms of lentils inoculated in the greenhouse were similar or identical to those observed in nature. Virus in-



Fig. 2. - Deformation, dwarfing, twisting and mottling of the leaflets, and shortening of the internodes are symptoms commonly observed in lentils infected with bean yellow mosaic (left) and cucumber mosaic (middle) viruses. Healthy plants, right.

Fig. 2. - Deformazione, nanismo, distorsione e maculatura delle fogliole, e accorciamento degli internodi sono sintomi comunemente osservabili in piante di Lenticchia infette da BYMV (a sinistra) e da CMV (al centro). A destra, una pianta sana.

fection did not appear to cause discoloration or necrosis of the roots.

Role of microorganisms in disease development. - Isolations were made from the roots and stems of lentil plants exhibiting symptoms of mottling, stunting, chlorosis, leaf dwarfing, twisting and deformation, and proliferation of the axillary buds. Microorganisms were seldom isolated from the vascular tissues of stems of diseased lentils exhibiting these symptoms. Fungi occasionally isolated from the roots of these plants were *Fusarium* spp., *Pythium* spp., *Macrophomina phaseoli*



Fig. 3. - Lentils infected with Pea leaf roll virus (right) are severely stunted, chlorotic, and the leaves deformed and twisted. Healthy lentils of the same age, left.

Fig. 3. - Le piante di Lenticchia infette da virus dell'accartocciamento fogliare del Pisello, PLRV, (a destra) mostrano rachitismo, clorosi, foglie deformate e distorte. A sinistra, piante sane della stessa età.

TABLE II. - Effect of two viruses, bean yellow mosaic (BYMV) and cucumber mosaic (CMV), on disease severity and seed yields of 30 Lentil lines in replicated field trials at Varamin, Iran, and subsequent reaction of these lines to each virus in greenhouse inoculation tests.

TABELLA II. - Influenza di due virus, BYMV e CMV, sulla severità della malattia e sulla produzione di granella di 30 linee di Lenticchia. Le linee sono state seminate a Varamin, Iran in prove di campo replicate. Nella tabella sono anche riportate le reazioni delle 30 linee ai due virus, in saggi condotti in serra.

Line No.	Source	Disease Rating / Grado di malattia			Yield Prodotto kg/ha (d)
		Field (a)	Greenhouse (b)		
Linea N.	Origine	Virus Symptoms	BYMV	CMV	
1	Isfahan, Iran	0	1/14 (c)	2/12	1166
2	Isfahan, Iran	1	3/14	0/14	994
3	Jiroft, Iran	1	6/15	1/14	979
4	Isfahan, Iran	1	5/13	5/14	957
5	Isfahan, Iran	1	7/14	2/16	952
6	Isfahan, Iran	1	3/14	5/15	931
7	Isfahan, Iran	1	11/16	4/15	912
8	Isfahan, Iran	1	4/13	2/13	903
9	Isfahan, Iran	1	4/15	4/15	880
10	Isfahan, Iran	1	1/15	3/15	824
11	Isfahan, Iran	1	4/15	3/15	809
12	Isfahan, Iran	1	2/14	6/15	770
13	Isfahan, Iran	2	9/15	6/16	617
14	Lebanon	5	12/15	9/14	284
15	Ahar, Iran	4	4/16	5/15	278
16	Iran	8	12/15	13/15	276
17	Arasbaran, Iran	7	12/15	12/15	231
18	Moghan, Iran	5	11/15	14/16	206
19	Ghazvin, Iran	5	10/15	10/14	201
20	Moghan, Iran	6	12/13	12/15	180
21	Tabriz, Iran	5	2/15	10/14	178
22	Azarbaijan, Iran	6	12/15	13/15	162
23	Cyprus	8	10/14	11/15	152
24	Ghazvin, Iran	8	13/14	12/14	139
25	Ghazvin, Iran	6	9/14	13/14	125
26	Moghan, Iran	7	10/14	9/15	124
27	Ardabil, Iran	5	12/15	10/15	120
28	Ghazvin, Iran	7	11/15	11/14	111
29	Azarbaijan, Iran	7	12/14	11/14	106
30	Ardabil, Iran	7	14/15	14/15	96

- (a) Lentil plots in the field were graded for virus infection on a scale of 0-9; 0 - no disease; 9 - 100% disease
 (b) Plants of each Lentil line were inoculated with Lentil isolates of BYMV and CMV in the greenhouse. In each inoculation test, plants not showing disease symptoms were re-inoculated 2-3 times and at the termination of the test, plants not exhibiting virus symptoms were back inoculated to susceptible indicator test plants.
 (c) Combined results of two inoculation experiments. Numerator is the number of plants infected; denominator is the number of plants inoculated.
 (d) Seed yields in kg/ha were from plots which were 4 rows wide and 5 m long with 4 replications per lentil line.

