EFFECTS OF BEAN YELLOW MOSAIC VIRUS INFECTION ON
THE GROWTH AND YIELD OF FABA BEAN (*Vicia faba* L.)

By
Abu Elgasim Elbashir Elamin
Sudan University for Science & Technology

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of M. Sc. in Plant Protection

Supervisor:
Prof. Ahmed Hashim Ahmed

Department of Crop Protection
Faculty of Agriculture
University of Khartoum

August - 2005
DEDICATION

To the soul of my father
To my dear mother
To my brothers and sisters
To my teachers and friends
With love and respect

Abuelgasim
Acknowledgement

Above all I render my thanks to the Merciful ALLAH who availed me the strength to accomplish this study.

I wish to express my sincere gratitude and appreciation to my supervisor Professor Ahmed Hashim Ahmed for his invaluable guidance and help during all the stages of this study.

Thanks are also due to Mr. Abdelmagid Adlaan, Head Department of the Plant Protection, Hudieba Research Station..

Thanks are extended to Salah Abdelmutalab, the technician of Hudieba Research Station..

Thanks are also due to my brother Dr. Kamil Elbashir Elamin for supporting me during this study.

Finally my sincere thanks are extended to all friends who encouraged me during the course of this study.
ABSTRACT

In the present study the effects of bean yellow mosaic virus on the growth, nodulation, pod setting and the final yield of nine faba bean entries, namely B.B.7, C-34, C-52, p.m. H-93, Sml, Sml-4, Sml-85 and C-28, have been investigated under the field conditions of Hudieba Research Station Farm during 2004/2005 season.

All the components of yield studied were consistently reduced by BYMV infection. The infection of the faba bean entries with BYMV before flowering reduced the shoot dry weight, root dry weight and dry weight of nodules. Similarly, BYMV infection before flowering resulted in a highly significant reduction in the number of pods produced by each entry.

In this trial BYMV infection at flowering also significantly reduced the number of pods and seeds per plant. Similarly it reduced the final yield of 80 plants inspected. These reductions ranged between 14.31% to 76.04% in entries p.m. and Sml when inoculated before, and during flowering. However, the third inoculation (after flowering) resulted in non significant differences in most of the varieties tested. In the present study the transmission of BYMV by sap inoculation and by aphids was confirmed.
C-28 ب.ب.7 ONAV 2005/2004
\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

 Bean Yellow Mosaic Virus

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]

\[\begin{array}{c}
\text{Sml-85 UC-52 UH-93 Sml UC-34}
\end{array}\]
The study of aphids (Aphids) showed that they produce a secretion that helps them spread the virus. This secretion contains substances that can cause the virus to spread from plant to plant and from plant to insect. The study also found that this secretion can cause damage to the plants and even kill them. This finding is important for controlling the virus, as it may help prevent the spread of the virus to other plants. Therefore, further research is needed to understand the mechanisms behind this secretion and how it can be controlled.
# LIST OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedication</td>
<td>i</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>ii</td>
</tr>
<tr>
<td>Abstract</td>
<td>iii</td>
</tr>
<tr>
<td>Arabic Abstract</td>
<td>iv</td>
</tr>
<tr>
<td>List of Contents</td>
<td>v</td>
</tr>
<tr>
<td>List of Figures</td>
<td>viii</td>
</tr>
<tr>
<td>List of Appendices</td>
<td>ix</td>
</tr>
</tbody>
</table>

## CHAPTER ONE: INTRODUCTION

1

## CHAPTER TWO: LITERATURE REVIEW

4

2.1. Bean yellow mosaic (BYMV) 4

2.1.1. History of BYMV 4

2.2. Distribution of BYMV 5

2.3. Host range of BYMV 6

2.4. Identification of BYMV isolates from faba bean 7

2.5. Strains of BYMV 7

2.6. The particles of BYMV 9
2.2.6. The physical properties of BYMV ................................................................. 9
2.7. Serological relationships .............................................................................. 9
2.8. Aphid transmission of BYMV .................................................................... 10
2.9. The effect of BYMV on yield ...................................................................... 11

CHAPTER THREE: MATERIALS AND METHODS ............................................ 13
3.1. Field surveys ............................................................................................... 13
3.2. Field experiment .......................................................................................... 13
3.2.2. Aphids transmission of BYMV ............................................................... 14
3.2.3. Mechanical Inoculations ......................................................................... 15
3.3. The effect of BYMV on the growth and yield components of Faba been ............................................................... 15
3.3.1. Plants Sampling ....................................................................................... 15

CHAPTER FOUR: RESULTS .............................................................................. 17
4.1.2. Field surveys ............................................................................................ 17
4.2. Effect of BYMV infection on the growth and yield of faba bean 17
4.2.1. Effect on shoot dry weight ...................................................................... 17
4.2.2. Effect on the root dry weight .................................................................. 18
4.2.3. Effect on the nodulation of faba bean .................................................... 18
4.2.4. Effect on the number of pods formed ........................................ 18
4.2.5. Effect on the number of seeds ........................................ 18
4.2.6. Effect on the weight of seeds ........................................ 19
4.2.7. Effect on the weight of 100 seeds .................................... 19
4.2.8. Effect on the final yield of 80 plants .................................. 19

CHAPTER FIVE: DISCUSSION ......................................................... 30

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS ....... 33

REFERENCES ............................................................................ 34

APPENDICES ............................................................................ 42


**LIST OF FIGURES**

<table>
<thead>
<tr>
<th>Fig.</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Incidence of BYMV in three <em>Faba bean</em> fields at Hudeiba Research Farm, 2004/05</td>
<td>22</td>
</tr>
<tr>
<td>2.</td>
<td>The effect of BYMV on the shoot and root dry weights (gm)</td>
<td>23</td>
</tr>
<tr>
<td>3.</td>
<td>The effect of BYMV on the nodulation</td>
<td>24</td>
</tr>
<tr>
<td>4.</td>
<td>The effect of BYMV on the number of pods</td>
<td>25</td>
</tr>
<tr>
<td>5.</td>
<td>The effect of BYMV on the number of seeds</td>
<td>26</td>
</tr>
<tr>
<td>6.</td>
<td>The effect of BYMV on the weight of seeds</td>
<td>27</td>
</tr>
<tr>
<td>7.</td>
<td>The effect of BYMV on the weight of seeds for 80 plants</td>
<td>28</td>
</tr>
<tr>
<td>8.</td>
<td>The effect of BYMV on the final yield of 80 plants from area</td>
<td>29</td>
</tr>
</tbody>
</table>
# LIST OF APPENDICES

