Egyptian J. Virol. 1, 215-221(2004)

Population Fluctuations of Aphids in Relation to Virus Disease Incidence in Egyptian Faba Bean Fields

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Infection induced by both *Faba bean necrotic yellows virus* (FBNYV) and mosaic-causing viruses were inspected during Oct. 2003 to Apr. 2004 on faba bean fields grown in Qualubia governorate. Population density of seven different aphid species on faba bean was arranged descendingly as follow: *Aphis craccivora* (270.9), *Myzus persicae* (89.0), *A. fabae* (52.5), *Acyrthosiphon. Pisum* (24.3), *A. gossypii* (4.7), *A. sesbaniea* (1.8), and *A. nerii* (0.7). Population fluctuation of previous aphid species was also recorded on faba bean during the same period at the same fields. Fluctuations of Infection rate for both virus-infection types (necrotic yellowing and mosaic) are the same. It starts with low rate and then increasing during season period and then declined at the end. It consists of four infection sub-cycles i.e. two small ones in the middle and two big more ones at the beginning and at the end of the period. Fluctuations of infection rate for both infection types were matched with the population fluctuations of aphid vectors. Infection curve studies and infection rate matching with aphid population fluctuations could help in getting integrated disease management (IDM) strategic manipulation during the growing season.

INTRODUCTION

Faba bean necrotic yellows virus (FBNYV) and other mosaic-causing virus infections are devastating broad bean cultivations in Egypt. The major diseases-causing loss in Egyptian legume is FBNYV (Rizkallah. 1993). Losses caused by FBNYV are more than 90% during the severe infection incidence (Rizkalla, 1993). It causes plant stunting, leaf yellowing and necrosis all over leaves, stems and podes. Podes are very small with no seeds or few small unmarketable seeds (Makkouk *et al*, 1988, 1992 and 1994). FBNYV has been invading Egyptian faba bean fields since 1993 which severe epidemic was occurred (Rizkalla, 1993). Seasonally, FBNYV infects many faba bean fields with different degrees of severity in Middle Egypt (Rizkalla, 1993). Faba bean cultivated area has been decreased up to 75% because of FBNYV invasion (Rizkalla, 1993). Cultivated area of faba bean is still as it is without increasing and farmers are afraid of FBNYV infection (Rizkalla. 1993).

This study aims to uncover some epidemic-causing factors i.e. population fluctuations of aphid vectors in relation to virus infections so that IDM program can be manipulated.

MATERIALS AND METHODS

Field Visits and sampling

Faba bean fields were visited once a week during December 13, 2003 and April 17, 2004 in Qualubia Governorate. Percentage of infection caused by viruses was recorded during the field visits. Virus-causing symptoms were categorized into 2 types of symptoms: 1. FBNYV-like symptoms (stunting, yellowing, small leaves and rolling as wel' as necrotic lesions on leaves and stems) and 2. Mosaic symptoms (severe and / or mild

mosaic, stunting, discoloration on leaves). Degree of infection severity (1-3 degrees, 1= mild, 2= moderate, 3= severe) was recorded. Aphid species occurrence, number of aphids of each species per plant were recorded as total number of insects on middle, upper and down part of faba bean plant. Ten plants were inspected each time.

Aphid species identification was done using morphological characters i.e. size of insect, colour and shape. Slides were prepared for each aphid species and then they were examined using light microscope. Aphid species were kindly identified using key of aphid identification by Entomologists at Dept. of Economic Entomology, Faculty of Agriculture, Cairo University. As pointed out by Threash, (1998) following calculations are made.

Infection rate (Infection occurred in a given time) = xt1-xt0/t1-t0

Percentage of infection rate = xt1-xt0/t1 – t0/100

xt0 = Infection at 0 time

xt1 = Infection at time 1

Virus Detection

FBNYV-like symptom containing-plant samples, were collected for virus detection using ELISA as serological test. Fifty samples were collected and categorized into two types i.e. FBNYV-like diseased samples and mosaic-diseased samples. FBNYV- infected plant samples were extracted in PBS pH 7.0 for TAS-ELISA (Three antibody sandwich, as indirect ELISA,) performance (Makkouk and Comeau, 1994). Monoclonal antibodies of FBNYV, that was kindly supplied by ICARDA, were used as attractive and detective antibodies. Goat-anti mouse antibody conjugated with alkaline phosphates was used as second antibody. Yellow color represents positive reaction. ELISA reader is used to calculate FBNYV occurrence. Healthy faba bean plants were used as negative control.