(Maubl.) Ashby, and *Rhizoctonia solani* Kühn. Virus-like symptoms were never reproduced in controlled greenhouse inoculation tests with these microorganisms. A few fungi, particularly isolates of *Pythium* spp. and *R. solani*, caused a discoloration and necrosis of the rootlets which often resulted in death of inoculated plants. Four viruses, AMV, BYMV, CMV, and PLRV which were isolated from diseased lentils, reproduced similar or identical symptoms in this host in

greenhouse and field inoculations when inoculated singly or in combination.

Effect of virus infection on yields of Lentil. - In field inoculation trials, yields of lentils inoculated with AMV, BYMV, CMV, and PLRV singly, and with BYMV + CMV simultaneously, at two stages of plant growth were reduced by 46 to 94% (Fig. 5). The effects of virus infection on plant growth and yields were most pronounced in lentil plants infected in

the seedling stage. The largest reduction in seed yields occurred at pre-bloom with BYMV + CMV, followed by PLRV, BYMV, CMV, and AMV (Fig. 5). Although virus symptoms, especially stunting, were most noticeable in plants infected prior to flowering, mortality was seldom observed, except with PLRV at pre-bloom where it exceeded 50%.

Effect of natural infection by BYMV and CMV on yield of 30 Lentil lines, and resistance of these lines in greenhouse inoculation trials. - In field trials at Varamin, Iran, the incidence of virus diseases, primarily BYMV and CMV, in 30 Lentil lines varied greatly (Table II). Virus infection was 30% or less in lines 1 to 13, while that of lines 14 to 30 was over 50%. There was good correlation between yields and incidence of disease. The highest yields of 617 to 1166 kg/ha were obtained from lines 1 to 13 which had the lowest disease incidence, whereas yields ranged from 96 to 284 kg/ha in lines 14-30 where virus infection was high (Table II, Fig. 6). In greenhouse inoculation studies with BYMV and CMV, the highest yielding Lentil lines generally had the lowest incidence of infection (Table II). Disease symptoms were usually more pronounced and severe in the lines with the lowest yields.

Insect transmission. - Several aphid species which commonly colonized lentils and other pulse crops under field conditions were vectors of AMV, BYMV, CMV, and PLRV. These aphids were *Aphis craccivora*, *Acyrthosiphon pisum*, and *A. sesbaniae*. All Lentil viruses, except PLRV, were transmitted by their aphid vectors in a stylet-borne (non-persistent) manner. These viruses were acquired in brief feeding probes of 10 to 60 sec, but were usually retained for only a few hours. PLRV was transmitted by aphids in a circulative (persistent) manner. Aphids usually required longer feeding periods to acquire PLRV, but retained and transmitted the virus for several days, often for the life span of the vector.

Seed transmission. - Lentil seeds from plants inoculated singly with AMV, BYMV, CMV, and PLRV were planted in the greenhouse where observations were made on seed transmission. None of these viruses was found to be seed-borne in 300-500 seeds tested. Transmission of these viruses was also negative in seed collected from naturally-infected lentils.

Annual and perennial hosts of viruses affecting Lentil. - Numerous cultivated crops, forage legumes,



Fig. 4. - Lentil plant infected with Alfalfa mosaic virus (left); healthy plant, right.

Fig. 4 - A sinistra, pianta di Lenticchia infetta da AMV; a destra, pianta sana.

and weeds were alternate hosts of the four viruses which infected Lentil in various regions of Iran (Table III). Many of these plants were also important reservoirs of aphid vectors of viruses infectious to *L. esculenta*. Plants in 41 genera from 16 families were found to be naturally-infected by one or more of viruses (Table III). CMV, which had the largest host range, infected plants in 35 genera from 15 families. Several perennial plants were important overwintering hosts of some viruses and their aphid vectors, e.g., *Melilotus alba* Desr. with BYMV, and *Medicago sativa* L. with AMV and PLRV.