<table>
<thead>
<tr>
<th>Append.</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The effect of BYMV on nodules, shoot and root dry weights</td>
<td>43</td>
</tr>
<tr>
<td>2.</td>
<td>The effect of BYMV on the number of seeds/plant and weight of seeds</td>
<td>44</td>
</tr>
<tr>
<td>3.</td>
<td>Effect on weight of seeds</td>
<td>45</td>
</tr>
<tr>
<td>4.</td>
<td>Effect on number of pods/plant</td>
<td>46</td>
</tr>
<tr>
<td>5.</td>
<td>Effect on number of seeds</td>
<td>47</td>
</tr>
<tr>
<td>6.</td>
<td>The effect of BYMV on the weight of seeds/80 plants when faba bean were inoculated</td>
<td>48</td>
</tr>
</tbody>
</table>
CHAPTER ONE

INTRODUCTION

Broad bean (*Vicia faba* L.) has many names, but the name faba bean has recently been widely used. Faba bean seeds are considered a good source of proteins, carbohydrates and fibers (Eltinay, *et al*. 1993) Faba bean originated in Egypt, but other studies concluded that it probably originated in west or central Asia (Abdalla, 1979). Yet the origin of the crop is still debatable (Duk, 1997). Faba bean is one of the several pulse crops (food legumes) for human consumption and about 5,000 hectares of Faba bean are grown, primarily in the north around the Caspian Sea and in the south near the Persian Gulf. In Khuzestan Province (South Western Iran) Faba beans are the major pulse crop grown.

Faba bean is an important food legume in the Sudan and the main producing areas are in the Northern State, north of latitude 16. The production is under small farming system in private pump schemes and few big pump schemes. Faba bean is considered among the most important annually produced crops.

The total area annually grown is about 20,000 ha and could reach 35,000 ha in some seasons, compared to an area of 6,700 ha in the early sixties, hence considerable production expansion has taken place. The
average yield is around 1.8 ton/ha but annual fluctuations are very common due to weather and biological factors. However, during the last two decades the area cultivated has increased since 1960 and since 1981/82 the Faba bean imports gradually decreased to 14,877 tons in 1991 (Salih et al., 1996).

In the Sudan Faba bean is considered an important human diet both in rural as well as in urban areas. During 2001/2002 season the crop was grown in an area of 58,000 feddans with an average yield of about 251 kg/ha (FAO, 2001). Most of the total Faba bean production in the Sudan comes from the Northern and River Nile States, with small amount from Khartoum State. As the result of the increasing demand for Faba bean efforts have been made to increase its yields in the traditional areas and to extend its cultivation to new areas in Gezira, Rahad and New Halfa schemes (Hassan 1984, Ageeb 1988).

In the Sudan pests and diseases are considered among the major constraints of Faba bean production (Hawtin and stewart 1979, Esia 1990). Several insect pests attack Faba bean such as storage pests and different species of aphids such as *Aphis craccivora, Myzus persicae, Aphis pisum, Aphis faba* and *laphygma sp.* (Siddig, 1982) which are insect pests as well as possible vectors of faba bean viruses (Saxena and Stewart, 1983).
The faba bean diseases in the Sudan include the root rot and wilt complex and other fungal and virus diseases (Hussein 1985). Nine virus diseases have been reported infecting faba bean in the Sudan (Makkook et al., 1988) Faba bean yields are affected by Bean yellow mosaic virus (Kaiser et al. 1967) and Broad bean mottle virus which are the most prevailing viruses in the Country (Ahmed and Hussien, 1989). The mosaic diseases became very common in Hudeiba Research Farm since 1968 (Abusalih, et al. 1973).

Hence the main objectives of the present study are:

1. To study the ecological relationship between the vectors and Bean yellow mosaic virus infecting faba bean at Hudeiba Research Station.

2. To study the extent of the Aphid transmission of Bean yellow mosaic virus.

3. To study the relationship between inoculation time and the yield loss induced by the virus infection.

4. To estimate the loss in yield of faba bean infected with BYMV under the field conditions at Hudeiba Research Farm.
CHAPTER TWO

LITERATURE REVIEW

2.1. Bean yellow mosaic virus (BYMV):

2.1.1. History of BYMV:

Bean yellow mosaic virus was first reported by Mclarty (1920) from a naturally infected sweet clover (Bos, 1934). The virus was later reported from a naturally infected Faba bean plant and designated as pea virus 2 (Pv2). It was identified on the basis of symptomatology, host range and insect transmission (Osborn, 1937). The type strain of the virus was described by Pierce (1934) from naturally infected beans (*Phaseolus vulgaris*).

Although Pierce (1934) introduced the name bean yellow mosaic virus, the causal agent of bean yellow mosaic was isolated from a naturally infected pea in Wisconsin in 1946 and identified on the basis of symptoms expression, host range, varietal reaction and physical properties (Hagedorn and Walker, 1950). Later, the identity of BYMV was confirmed serologically by different workers (Beemster and Van Bercks, 1960).
2.2. Distribution of BYMV:

Bean yellow mosaic virus is worldwide in distribution as reported by Bos (1970) as it was considered the main cause of the mosaic symptoms in Faba bean. Since the early discovery of the virus it was reported from thirty countries including Newzealand, Australia, Great Britain, Canada, Kenya, China and sevral Arab countries (Chamerlain, 1936, Wade, 1950, Heathcote and Gibbs, 1962, Evans, 1973, Back, et al., 1973, Makkouk, et al., 1980). The virus was reported as one of the most common viruses naturally infecting faba bean in Egypt, Sudan, Syria and Tunisia. In these Arab countries, the incidence of the virus reached 67, 50, 33.4 and 35.7%, respectively (Makkouk et al., 1988). In Morocco the disease incidence was relatively low, it was detected in only 3.7 % of the samples tested (Fortass and Boss, 1991). In the Sudan, the disease was first observed in 1959 in Shambat area and other parts of the State with majority of the fields showing epidemic attack ranging from 20 to 75% (Nour and Nour, 1962). The disease was also observed at Hudeiba Research Farm in season 1968-69 (Abusalih, et al., 1973). According to Hussein (1992), the virus was detected in 73% of the samples collected from Faba bean fields in the Broad bean Nile Province in 1974, and 8% were in mixed infections with
mottle virus (BBMV). The results of field surveys for Faba bean viruses showed that Bean yellow mosaic virus was the most common among the sap-transmissible viruses in all the new and traditional areas surveyed (Makkouk, 1986, Ahmed and Hussein 1988). Recently, the result of surveys showed that BYMV was frequently encountered in faba bean plants showing mosaic symptoms collected from different production areas. It was detected in 38.7% of the samples tested. The incidence of the virus varied from 10.8% in Rahad to 29.7 in Khartoum. The disease incidence varied from 6.4 to 100% at Wad – Hamid and Hudeiba, respectively (Makkouk et al. 1994 unpublished data).

2.3. Host range of BYMV:

The earliest reports of natural infection of Faba bean were reported by Boning (1927) and Nerkel (1929) in Germany and Fukushi (1930) in Japan, and, mosaic disease of faba bean was reported earlier by Dickson (1921) in Canada as induced by BYMV. Alternate hosts such plants as alsike clover (*Trifolium hybridum* L., red and sweet clovers and *Medicago oficinalis*, L.), vetches (*Vicia* spp.) and gladiolus are all considered the main sources of the virus (Smith et al.,
Many species from the genera *Proboscidea* and *Martynia* were found naturally infected with BYMV (Provvidenti and Schroeder, 1964).

**2.4. Identification of BYMV isolates from faba bean:**

The faba bean virus isolates from Sudan, Syria and the Netherlands were identified as BYMV isolates especially adapted to faba bean. All of them were weak pathogeneic to *Phaseolus* bean, with the exception of SV 205, assuming an intermediate between *Phaselous* bean isolate with low pathogenic to faba bean. The faba bean isolates, had pathogencity to *Phaseolus* bean. (Fortass and Bos, 1993).

**2.5. Strains of BYMV:**

The strains of Bean yellow mosaic virus were reported by Bos (1970) who mentioned that BYMV could be distinguished from most other viruses reported in faba bean by symptomatology, particle morphology and test plant reactions. In *Chenopodium amartanticolor* the different strains induced chlorotic or necrotic local lesions without systemic symptoms or symptoms ranging from chlorotic spots to veinal chlorosis and leaf malformation (Bos et al., 1974).
Various local strains differing in the symptoms they produced in certain varieties have been recognized, their distinction being especially important in breeding for resistant varieties of crop plants.

Pea mosaic strain of BYMV (Doolittle and Jones, 1925) was long considered as a separate virus, differing from bean yellow mosaic virus by the bright yellow symptoms it causes in pea and Faba bean, and by not infecting other varieties. Bean varieties, however are most susceptible to BYMV (Schroeder and Provridenti, 1966, Cousin, 1969). Resistance in pea to isolates of both viruses was reported by Barton et al., (1964).

The type strain of BYMV was first described by Pierce (1934). Since then, many isolates with widely varying host ranges have been reported. The cowpea strain of Anderson (1955) and Brierly and Smith (1962) isolated from Faba bean and produced systemic symptoms in Vigna sinensis, which was not infected by the common strains of the virus. Red clover necrosis strain of Zaumeyer and Coth (1963) produced necrosis in red clover and pea, local and systemic necrosis in Chenopodium amaranticolor, death of Trifolium incarnatum, and Vicia faba.
2.6. The particles of BYMV:

BYMV belongs to the poty virus group, with filamentous particles 750µm long and 15µm wide and which sediments as a single component (Huttinga, 1975). As with some other poty viruses, the length and flexousness of the particles in plant extracts are affected by the presence of magnesium ions in the extracting fluid (Covier and Woods, 1971).

2.2.6. The physical properties of BYMV:

According to Bos (1970) the thermal inactivation point in crude juice is usually 55 to 60°C, the dilution end-point about $10^{-3}$- $10^{-4}$ and longevity in vitro at room temperature is usually few days. However, the dilution end point of an isolate of the pea mosaic strain from faba bean was $10^{-6}$ – $10^{-7}$ when tested on *Chenopodium amaranticolor* (Nitzani and Cohen, 1962). The latter isolate was found infective after years in dried leaf tissues stored over calcium chloride at 4°C (Bos, 1969).

2.7. Serological relationships:

Strains of bean yellow mosaic virus differ serologically to various extents, but there is not sharp distinction between closely and distantly related strains (Bercks, 1960). Pea mosaic virus is now considered a strain, even though it may differ considerably in particle length (Taylor and Smith,
Bean common mosaic is serologically related to bean yellow mosaic virus (Beemster and Van der want, 1951, Bercks 1960) but differs in that it rarely infects plants other than French bean and is being commonly seed-transmitted in this host. Other viruses closely related to BYMV include: bean western mosaic, cowpea aphid borne mosaic, clover yellow vein, lupin mottle, peanut mottle, Pea leaf roll, pea necrosis and wisteria vein mosaic viruses. BYMV is distantly serologically related to potato Y and beet mosaic viruses (Bercks, 1961) and to many others of the potato viruses Y group, all of which have particles of related size and morphology. These may have more features in common than hitherto supposed, e.g. several nonlegume virus cause natural infection of legumes and BYMV infects several nonlegumes. Within the potato virus Y group, there seems to exist a cluster of viruses closely related to BYMV (Bos, 1970). Partial, or sometimes complete, cross protection in plants has been found between BYMV and Bean common mosaic virus (BCMV) (Crogan and Walker, 1948, Quantz, 1961).