As for mosaic-diseased plant samples were also used for mosaic-causing virus detection (Makkouk and Comeau, 1994). Polyclonal antibodies of *Cucumber mosaic virus* (CMV), *Bean yellow mosaic virus* (BYMV), *Pea seed-borne mosaic virus* (PSbMV) and *Alfalfa mosaic virus* (AMV) were used (ELISA kits were supplied from Sanofi, Sante Animal, Paris, France). Previous virus antibodies were used as attractive and detective antibodies in DAS-ELISA tests (Double antibody sandwich enzyme-linked immuno sorbent assay). Reaction values were read on ELISA reader at 405 nm wavelength. Twice as much of ELISA-reading for negative-control samples were considered positive.

RESULTS AND DISCUSSION

Finding out relationship between fluctuations of virus-infection rate and population fluctuations of aphid vectors could help in getting integrated disease management (IDM) that can help plant growers to face viral infection during growing season.

Both Samples of FBNYV-diseased plant and mosaic-diseased plant of faba bean were collected for virus-infection confirmation using ELISA. All FBNYV-diseased samples were reacted positively with FBNYV monoclonal antibodies (Aboul-Ata, *et al.*, 2004). As for mosaic infection, tested samples serologically, has proved that mixed infections could be caused by two or more viruses of the following i.e. AMV, BYM, CMV and PSbMV (Table 1). It is also shown that, AMV occurrence in those mixed infections causes severe and moderate mosaic symptom appearance (Table 1). That finding is in agreement with Fortass and Bos (1991). Also, PSbMV was found in all tested samples (50

samples). Major occurrence of PSbMV, in those tested samples, is logic because of high ability of seed-transmission of PSbMV in seeds of faba bean (Fletcher, 1993).

1. Virus infection progress curves

Infection curves, during growing season (Dec. 13, 2003 – Apr. 17, 2004) of both FBNYV and mosaic-causing viruses are shown in (Fig. 1). The three phases of infection curve that was pointed out by Thresh (1998), i.e. initial, logarithmic and decrease of spread, are being shown in both curves (Fig. 1). Logarithmic phase has been mathematically analyzed to show fluctuations of the infection rate (Fig. 2 and Tables 2 and 3). Tables (2) and (3) show the date of Five peak occurrence for fluctuations of both FBNYV and mosaic-causing viruses respectively. Peaks of infection-rate fluctuations (Fig. 2 and Table 2 and 3) are representing new spreading of infection. Those peaks could be called as sub-cycles of infection as new definition in the domain of virus epidemiology. Two to three weeks are interval period between two peaks (Table 2 and 3). Field observations for infection-rate fluctuations could help in getting IDM measures during the growing season to stop new spreading of virus infection.

2. Population fluctuations of aphid vectors in relationship to fluctuations of virus-infection rate

Population fluctuations of aphid vectors (*Aphis craccivora, A. fabae, Acerthosiphon pisum* and *Myzus persicae*) are shown in Fig. (3). Aboul-Ata *et al.* (2004) pointed out that the first three species i.e *A. craccivora* (93.84%), *A. ffabae* (89.09%), *A. pisum* (77.50%), are vectors of FBNYV with different percentage of transmission ability that was written between bracts. Previously mentioned four aphid species are vectors for mosaic-causing viruses (Bos, 1982).

a. Persistent Faba bean necrotic yellows virus (FBNYV)

Table (2) shows dates of peek occurrence for both fluctuations of FBNYV-infection rate and population fluctuations of its aphid vectors. Aboul-Ata, *et al.* (2004) studied the elapsed period for getting new infection by FBNYV in faba bean fields. He pointed out that FBNYV can infect new faba bean plants by *A. craccivora* after, at least, five-day period (AAP is 2 hr + IAP is 0.5 hr + latent period is 18 hr + 4-day post-inoculation period = Total period is almost 5 days). Previous calculation leads to one week could be enough to getting new infection done by viruliferous aphids. So, peak of aphids will have one week for responsibility in getting new peak of infection. So, shifting one week between date of occurrence for aphid population and infection peak, will help in studying virus-vector relationship for infection prediction (Kerry, F. H., 1980). Four dates of peak occurrence out of five ones are matched with *A. craccivora* (Tables 2 and Fig. 4). Three dates out of five are matched with *A. fabae* (Tables 2 and Fig. 4). That statement leads to possibility of using IDM program during growing season to stop spread ng out of virus infection.

b. Non-persistent mosaic-causing viruses

Table (3) shows dates of occurrence for peeks of population fluctuations of aphid vectors i.e. *Aphis craccivora, A. fabae* and *M. persicae* as well as peeks of fluctuations of mosaic-causing virus-infection rate. Previous statement could be manipulated with the mosaic-causing viruses by their three aphid vectors.