Discussion

In Iran food legumes are affected by at least seven viruses (Kaiser and Danesh, 1971; Kaiser *et al.*, 1968). Four of these viruses,

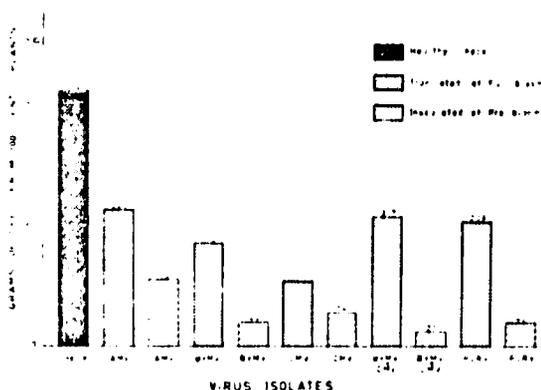


Fig. 5 - Effect of infection by Alfalfa mosaic (AMV), Bean yellow mosaic (BYMV), Cucumber mosaic (CMV), and Pea leaf roll viruses at two stages of plant growth on yields of Lentil in field inoculation trials at Karaj, Iran.

Fig. 5 - Influenza di AMV, BYMV, CMV e PLRV sulla produzione di piante di Lenticchia infettate artificialmente in campo in due differenti stadi di vegetazione.

TABLE III. - Natural infection of annual and perennial plants by four viruses affecting Lentil in Iran.
 TABELLA III. - Infezione in natura su piante annuali e perenni dovute ai quattro virus che infettano la Lenticchia in Iran.

Hosts / Ospiti	Virus (a)			
	AMV	BYMV	CMV	PLRV
Amaranthaceae				
<i>Amaranthus retroflexus</i> L.			+	(b)
Boraginaceae				
<i>Heliotropium curassavicum</i> L.			+	
<i>Echium amoenum</i> F. et M.			+	
Chenopodiaceae				
<i>Beta vulgaris</i> L.			+	
<i>Chenopodium album</i> L.			+	
<i>Spinacia oleracea</i> L.			+	
Compositae				
<i>Carthamus tinctorius</i> L.	+		+	
<i>Lactuca</i> sp.	+			
<i>Tagetes patula</i> L.			+	
<i>Taraxacum officinale</i> Weber			+	
<i>Zinnia elegans</i> Jacq.			+	
Cruciferae				
<i>Brassica kaber</i> (DC.) Wheeler			+	
Cucurbitaceae				
<i>Cucumis melo</i>			+	
<i>C. sativus</i> L.			+	
<i>Cucurbita pepo</i> L.			+	
Fumariaceae				
<i>Fumaria</i> sp.			+	
Iridaceae				
<i>Gladiolus</i> sp.		+		
Labiatae				
<i>Salvia splendens</i> Ker-Gawl.			+	
Leguminosae				
<i>Cassia occidentalis</i> L.		+		
<i>Cicer arietinum</i> L.	+	+	+	+
<i>Lathyrus odoratus</i> L.		+		
<i>L. sativus</i> L.		+		
<i>Lens esculenta</i> Moench	+	+	+	+
<i>Lotus corniculatus</i> L.	+			
<i>Medicago hispida</i> Gaertn.		+	+	+
<i>M. lupulina</i> L.	+	+		+
<i>M. sativa</i> L.	+	+	+	+
<i>Melilotus alba</i> Desr.		+	+	
<i>M. indica</i> (L.) All.		+	+	+
<i>M. officinalis</i> (L.) Lam.	+	+		
<i>Onobrychis viciaefolia</i> Scop.		+		
<i>Phaseolus aureus</i> Roxb.	+		+	
<i>P. lunatus</i> L.			+	
<i>P. vulgaris</i> L.		+	+	+
<i>Pisum sativum</i> L.		+	+	+
<i>Trifolium alexandrinum</i> L.			+	
<i>T. pratense</i> L.		+		
<i>T. resupinatum</i> L.		+	+	+
<i>T. rytidosemium</i> Boiss. et Hoh.	+			
<i>Trigonella foenum-graecum</i> L.		+	+	+
<i>Trigonella</i> sp.				+
<i>Vicia faba</i> L.	+	+	+	+
<i>V. narbonensis</i> L.	+	+		+
<i>V. sativa</i> L.				+
<i>Vigna sinensis</i> (L.) Savi ex Hassk.	+		+	+
Polygonaceae				
<i>Rumex</i> sp.			+	
Portulacaceae				
<i>Portulaca oleracea</i> L.	+		+	
Ranunculaceae				
<i>Ranunculus</i> sp.			+	
Scrophulariaceae				
<i>Antirrhinum majus</i> L.			+	
Solanaceae				
<i>Capsicum annuum</i> L.			+	
<i>Datura stramonium</i> L.			+	
<i>Lycopersicon esculentum</i> Mill.			+	
<i>Petunia hybrida</i> Vilm.			+	
<i>Solanum melongena</i> L.			+	
<i>S. nigrum</i> L.	+			
Violaceae				
<i>Viola tricolor</i> L.			+	

(a) Viruses are: AMV (alfalfa mosaic); BYMV (bean yellow mosaic); CMV (cucumber mosaic); and PLRV (pea leaf roll).
 (b) + indicates recovery of the virus.