2.8. Aphid transmission of BYMV:

BYMV is transmitted by sap inoculation and by Aphids in a non-persistent manner (Bos, 1970). Many aphid species have been reported to
be involved in the virus transmission including *Aphis craccivora*, *Aphis faba*, *Aphis pisum* and *Myzus persicae* (Hebblethwaite, 1983, Nour and Nour 1963). In the Sudan the virus was reported to be transmitted by the following species of aphids: *Acyrthosiphon sesbaniae*, *Aphis craccivora*, *longiunuis sacchari* and *Aphis gossypii* (Nour and Nour 1962). This was confirmed by Abusalih, 1973, as his results showed that both *Aphis craccivora* and *Aphis sesbaniae* could transmit the Sudanese broad bean mosaic virus.

2.9. The effect of BYMV on yield:

The effect of infection on the yield of faba bean depends on the time of infection and on the virus strain. In Iran Faba bean plants inoculated with BYMV before, during and after flowering yielded, 44, 42 and 23%, less than uninoculated plants, respectively (Kaiser, 1973). In Canada, field beans inoculated with a mild isolate 5, 7 or 9 weeks after sowing yielded 59, 48 and 17% less than the uninoculated plants respectively, and plants inoculated with severe isolate yielded 96, 70 and 17% less than uninoculated plants respectively (Bernier, 1977). Field experiments conducted in Syria to evaluate the yield losses induced by BYMV resulted in significant losses when faba bean plants were inoculated before, during
and after-flowering; the reductions induced were 81, 56 and 38% respectively (Makkouk, 1987). In the Sudan, Hago (1991) working with Faba bean, reported that effect of BYMV on the growth and yield were reduced significantly when plants were inoculated at flowering. No significant reductions were obtained when plants were inoculated after flowering. Similarly, Nour and Nour (1962) working with Faba bean reported that natural infection of Pea mosaic strain caused 67 – 82% fewer pods per plant. Similarly, Ahmed (1986) working with the same faba bean plants infected with pea mosaic strain reported 91% to 93% yield reductions. BYMV was also reported to reduce number of pods and average seed weight per plant by 68 and 79% respectively, under natural conditions (Hussien, 1992).
CHAPTER THREE
MATERIALS AND METHODS

3.1. Field surveys:
In the present study three separate fields, 10 feddans each, grown with faba bean at Hudeiba Research Farm in the River Nile State were inspected for virus infection during 2004/2005 growing season. The inspection was based on visual symptoms. In each field five locations (one m² each) were chosen at random representing the north, central, eastern and western directions to detect vector movement in relation to infection. Thirty three plants from each m² were inspected at flowering stage for virus infection.

3.2. Field experiment:
A field experiment was carried out during 2004/2005 winter season at Hudeiba Research Farm. The land was disc-ploughed, disc-harrowed, leveled and ridged (60 cm between ridges) and divided into plots with four 6m) each. The plots were randomly allocated to each treatment. ridges (2 Spacing 30 cm between holes, 60 cm between ridges and two to three seeds per hole. Seeds of three Faba bean cultivars, namely Hudeiba. 93, Selaim large and Beladi Basabeer 7, two selections namely Selaim large-4 and
Selaim large-85, and four Faba bean crosses namely C-28, C-34, C-52 and P.M/1/2/1. were sown and the effect of Bean yellow mosaic virus infection on the growth and yield of all entries of faba bean was investigated and data obtained was later compared by T-test.

In this experiment 36 plots were grown at random with each entries. The plants in every three plots were inoculated with Bean yellow mosaic virus using virulferous aphids or left un-inoculated as control. The first inoculation was done before flowering while the second inoculation was done at flowering and the third inoculation was done after flowering.

The control plots were sprayed, to minimize the transmission of the .BYMV, by folimat emulsifiable concentrate at the rate of 1ml/liter first spray was made at the first inoculation and then sprayed regularly at fifteen days intervals.

3.2.2. Aphid transmission of BYMV:

For the establishment of a pure culture of *Aphis faba* single adult, apterous aphids were obtained from healthy plants transferred to Petri dishes lined with moistened filter papers. Using moistened camel hair brushes the newly unfed nymphs were removed and transferred to healthy
faba bean plants kept in cages; one side of each cage, was fitted with a sliding door to facilitate watering the plants and handling of the aphids. The test was carried out by allowing apterous adults of *Aphis faba* to feed on the infected faba bean for weeks. The viruliferous aphids were then transferred to healthy faba bean plants and allowed to feed for two days after which the plants were sprayed with folimat to kill the aphids.

3.2.3. Mechanical Inoculation:

BYMV infected plants were obtained from the field. The leaves were ground in sterilized morter containing few mls of distilled water and inoculated on 600 mesh carborundum- dusted leaves of test plants. The inoculated leaves were rinsed with water using fine sprays. For each one ridge the inoculated plants were observed frequently for symptom development.

3.3. The effect of BYMV on the growth and yield components of Faba bean:

3.3.1. Plants Sampling:

Faba bean samples were taken at random for assessing the effect of BYMV infection on the growth, nodulation and the final yield of faba bean. A total of 10 samples were taken from each plot of the first inoculation trial.
These samples were taken two weeks after inoculation. During each sampling, 10 plants were taken from each plot together with their roots. Plants representing each treatment in each plot were placed in paper bags and taken to the laboratory where the roots were separated from the shoots and were dried in the oven at 85°C for 48 hours and then the oven dry weights were recorded. For the determination of the effect of virus infection on nodulation, plants from each plot were carefully up-rooted, and the roots were carefully washed and the nodules were collected in paper bags, and their oven dry weights were determined. Starting from the onset of pods, ten plants were taken at random from each plot to determine the number of pods, seeds and weight of seeds. At maturity, the total seed yield of each plot was recorded and used for the determination of the final yield per unit area for statistical analysis.
CHAPTER FOUR

RESULTS

4.1. Field surveys:

Three faba bean fields in Hudeiba Research Farm during 2004/05 winter season were surveyed for BYMV infection. In each field the disease incidence was recorded in northern, central, eastern and western directions. The disease incidence in the fields is shown in Fig. 1.A. Moreover, these results indicated that disease incidence was higher in the northern direction as show in Fig. 1.B.