Non-persistency can shorten new infection period occurrence (Kerry, 1980). So, two dates out of five ones are matched for the three aphid species (Table 3 and Fig. 5).

Generally, Population fluctuations of virulefirous aphids is strong evidence for the virus infection occurrence (Kerry, 1980).

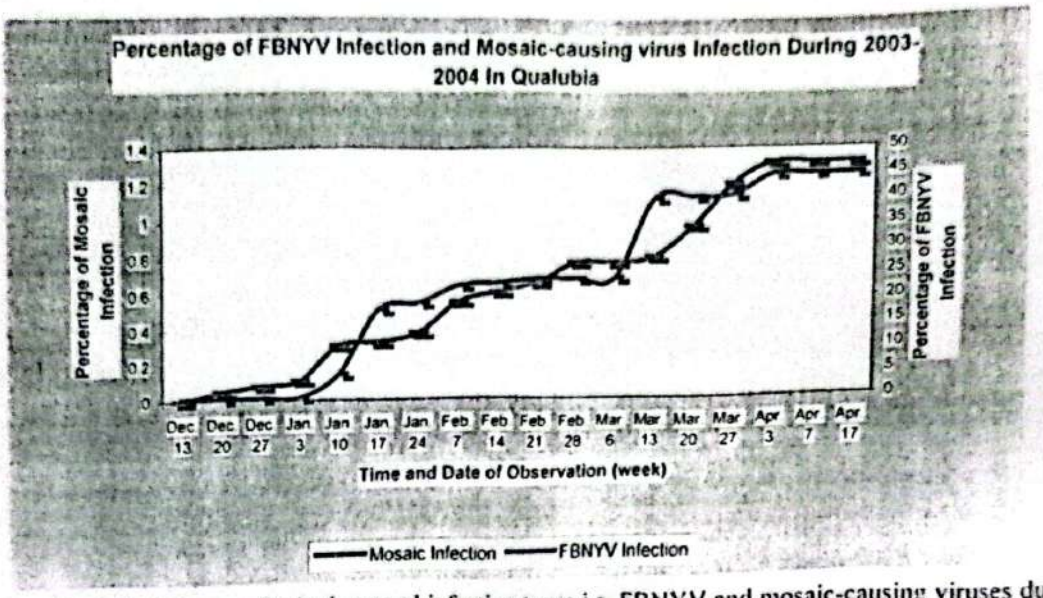

Fig. (1): Infection curve for both natural infection types i.e. FBNYV and mosaic-causing viruses during 2003-2004 faba bean growing season in Qualubia