AMV, BYMV, CMV, and PLRV, were isolated from diseased Lentils in various pulse producing regions of Iran. These viruses, especially BYMV and CMV, are potentially limiting factors in the cultivation of *Lens*, particularly in areas of intensive crop production where large reservoirs of the viruses and their aphid vectors exist. Some of these viruses affect lentils in other countries of the Middle East where they are cultivated as a food crop. The author has isolated BYMV, CMV, and PLRV from diseased food legumes in Turkey which infected lentils in greenhouse inoculation studies (unpublished data).

Over 50 annual and perennial plants in Iran were found to be alternate and overwintering hosts of four viruses affecting *L. esculenta* and several of their aphid vectors. Plants in the *Leguminosae*, especially forage legumes such as Alfalfa, were the most important reservoir and overwintering hosts of AMV, BYMV, and PLRV. The host range of CMV was considerably larger, affecting cultivated and weed plants in 15 families. Numerous strains of AMV, BYMV, and CMV have been isolated from different alternate hosts, most of which were highly infectious to different food legumes, including *L. esculenta* (Kaiser and Danesh, 1971a). Due to the importance of reservoir hosts in the epidemiology of these viruses, Lentil plantings should not be established near important alternate hosts.

Over 50% of the Lentil lines included in a replicated yield trial at Varamin, Iran were heavily infected with BYMV and CMV. Most plants in many Lentil lines were diseased and yields from these virus-infected plots were drastically reduced. At Ghazvin, Iran where the same 30 Lentil lines were



Fig. 6. - Virus infection under natural field conditions resulted in reduced plant vigor and yields (139 kg/ha) (right), in comparison to a resistant lentil line (824 kg/ha) (left).

Fig. 6. - La malattia da virus determina in campo riduzione di vigore e bassa produzione (139 kg/ha) nelle piante suscettibili (a destra). Le piante di linee resistenti (a sinistra) sono più vigorose e più produttive (824 kg/ha).

also planted and the incidence of disease was negligible, yields of virus-susceptible lines were 4.5 to 10 times greater than those in the Varamin trial. However, at Varamin several of the small-seeded types from the Isfahan area of Iran exhibited high levels of field and greenhouse resistance to virus infection. Many of the small-seeded lines were also resistant to root rot which is a serious disease in certain areas where lentils are grown under irrigation (Kaiser, *et al.*, 1968). Since the small-seeded lines are not as desirable as large-seeded types in the market place, they are being included in the Lentil breeding program of Iran to incorporate virus and root rot resistance into disease susceptible, but preferred, large-seeded Lentil lines.

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Summary

Four viruses were isolated from diseased plants of Lentil (*Lens esculenta* Moench.) in various areas of Iran. The viruses were: Alfalfa mosaic (AMV), Bean yellow mosaic (BYMV), Cucumber mosaic (CMV), and Pea leaf roll (PLRV).

Methods utilized in virus identification were symptomatology, host range studies, physical property tests, vector-virus relationships, serology, and electron microscopy. Virus symptoms commonly observed were mottling, stunting, leaflet deformation, dwarfing and twisting, shortening of the internodes, and proliferation of the axillary buds. Microorganisms were seldom isolated from the roots or stems of virus-infected lentils, and disease symptoms were not reproduced in controlled inoculation tests with various fungi. In field inoculation studies with the four viruses, infection resulted in decreased yields of 46 to 94%. Largest yield reductions occurred when lentils were infected in the seedling stage. In yield trials over 50% of 30 lines were heavily infected under natural conditions by BYMV and CMV, and yields were greatly reduced. Several high yielding, small-seeded lentil types were resistant to both viruses in the field and in greenhouse inoculation tests.

Aphids which usually colonized lentils in nature and were vectors of the four viruses were *Aphis craccivora* Koch, *Acyrtosiphon pi-*

sum Harris, and *A. sesbaniae* David. AMV, BYMV, and CMV were transmitted in a stylet-borne (nonpersistent) manner, whereas PLRV was transmitted in a circulative (persistent) way. None of the viruses appeared to be seed-borne in *L. esculenta*. Annual and perennial plants in 41 genera from 16 families were alternate and overwintering hosts of these viruses and some of their insect vectors.

Riassunto

EZIOLOGIA E BIOLOGIA DEI VIRUS CHE INFETTANO LA LENTICCHIA (*LENS ESCULENTA* MOENCH.) IN IRAN.