4.2. Effect of BYMV infection on the growth and yield of faba bean:

4.2.1. Effect on shoot dry weight:

BYMV infection caused significant reductions in shoot dry weights (Fig. 2). These reductions ranged between 0.97% to 43.29% in cultivars C-28 and H-93, respectively. The reductions in shoot dry weights are statistically significant, except in entries p.m. C-52 and C-28 (as shown in appendix 6).

4.2.2. Effect on the root dry weight:

As shown in Fig. 2 early infection of BYMY caused significant reductions in the dry weight of most of entries tested. However, these reductions varied between C-34, H-93, C-28, Sml – C-34, C-52 and P.M.
4.2.3. Effect on the dry nodules of faba bean:

As shown in Fig. 3 early infection of BYMV caused significant reduction in the dry weight of nodules in all the entries treated. These reductions ranged between 11.1 to 64.44% in cultivars B.B.7 and SML, respectively.

4.2.4. Effect on the number of pods formed:

Ten plants were taken from each plot at random to determine the effect of BYMV infection on the formation of pods and the results are shown in Fig. 4. The virus infection caused significant reductions in the number of pods formed by entries BB-7, C-34, C-28, Sml, Sml 85, Sml-4, P.M. and H-93 in the first and second inoculations. However, no significant reductions in the number of pods were obtained by entries B.B.7, C-28, C-34 and H-93. However, in entries Sml-4, C-52,P.M. and Sml-85 no significant reductions in the number of pods were obtained from the third inoculations.

4.2.5. Effect on the number of seeds/plant:

In these results ten plants were taken from each plot to determine the effect of BYMV infection on the number of seeds per plant of faba bean. The results are shown in Fig. 5. BYMV caused significant reductions in the
number of seeds of all the entries in the first and second inoculations. However, no significant reductions in the number of seeds were obtained by entries B.B.7, C-28, C-34 and p.m. in third inoculation.

4.2.6. Effect on the weight of seeds:

The effect of BYMV infection on the weight of seeds per plant is shown in Fig. 6. BYMV caused significant reductions in the weight of seeds per plant in all the entries treated, except in C-34 in the third inoculation.

4.2.7. Effect of BYMV infection on the weight of 100 seeds:

The effect of BYMV infection on the weight of 100 seeds resulted in significant differences as shown in table 1.

4.2.8. Effect of BYMV infection on the final yield of 80 plants:

The effect of BYMV infection on the final yield of 80 plants (including all the entries tested) grown in the same field is shown in Fig. 7. These results revealed that in all the inoculations BYMV significantly reduced the yield of the inoculated faba bean plants. Moreover, these results revealed that the first inoculation caused highly significant reductions in the yield of faba bean. Also, these reductions varied from one entry to the other as shown in Fig. 8. As the result of BYMV infection the yield ranged
between 0.45 ton/ha. to 1.35 ton/ha in the cultivars C-34 and H-93, respectively, compared to the control plants which produced 1.36 ton/ha. to 2.22 ton/ha.

In the second inoculation these cultivars produced 1.04 ton/ha. and 1.84 ton/ha, respectively. In the third inoculation production of these entries ranged between 0.92 ton/ha. to 1.85 ton/ha, respectively.
Table (1) The effect of BYMV on the weight of 100 seeds/g when faba bean plant were inoculated

<table>
<thead>
<tr>
<th>Variety</th>
<th>First inoculation before the flowering</th>
<th>Second inoculation at flowering</th>
<th>Third inoculation after flowering</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB7</td>
<td>32.5</td>
<td>37.9</td>
<td>38.8</td>
<td>39.5</td>
</tr>
<tr>
<td>C-28</td>
<td>31.5</td>
<td>33.4</td>
<td>46.3</td>
<td>41.3</td>
</tr>
<tr>
<td>SML</td>
<td>38.1</td>
<td>41.5</td>
<td>45.0</td>
<td>39.8</td>
</tr>
<tr>
<td>C-34</td>
<td>36.7</td>
<td>37.6</td>
<td>37.2</td>
<td>38.3</td>
</tr>
<tr>
<td>H-93</td>
<td>33.8</td>
<td>34.8</td>
<td>36.0</td>
<td>38.8</td>
</tr>
<tr>
<td>C.52</td>
<td>32.7</td>
<td>37.8</td>
<td>41.5</td>
<td>40.1</td>
</tr>
<tr>
<td>SML4</td>
<td>40.8</td>
<td>43.7</td>
<td>45.4</td>
<td>49.4</td>
</tr>
<tr>
<td>P.M</td>
<td>33.8</td>
<td>38.0</td>
<td>41.8</td>
<td>43.4</td>
</tr>
<tr>
<td>SML85</td>
<td>38.5</td>
<td>40.4</td>
<td>41.5</td>
<td>48.5</td>
</tr>
</tbody>
</table>
Fig. 1: Incidence of BYMV in three *Faba bean* fields at Hudeiba Research Farm, 2004/05

Fig. 1A: Incidence in relation to the direction of wind

Fig. 1B: Mean incidence of the three fields in relation to direction of wind
Fig. 2. The effect of BYMV on the shoot and root dry weights (gm)
Fig. 3. The effect of BYMV on dry weight of nodules

Faba bean entries

Reduction (%)
Fig. 4. The effect of BYMV on the number of pods/plant
Fig. 5. The effect of BYMV on the number of seeds/plant

![Graph showing the effect of BYMV on the number of seeds/plant across different varieties. The graph plots reduction in percentage against variety.]
Fig. 6. The effect of BYMV on the weight of seeds/g

Variety

Reduction (%)
Fig. 7. The effect of BYMV on the weight of seeds for 80 plants
Fig. 8. The effect of BYMV on the final yield of 80 plants from area

