

**“RELATIVE SUSCEPTIBILITY OF PIGEONPEA  
GENOTYPES TO PULSE BEETLE IN STORAGE”**

by

**Miss. HOLAY PRIYANKA PANDHARINATH**  
**(Reg.No.014/156)**

**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY  
POST GRADUATE INSTITUTE  
MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722, DIST. AHMEDNAGAR,  
MAHARASHTRA, INDIA**

**2016**

**“RELATIVE SUSCEPTIBILITY OF PIGEONPEA  
GENOTYPES TO PULSE BEETLE IN STORAGE”**

by

**Miss. HOLAY PRIYANKA PANDHARINATH**  
(Reg. No.014/156)

A thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722, DIST. AHMEDNAGAR,  
MAHARASHTRA, INDIA**

in partial fulfilment of the requirements for the degree

of

**MASTER OF SCIENCE (AGRICULTURE)**

in

**AGRICULTURAL ENTOMOLOGY**

**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY  
POST GRADUATE INSTITUTE,  
MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722, DIST. AHMEDNAGAR,  
MAHARASHTRA, INDIA**

**2016**

**“RELATIVE SUSCEPTIBILITY OF PIGEONPEA  
GENOTYPES TO PULSE BEETLE IN STORAGE”**

by

**Miss. HOLAY PRIYANKA PANDHARINATH**  
(Reg. No.014/156)

A thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722, DIST. AHMEDNAGAR,  
MAHARASHTRA, INDIA**

in partial fulfilment of the requirements for the degree  
of

**MASTER OF SCIENCE (AGRICULTURE)**  
in  
**AGRICULTURAL ENTOMOLOGY**

Approved by

**Dr. S. K. Patil**  
(Chairman and Research Guide)

**Dr. U. K. Kadam**  
(Committee Member)

**Prof. A. P. Chavan**  
(Committee Member)

**Dr. P. K. Lokhande**  
(Committee Member)

**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY  
POST GRADUATE INSTITUTE,  
MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722, DIST. AHMEDNAGAR,  
MAHARASHTRA, INDIA**

**2016**

## **CANDIDATE'S DECLARATION**

*I hereby declare that this thesis or part  
there of has not been submitted  
by me or other person to any  
other University or Institute  
for a Degree or  
Diploma.*

Place: MPKV, Rahuri

Date:     /     /2016

(P. P. Holay)

**Dr. S. K. Patil**

Assistant Professor,  
Department of Agricultural Entomology,  
Mahatma Phule Krishi Vidyapeeth,  
Rahuri – 413 722, Dist- Ahmednagar,  
Maharashtra State (INDIA)

## **CERTIFICATE**

This is to certify that the thesis entitled,  
**“RELATIVE SUSCEPTIBILITY OF PIGEONPEA  
GENOTYPES TO PULSE BEETLE IN STORAGE”**  
submitted to the Faculty of Agriculture, Mahatma Phule  
Krishi Vidyapeeth, Rahuri in partial fulfilment of the  
requirements for the award of the degree of **MASTER OF  
SCIENCE (AGRICULTURE)** in **AGRICULTURAL  
ENTOMOLOGY**, embodies the results of a piece of *bona fide*  
research work carried out by **Miss. HOLAY PRIYANKA  
PANDHARINATH**, under my guidance and supervision and  
that no part of the thesis has been submitted to any other  
University for Degree or Diploma.

The assistance and help rendered during the course  
of this investigation have been duly acknowledged.

Place: MPKV, Rahuri  
Date: / /2016

**(S. K. Patil)**  
**Research Guide**

**Dr. B. R. Ulmek**

Associate Dean,  
Post Graduate Institute,  
Mahatma Phule Krishi Vidyapeeth,  
Rahuri - 413 722, Dist. Ahmednagar,  
Maharashtra State (INDIA).

## **CERTIFICATE**

This is to certify that the thesis entitled, “**RELATIVE SUSCEPTIBILITY OF PIGEONPEA GENOTYPES TO PULSE BEETLE IN STORAGE**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY**, embodies the results of a piece of *bona fide* research work carried out by **Miss. HOLAY PRIYANKA PANDHARINATH**, under the guidance and supervision of **Dr. S. K. PATIL**, Assistant Professor, Department of Agricultural Entomology, Post Graduate Institute, MPKV, Rahuri and that no part of the thesis has been submitted to any other University for Degree or Diploma.