Da piante di Lenticchia (*Lens esculenta* Moench.) allevate in varie zone dell'Iran sono stati isolati 4 virus e cioè gli agenti del mosaico dell'Erba medica (AMV), del mosaico giallo del Fagiolo (BYMV), del mosaico del Cetriolo (CMV), e dell'accartocciamento fogliare del Pisello (PLRV).

Per l'identificazione dei virus sono stati impiegati i seguenti metodi: osservazione dei sintomi, inoculazione di ospiti differenziali, saggi sulle proprietà fisiche, relazioni tra virus e vettori, sierologia, microscopia elettronica. I sintomi dovuti ai virus più comunemente osservati sono stati: maculatura, rachitismo, deformazione delle fogliole, nanismo e distorsione, accorciamento degli internodi e proliferazione di gemme ascellari. Raramente sono stati isolati microrganismi dalle radici e dai fusti di piante virosate. Comunque, inoculazioni eseguite in serra con i vari funghi isolati non hanno riprodotto i sintomi.

Inoculazioni eseguite in campo con i 4 virus hanno determinato un decremento di produzione dal 46 al 94%. Le più forti riduzioni di produzione sono state ottenute in piante infettate in uno stadio precocissimo di sviluppo. In prove di campo, oltre il 50% di 30 linee di Lenticchia sono state fortemente attaccate da infezioni naturali di BYMV e CMV. La produzione di tali linee è risultata grandemente ridotta.

In prove di infezione artificiale condotte sia in campo che in serra, un gran numero di linee altamente produttrici, quelle del tipo a semi molto piccoli, sono risultate resistenti ai due virus.

Gli afidi che colonizzano in natura la Lenticchia, *Aphis craccivora* Koch., *Acyrtosiphon pisum* Harris, e *A. sesbaniae* David, sono risultati vettori dei 4 virus. AMV, BYMV e CMV sono stati trasmessi « per stiletto » (in maniera non persistente), mentre PLRV è stato trasmesso in modo persistente (« circolativo »). Nessun virus è sembrato essere trasmissibile per seme. Piante annuali e perenni appartenenti a 41 generi e a 16 famiglie si sono comportate da ospiti intermedi oppure da ospiti su cui i virus o gli insetti vettori hanno potuto svernare.

Résumé

ÉTIOLOGIE ET BIOLOGIE DES VIRUS QUI AFFECTENT LA LENTICCHIA (*LENS ESCULENTA* MOENCH.) DANS L'IRAN.

Quatre virus ont été isolés des plantes ma-

lades de Lentille (*Lens esculenta* Moench.) en différentes régions d'Iran. Ces virus sont: la mosaïque jaune du Haricot (BYMV), la mosaïque du Concombre (CMV), l'enroulement des feuilles du Pois (PLRV), la mosaïque de la Luzerne (AMV).

Les méthodes utilisées pour l'identification du virus ont été: symptomatologie, série d'études sur les hôtes, essais des propriétés physiques, rapports vecteur-virus, sérologie et microscopie électronique. Les symptômes du virus observés communément sont: tacheture, rabougrissement, déformation des folioles, nanisme et entortillement, court-noué et prolifération des bourgeons axillaires.

Des microrganismes ont rarement été isolés des racines ou des tiges de lentilles infectées par le virus, cependant les symptômes ne se reproduisent pas lors des essais d'inoculation avec les différents champignons isolés. Dans le champ, l'inoculation avec les quatre virus a causé une diminution de 46 à 94% de la production. Des diminutions de rendements plus importantes sont survenues lorsque les lentilles étaient infectées dans la phase de petite plante. Dans les essais de rendement, plus de 50% de 30 lignes de Lentille ont été fortement infectées dans des conditions naturelles par le BYMV et le CMV et la production a été très réduite.

Plusieurs lignes de Lentille à petite graine et à rendement très élevé ont montré être résistantes aux deux virus dans le champ et lors d'essais d'inoculation en serre. Des aphidiens qui couramment colonisent les lentilles dans la nature, les suivants ont été porteurs des 4 virus: *Aphis craccivora* Koch., *Acyrtosiphon pisum* Harris et *A. sesbaniae* David. AMV, BYMV et CMV ont été transmis de manière non persistante (« stylet-borne ») tandis que PLRV était transmis de manière « circulative » (persistante). Aucun des virus n'a été transmis par les graines de *L. esculenta*. Des plantes annuelles et vivaces de 41 espèces appartenant à 16 familles différentes ont été hôtes alternatifs ou bien hôtes sur lesquels ces virus ou des insectes vecteurs ont pu hiverner.

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