<table>
<thead>
<tr>
<th>Variety</th>
<th>Control</th>
<th>First inoculation</th>
<th>Second inoculation</th>
<th>Third inoculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SML</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-93</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SML4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P.M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SML85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER FIVE

DISCUSSION

*The results of the field surveys revealed heavy infestation of* *Aphis fabae* *on faba bean. It was commonly found colonizing the inflorescence and tips of the branches. Similar observations were reported by Saxena and Stewart (1983) and Siddig (1982) using *Aphis craccivora* as the virus vector. Moreover, the results obtained in Hudieba Research Farm that the disease incidence increases according to the direction of the wind and the source of infection. The present investigation revealed that the growth of nine faba bean entries was severely affected by BYMV. The highest reductions on the shoot dry weight occurred when the plants were inoculated before-flowering such that the reduction in the cultivars H-93 infected with BYMV was 43.28%. In similar field inoculation trials, Hago (1991) reported that BYMV infection reduced the shoot dry weight of the faba bean by 44% in the cultivar Selaim. Moreover, Frowd and Bernier (1977) in Canada reported severe reductions of the faba bean shoot dry weight as the result of BYMV infection. The reduction in the shoot dry weight in the cultivars ranged between 0.97% to 43.28% in entries C-38 and H-93, respectively.
The reduction in the root dry weight infected with BYMV ranged between 11.18% to 30.10% in c.v. C-52 and H-93, respectively. These reductions may be due to fungal disease infection. In similar field inoculation trail, Hago (1991) using the varieties Hudeiba 72 and Siliam and pea mosaic virus (PMV) obtained similar results and reported faba bean growth was also affected by BYMV infection. Similarly Ahmed (1986) reported that PMV infection induced 80% reduction in the nodules dry weight of cultivar Siliam. In the present study BYMV infection resulted in up to 64.44% reduction in the nodules dry weight. These reductions ranged between 11.1% to 64.44% in c.v. B.B.7 and Sml, respectively. Similarly Hago (1991) working with PMV on faba bean obtained 65.2% and 82.2% reductions in the nodulation of the varieties Hudieba and Siliam respectively. He also reported that reduction in the nodulation by faba bean is directly correlated with virus infection. The final yield when monitored by the number of pods per plant, number of seeds per plant and weight of seeds of 80 plants from the area showed a highly significant reductions in faba bean yield when inoculated before flowering; the reductions ranged between 14.31% to 76.04% in entries P.M. and Sml, respectively. In the third inoculation (after flowering) the entry C-34
obtained high significant reductions noticed was attributed to the flooding of the crop.

The results of the present study are in close agreement with those described by Makkaouk et al. (1988) who reported the effect of BYMV in faba bean in Syria. In similar trials, Kaiser (1973) working in Iran reported that BYMV infection caused 44%, 42% and 23% in the yield of faba bean when inoculated before, during and after flowering, respectively.

In Canada, Frowd and Bernier (1977) reported that when the field beans were inoculated with BYMV, 59% reductions occurred in the yield. In the Sudan yield effects of similar magnitude were also reported on natural faba bean infected with BYMV (Nour and Nour, 1962).
CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

The results of the present study, on the effect of BYMV infection on the growth and yield components of Faba bean, have shown that the virus infection before and at flowering significantly reduced the growth and yield of Faba bean. Moreover, the virus infection after flowering did not significantly reduced the growth and yield of Faba bean. Also the yield reduction varied from one entry to the other as the result of BYMV infection. Reductions yield ranged between 0.45 ton/ha to 1.35 ton/ha in entries C-34 and H.93 respectively. Hence it is recommended that the virus infection should be minimized during the early growth of the crop by regular chemical spraying of the aphid vectors. Furthermore, the production of BYMV resistant cultivars would be the proper approach to solve the problem.
REFERENCES


Beemster and Van der want,( 1951). Antonievan net 17: 15.


Eisa, I. B. (1990) studies on the three legume viruses effecting faba been (*Vicia faba. L.*) in Shamabt area M.S.c theses U of K 72 PP.


Phytopathology 27: 589 – 603.


Quantz, L. (1954). Untersuchungen über die virus krankherten der


Saxena, M. C. and R. A. Stewart (eds)(1983). Faba bean in the Nile Valley
ICARDA/IFAD, Nile Valley Project and Martins Nijhoff, The
Hague, The Netherlands.


improvement, ed. G. Hawtin and C. Webb, 227–283. ICARDA-


Smith, P. R. (1968). The relationship between yellow mosaic virus and pea


Appendices
### Appendix (1). The effect of BYMV on the dry nodules, shoot dry and root dry weight

<table>
<thead>
<tr>
<th>Variety</th>
<th>Dry nodules</th>
<th>Shoot dry</th>
<th>Roots dry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Infected</td>
<td>T-cal</td>
</tr>
<tr>
<td>BB7</td>
<td>0.27±0.11</td>
<td>0.24±0.10</td>
<td>0.63(^{NS})</td>
</tr>
<tr>
<td></td>
<td>11.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-28</td>
<td>0.45±0.13</td>
<td>0.34±0.16</td>
<td>1.67(^{NS})</td>
</tr>
<tr>
<td></td>
<td>24.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SML</td>
<td>0.45±0.26</td>
<td>0.16±0.09</td>
<td>3.31(^{**})</td>
</tr>
<tr>
<td></td>
<td>64.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-34</td>
<td>0.54±0.32</td>
<td>0.19±0.12</td>
<td>3.23(^{**})</td>
</tr>
<tr>
<td></td>
<td>34.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.93</td>
<td>0.32±0.07</td>
<td>0.21±0.08</td>
<td>3.18(^{**})</td>
</tr>
<tr>
<td></td>
<td>64.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-52</td>
<td>0.37±0.08</td>
<td>0.28±0.09</td>
<td>2.33(^{*})</td>
</tr>
<tr>
<td></td>
<td>24.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SML4</td>
<td>0.42±0.21</td>
<td>0.18±0.04</td>
<td>3.46(^{**})</td>
</tr>
<tr>
<td></td>
<td>57.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P.M</td>
<td>0.55±0.28</td>
<td>0.22±0.09</td>
<td>2.52(^{**})</td>
</tr>
<tr>
<td></td>
<td>60.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SML85</td>
<td>0.28±0.10</td>
<td>0.23±0.08</td>
<td>0.36(^{NS})</td>
</tr>
<tr>
<td></td>
<td>17.86</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{**}\) = significant at \(P < 0.01\), \(^{*}\) = significant at \(P < 0.05\), \(^{NS}\) = Not significant
Appendix (2). The effect of BYMV on the number of seeds/plant and weight of seeds/g