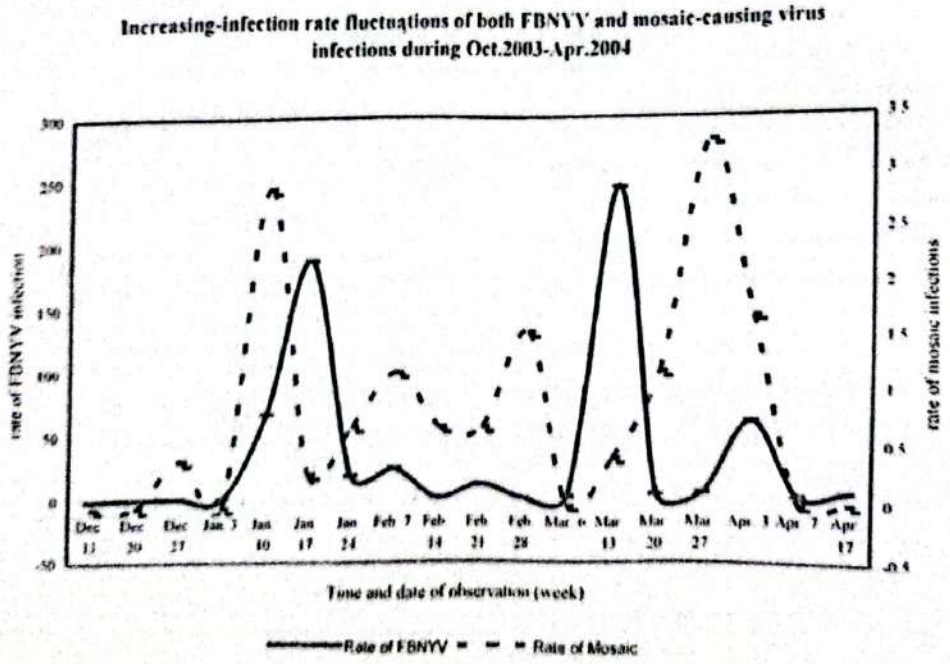

Fig. (2): infection-rate fluctuations for both natural virus infections i.e. FBNYV and mosaic-causing viruses during Oct. 2003 - Apr. 2004 on faba bean fields grown in Qualubia.

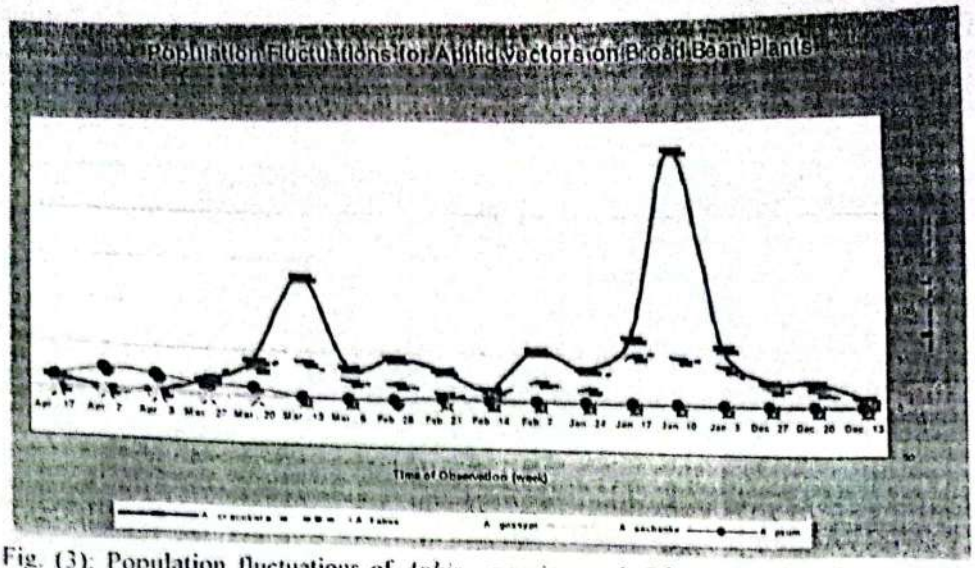

Fig. (3): Population fluctuations of *Aphis craccivora*, *A. fabae* , *Acerthosiphum pisum* and *Myzus persicae* during Oct.2003 - Apr. 2004 on faba bean fields grown in Qualubia

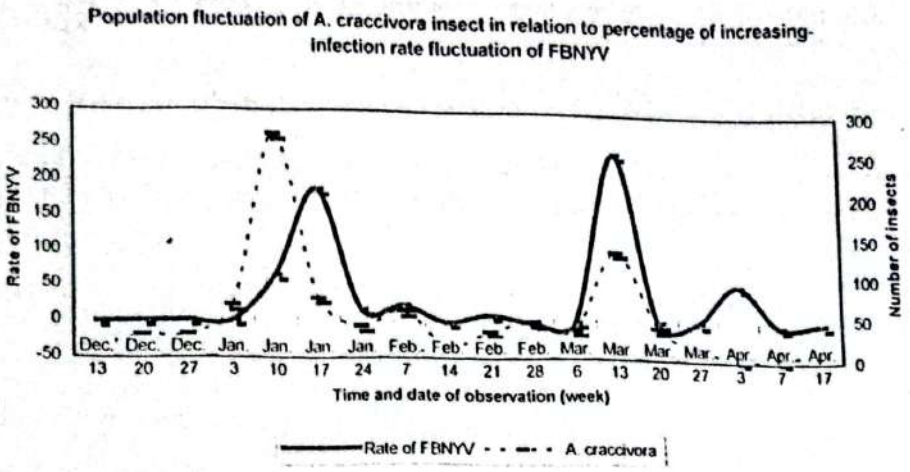

Fig. (4): Population fluctuations of *Aphis craccivora* in relation to infection-rate fluctuations of FBNYV during Oct.2003 - Apr. 2004 on faba bean fields grown in Qualubia