Place: MPKV, Rahuri

**(B. R. Ulmek)**

Date :    /    /2016

## ACKNOWLEDGEMENT

*I avail this golden opportunity to express sense of gratitude and indebtedness towards the man of golden heart and honourable Research Guide and Chairman of Advisory committee, Dr. S. K. Patil, Assistant Professor of Agricultural Entomology, Department of Agricultural Entomology, Post Graduate Institute, MPKV, Rahuri. I owe to him for his constant inspiration and well versed advice and keen criticism, prompt suggestions regarding research problems, constant encouragement and sympathetic attitude throughout the course of investigation and the completion of thesis.*

*I give my special thanks with great respect to the advisory committee members, Dr. U. K. Kadam, Assistant Seed Research Officer (Seed Entomology), Seed Technology Research Unit, MPKV, Rahuri, Prof. A. P. Chavan, Scientist (Pulses Entomology), Pulses Improvement Project, MPKV, Rahuri and Dr. P. K. Lokhande, Associate Professor of Biochemistry, Department of Biochemistry, Post Graduate Institute, MPKV, Rahuri for their valuable suggestions and kind co-operation in the conduct of this research.*

*I sincerely thank to Dr. B. R. Ulmek, Associate Dean, Post Graduate Institute, MPKV, Rahuri and Dean, faculty of Agriculture for providing necessary facilities for successful completion of my research work.*

*I am very thankful to Dr. S. S. Jadhav, Head, Department of Agricultural Entomology, MPKV, Rahuri and other all staff members of Department of Agril. Entomology, MPKV, Rahuri for their immense help, support and co-operation during the conduct of this research work.*

*I am extremely thankful to my seniors Swati Gurave and Ankush Chormule for their kind co-operation and suggestions during this investigation.*

*I have no words to express my feelings towards my family but I make a mention of my grandparents and my father Shri. Pandharinath Damodhar Holay and loving mother Sau. Vimal Pandharinath Holay. I express my deep sense of appreciation towards my uncle Navanath and sisters Ekta, Smita, Anita and Brothers Nikhil, Krishna, Mahesh Akshay and Shashank for their never ending love, constant encouragement, blessing and eternal*

*moral support which have brought my educational carrier to this stage.*

*I cannot express my sincere thanks to my beloved friends Aparna, Vikas, Surekha and Swati for supporting me and providing valuable help.*

*It gives me immense pleasure to all my batch mates Snehal, Amruta, Poonum, Aarti, Rupali, Arati and Kalyani for their excellent company and valuable help.*

*While travelling on this path of education, many hands pushed me forth, learned hearts put me on the right track enlightened by their knowledge and experience. I ever rest thanks to all of them.*

Place: MPKV, Rahuri

Date:    /    /2016

( P. P. Holay)

# CONTENTS

|                                |  |      |
|--------------------------------|--|------|
| <b>CANDIDATE'S DECLARATION</b> |  | iii  |
| <b>CERTIFICATES</b>            |  |      |
| i.                             | Research Guide   | iv   |
| ii.                            | Associate Dean (PGI)   | v    |
| ACKNOWLEDGEMENT                |  | vi   |
| <b>CONTENTS</b>                |  | vii  |
| <b>LIST OF TABLES</b>          |  | xi   |
| <b>LIST OF FIGURES</b>         |  | xii  |
| <b>LIST OF PLATES</b>          |  | xiii |
| <b>LIST OF ABBREVIATIONS</b>   |  | xiv  |
| <b>ABSTRACT</b>                |  | xv   |
| <b>1.</b>                      | <b>INTRODUCTION</b>  | 1    |
| <b>2.</b>                      | <b>REVIEW OF LITERATURE</b>  | 5    |
| 2.1                            | Susceptibility of pulse crops to pulse beetle under "Free choice" and "No choice" test in storage                | 5    |
| 2.2                            | Seed characteristics of pulse crops for the host preference to pulse beetle                                      | 13   |
| 2.3                            | Effect of biochemical constituents imparting resistance / susceptibility in seeds of pulse crops to pulse beetle | 18   |
| <b>3.</b>                      | <b>MATERIALS AND METHODS</b>   | 22   |
| 3.1                            | Materials  | 22   |
|                                | 3.1.1 Seed   | 22   |
|                                | 3.1.2 Pulse beetle culture   | 23   |
|                                | 3.1.3 Other material   | 23   |