<table>
<thead>
<tr>
<th>Variety</th>
<th>First inoculation</th>
<th>Second inoculation</th>
<th>Third inoculation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Infected</td>
<td>T-cal</td>
</tr>
<tr>
<td>BB7</td>
<td>No. of seeds</td>
<td>20.3±1.6</td>
<td>9.7±0.7</td>
</tr>
<tr>
<td></td>
<td>Weight of seeds</td>
<td>64.5±2.6</td>
<td>25.2±2.5</td>
</tr>
<tr>
<td>C-28</td>
<td>No. of seeds</td>
<td>29.5±0.7</td>
<td>9.3±0.7</td>
</tr>
<tr>
<td></td>
<td>Weight of seeds</td>
<td>74.8±4.2</td>
<td>30.2±2.4</td>
</tr>
<tr>
<td>SML</td>
<td>No. of seeds</td>
<td>28.5±0.6</td>
<td>6.8±0.4</td>
</tr>
<tr>
<td></td>
<td>Weight of seeds</td>
<td>71.5±2.0</td>
<td>27.1±3.3</td>
</tr>
<tr>
<td>C-34</td>
<td>No. of seeds</td>
<td>26.2±0.5</td>
<td>6.8±0.3</td>
</tr>
<tr>
<td></td>
<td>Weight of seeds</td>
<td>68.8±2.4</td>
<td>26.9±1.5</td>
</tr>
<tr>
<td>H-93</td>
<td>No. of seeds</td>
<td>35.4±0.6</td>
<td>20.3±0.7</td>
</tr>
<tr>
<td></td>
<td>Weight of seeds</td>
<td>89.0±7.2</td>
<td>51.5±2.1</td>
</tr>
<tr>
<td>C.52</td>
<td>No. of seeds</td>
<td>25.7±0.5</td>
<td>12.1±0.6</td>
</tr>
<tr>
<td></td>
<td>Weight of seeds</td>
<td>66.7±1.9</td>
<td>36.8±3.5</td>
</tr>
<tr>
<td>SML4</td>
<td>No. of seeds</td>
<td>28.8±0.5</td>
<td>17.5±0.6</td>
</tr>
<tr>
<td></td>
<td>Weight of seeds</td>
<td>77.4±3.5</td>
<td>43.5±2.5</td>
</tr>
<tr>
<td>P.M</td>
<td>No. of seeds</td>
<td>24.6±0.3</td>
<td>21.1±0.6</td>
</tr>
<tr>
<td></td>
<td>Weight of seeds</td>
<td>79.0±2.8</td>
<td>52.2±3.0</td>
</tr>
<tr>
<td>SML8</td>
<td>No. of seeds</td>
<td>25.6±0.4</td>
<td>9.4±0.8</td>
</tr>
<tr>
<td>5</td>
<td>Weight of seeds</td>
<td>53.3±2.7</td>
<td>22.0±3.8</td>
</tr>
</tbody>
</table>

** = significant at P < 0.01.  * = significant at P < 0.05  N.S. = Not significant
## Appendix (3) Weight of seeds

<table>
<thead>
<tr>
<th>Variety</th>
<th>First inoculation</th>
<th>Second inoculation</th>
<th>Third inoculation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Infected</td>
<td>T-cal</td>
</tr>
<tr>
<td>BB7</td>
<td>20.3±1.6</td>
<td>9.7±0.7</td>
<td>19.19**</td>
</tr>
<tr>
<td>C-28</td>
<td>29.5±0.7</td>
<td>9.3±0.7</td>
<td>64.58**</td>
</tr>
<tr>
<td>SML</td>
<td>28.5±0.6</td>
<td>6.8±0.4</td>
<td>95.16**</td>
</tr>
<tr>
<td>C-34</td>
<td>26.2±0.5</td>
<td>6.8±0.3</td>
<td>105.21**</td>
</tr>
<tr>
<td>H-93</td>
<td>35.4±0.6</td>
<td>20.3±0.7</td>
<td>51.79**</td>
</tr>
<tr>
<td>C.52</td>
<td>25.7±0.5</td>
<td>12.1±0.6</td>
<td>55.06**</td>
</tr>
<tr>
<td>SML4</td>
<td>28.8±0.5</td>
<td>17.5±0.6</td>
<td>45.75**</td>
</tr>
<tr>
<td>P.M</td>
<td>24.6±0.3</td>
<td>21.1±0.6</td>
<td>16.69**</td>
</tr>
<tr>
<td>SML85</td>
<td>25.6±0.4</td>
<td>9.4±0.8</td>
<td>57.28**</td>
</tr>
</tbody>
</table>

** = significant at P < 0.01.     * = significant at P < 0.05     N.S. = Not significant
Appendix (4) Number of pods/plant