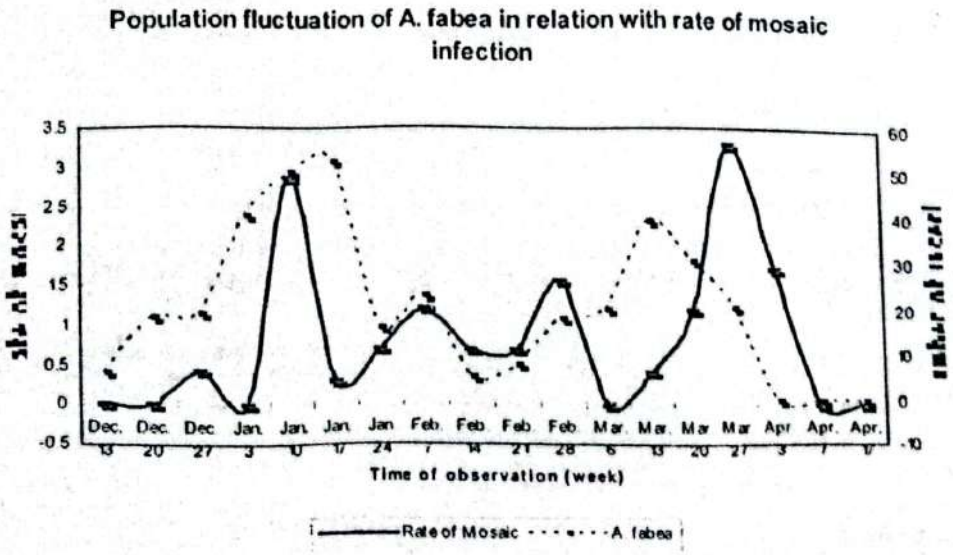

Fig. (5): Population fluctuations of *Aphis fabea* insect in relation to infection-rate fluctuations of mosaic-causing infections during Oct.2003 - Apr. 2004 on faba bean fields grown in Qualubia

Table (1). Detection of viruses cause mosaic symptoms on faba bean samples (50 samples), those collected from different fields in Qualubia Governorate, using DAS-ELISA

Sample Identification	Virus antiserum			
	AMV	CMV	BYMV	PsbMV
Severe Mosaic (5 samples)	+	-	+	+
Moderate Mosaic (3 samples)	+	+	+	+
Mild Mosaic (4 samples)	-	+	+	+
Mild Mosaic (2 samples)	-	-	-	+
Mild Mosaic (8 samples)	-	+	+	+
Mild Mosaic (5 samples)	-	+	+	+
Mild Mosaic (6 samples)	-	-	+	+
Severe Mosaic (7 samples)	+	+	+	+

PsbMV = *Pea seed-borne mosaic virus*
AMV = *Alfalfa mosaic virus*
BYMV = *Bean yellow mosaic*
CMV = *Cucumber mosaic virus*
+ = Positive reaction
- = Negative reaction

Table (2). Dates of peak incidence of both infection-rate fluctuations of FBNYV and population fluctuations of aphid vectors (*Aphis craccivora*, and *A. fabae*)

Date of Disease Sub-Cycle Occurrence	Dec. 20	Dec. 27	Jan. 10	Jan. 17	Feb. 7	Feb. 21	Feb. 28	Mar. 13	Mar. 27	Apr. 3
FBNYV	-	-	-	+	+	+	-	+	-	+
A. craccivora	-	-	+	-	+	-	+	+	+	-
A. fabea	+	-	-	+	+	-	+	+	-	-

+ = Fluctuation peek
- = No Fluctuation peek

Table (3). Dates of peak incidence of both infection-rate fluctuations of mosaic-causing viruses and population fluctuations of aphid vectors (*Aphis craccivora*, *Aphis fabae*, and *Myzus persicae*)

Date of Disease Sub-Cycle Occurrence	Dec. 20	Dec. 27	Jan. 10	Jan. 17	Feb. 7	Feb. 21	Feb. 28	Mar. 13	Mar. 27	Apr. 3
MosaicCausing Viruses	-	+	+	-	+	-	+	-	+	-
A. craccivora	-	-	+	-	+	-	+	+	+	-
A. fabea	+	-	-	+	+	-	+	+	-	-
M. persicae	-	-	-	-	+	+	-	+	-	-

+ = Fluctuation peek
- = No Fluctuation peek

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