<table>
<thead>
<tr>
<th>Variety</th>
<th>First inoculation</th>
<th>Second inoculation</th>
<th>Third inoculation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Infected</td>
<td>T-cal</td>
</tr>
<tr>
<td>BB7</td>
<td>34.2±9.6</td>
<td>12.8±4.5</td>
<td>6.38**</td>
</tr>
<tr>
<td></td>
<td>62.57</td>
<td>31.87</td>
<td></td>
</tr>
<tr>
<td>C-28</td>
<td>31.3±5.1</td>
<td>14.2±3.0</td>
<td>9.14**</td>
</tr>
<tr>
<td></td>
<td>54.63</td>
<td>17.89</td>
<td></td>
</tr>
<tr>
<td>SML</td>
<td>30.4±2.3</td>
<td>12.8±4.5</td>
<td>11.01**</td>
</tr>
<tr>
<td></td>
<td>57.89</td>
<td>34.86</td>
<td></td>
</tr>
<tr>
<td>C.34</td>
<td>28.1±3.3</td>
<td>12.8±2.7</td>
<td>11.35**</td>
</tr>
<tr>
<td></td>
<td>54.45</td>
<td>11.03</td>
<td></td>
</tr>
<tr>
<td>H.93</td>
<td>28.0±2.4</td>
<td>20.4±2.9</td>
<td>6.38**</td>
</tr>
<tr>
<td></td>
<td>27.14</td>
<td>4.64</td>
<td></td>
</tr>
<tr>
<td>C-52</td>
<td>30.2±2.3</td>
<td>14.9±1.5</td>
<td>17.62**</td>
</tr>
<tr>
<td></td>
<td>50.66</td>
<td>49.00</td>
<td></td>
</tr>
<tr>
<td>SML4</td>
<td>31.3±2.7</td>
<td>16.1±1.7</td>
<td>15.17**</td>
</tr>
<tr>
<td></td>
<td>48.56</td>
<td>21.08</td>
<td></td>
</tr>
<tr>
<td>P.M</td>
<td>29.0±1.8</td>
<td>20.0±1.6</td>
<td>11.82**</td>
</tr>
<tr>
<td></td>
<td>31.03</td>
<td>20.34</td>
<td></td>
</tr>
<tr>
<td>SML85</td>
<td>24.5±3.0</td>
<td>10.2±2.1</td>
<td>12.35**</td>
</tr>
<tr>
<td></td>
<td>58.36</td>
<td>34.69</td>
<td></td>
</tr>
</tbody>
</table>

** = significant at P < 0.01.  * = significant at P < 0.05  N.S. = Not significant
<table>
<thead>
<tr>
<th>Variety</th>
<th>First inoculation</th>
<th>Second inoculation</th>
<th>Third inoculation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Infected</td>
<td>T-cal</td>
</tr>
<tr>
<td>BB7</td>
<td>64.5±2.6</td>
<td>25.2±2.5</td>
<td>34.44**</td>
</tr>
<tr>
<td>C-28</td>
<td>74.8±4.2</td>
<td>30.2±2.4</td>
<td>29.16**</td>
</tr>
<tr>
<td>SML</td>
<td>71.5±2.0</td>
<td>27.1±3.3</td>
<td>36.37**</td>
</tr>
<tr>
<td>C-34</td>
<td>68.8±2.4</td>
<td>26.9±1.5</td>
<td>46.61**</td>
</tr>
<tr>
<td>H-93</td>
<td>89.0±7.2</td>
<td>51.5±2.1</td>
<td>15.81**</td>
</tr>
<tr>
<td>C-52</td>
<td>66.7±1.9</td>
<td>36.8±3.5</td>
<td>23.74**</td>
</tr>
<tr>
<td>SML4</td>
<td>77.4±3.5</td>
<td>43.5±2.5</td>
<td>24.92**</td>
</tr>
<tr>
<td>P.M</td>
<td>79.0±2.8</td>
<td>52.2±3.0</td>
<td>20.65**</td>
</tr>
<tr>
<td>SML85</td>
<td>53.3±2.7</td>
<td>22.0±3.8</td>
<td>21.23**</td>
</tr>
</tbody>
</table>

** = significant at P < 0.01.  * = significant at P < 0.05  N.S. = Not significant
Appendix (6). The effect of BYMV on the weight of seeds/80 plants when faba bean were inoculated

<table>
<thead>
<tr>
<th>Variety</th>
<th>First inoculation</th>
<th>Second inoculation</th>
<th>Third inoculation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Infected</td>
<td>T-cal</td>
</tr>
<tr>
<td>BB7</td>
<td>162.64±2.7</td>
<td>77.76±2.9</td>
<td>64.3**</td>
</tr>
<tr>
<td></td>
<td>52.19</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>C-28</td>
<td>235.6±3.3</td>
<td>74.61±10.3</td>
<td>44.84**</td>
</tr>
<tr>
<td></td>
<td>68.47</td>
<td>46.84</td>
<td></td>
</tr>
<tr>
<td>SML</td>
<td>227.8±7.9</td>
<td>54.56±5.2</td>
<td>64.40**</td>
</tr>
<tr>
<td></td>
<td>76.04</td>
<td>36.12</td>
<td></td>
</tr>
<tr>
<td>C-34</td>
<td>209.6±3.4</td>
<td>54.4±3.07</td>
<td>101.44**</td>
</tr>
<tr>
<td></td>
<td>74.07</td>
<td>23.01</td>
<td></td>
</tr>
<tr>
<td>H-93</td>
<td>565.76±2.29</td>
<td>96.8±14.3</td>
<td>16.99**</td>
</tr>
<tr>
<td></td>
<td>42.69</td>
<td>41.29</td>
<td></td>
</tr>
<tr>
<td>C.52</td>
<td>282.96±6.4</td>
<td>162.24±4.9</td>
<td>56.15**</td>
</tr>
<tr>
<td></td>
<td>52.94</td>
<td>63.44</td>
<td></td>
</tr>
<tr>
<td>SML4</td>
<td>231.04±5.1</td>
<td>140.2±2.6</td>
<td>47.8**</td>
</tr>
<tr>
<td></td>
<td>39.32</td>
<td>4.68</td>
<td></td>
</tr>
<tr>
<td>P.M</td>
<td>197.04±4.4</td>
<td>168.8±4.4</td>
<td>8.83**</td>
</tr>
<tr>
<td></td>
<td>14.31</td>
<td>1.09</td>
<td></td>
</tr>
<tr>
<td>SML85</td>
<td>204.96±3.6</td>
<td>74.87±6.2</td>
<td>54.66**</td>
</tr>
<tr>
<td></td>
<td>63.47</td>
<td>15.40</td>
<td></td>
</tr>
</tbody>
</table>

** = significant at P < 0.01.
* = significant at P < 0.05
N.S. = Not significant