|          |                               |   |  |           |
|----------|-------------------------------|---|--|-----------|
|          | 3.2                           | Methodology   |  | 23        |
|          |                               | 3.2.1   | Experimental details   | 23        |
|          |                               |   | 3.2.1.1 Free choice and no choice test                             | 24        |
|          |                               |   | 3.2.2.2 Methods of recording observations                          | 25        |
|          |                               |   | 3.2.2.2.1 Physical characters of seed                              | 25        |
|          |                               |   | 3.2.2.2.2 Biological study of pulse beetle, <i>C. maculatus</i>    | 26        |
|          |                               |   | 3.2.2.2.3 Biochemical constituents                                 | 28        |
|          |                               |   | 3.2.2.2.4 Correlation coefficient 'r'                              | 29        |
|          |                               | 3.2.2   | Statistical analysis   | 29        |
| <b>4</b> | <b>RESULTS AND DISCUSSION</b> |   |  | <b>31</b> |
|          | 4.1                           | Studies on seed characters of different pigeonpea genotypes                                 |  | 31        |
|          |                               | 4.1.1   | Seed colour  | 31        |
|          |                               | 4.1.2   | Seed size  | 32        |
|          |                               | 4.1.3   | Seed volume  | 32        |
|          |                               | 4.1.4   | Seed length  | 32        |
|          |                               | 4.1.5   | Seed breadth   | 33        |
|          |                               | 4.1.6   | 100 grain weight   | 33        |
|          |                               | 4.1.7   | Seed hardness  | 33        |
|          | 4.2                           | Orientation of pulse beetle adults to seeds of pigeonpea genotypes under "Free choice" test |  | 36        |
|          | 4.3                           | Influence of pulse beetle reared on seeds of pigeonpea genotypes under "No choice" test     |  | 37        |
|          |                               | 4.3.1   | Ovipositional preference   | 37        |
|          |                               | 4.3.2   | Incubation period, hatching per cent and total larval-pupal period | 39        |
|          |                               | 4.3.3   | Adult emergence and longevity                                      | 40        |

|           |  |   |    |
|-----------|--|---|----|
|           | 4.3.4  | Development period  | 43 |
|           | 4.3.5  | Growth index  | 43 |
| 4.4       | Grain infestation caused by pulse beetle in pigeonpea seeds                          |   | 45 |
|           | 4.4.1  | Grain infestation (No. and Wt. basis)   | 46 |
|           | 4.4.2  | Seed weight loss  | 47 |
| 4.5       | Reaction of biochemical constituents of seeds of pigeonpea genotypes to pulse beetle |   | 48 |
|           | 4.5.1  | Protein content   | 48 |
|           | 4.5.2  | Carbohydrate content  | 48 |
|           | 4.5.3  | Fat content   | 49 |
|           | 4.5.4  | Ash content   | 49 |
|           | 4.5.5  | Moisture content  | 19 |
| 4.6       | Correlation coefficient 'r' between pulse beetle and seeds of pigeonpea genotypes    |   | 52 |
| <b>5</b>  | <b>SUMMARY AND CONCLUSIONS</b>   |   | 62 |
| 5.1       | Summary  |   | 62 |
|           | 5.1.1  | Effect of seed characters of pigeonpea imparting resistance to pulse beetle                   | 62 |
|           | 5.1.2  | Susceptibility of seeds of pigeonpea to pulse beetle under "Free choice" and "No choice" test | 63 |
|           | 5.1.3  | Reaction of biochemical constituents of seeds of pigeonpea genotypes to pulse beetle          | 63 |
| 5.2       | Conclusions  |   | 65 |
| <b>6.</b> | <b>LITERATURE CITED</b>  |   | 67 |
| <b>7.</b> | <b>VITA</b>  |   | 78 |

## LIST OF TABLES

| Sr. No. | Title   | Page No. |
|---------|---|----------|
| 1.      | Seed characteristics of different pigeonpea genotypes   | 34       |
| 2.      | Reaction of pulse beetle adults oriented to seeds of pigeonpea genotypes under “free choice” method                             | 36       |
| 3.      | Biological parameters of pulse beetle reared on seeds of different pigeonpea genotypes  | 41       |
| 4.      | Growth and development of pulse beetle in seeds of different pigeonpea genotypes  | 44       |
| 5.      | Grain infestation caused by pulse beetle in different pigeonpea genotypes   | 47       |
| 6.      | Biochemical reaction to pulse beetle in seeds of pigeonpea genotypes  | 51       |
| 7.      | Correlation coefficient ‘r’ between pulse beetle adults oriented to host preference of pigeonpea genotypes                      | 53       |
| 8.      | Correlation coefficient ‘r’ between seed characteristics of pigeonpea genotypes and per cent weight loss caused by pulse beetle | 54       |
| 9.      | Correlation coefficient ‘r’ between biological parameters of pulse beetle and per cent grain weight loss                        | 57       |
| 10.     | Correlation coefficient ‘r’ between seed characteristics and biochemical constituents with per cent grain weight loss           | 58       |
| 11.     | Correlation coefficient ‘r’ between biochemical constituents to pulse beetle in seeds of pigeonpea genotypes                    | 61       |

## LIST OF FIGURES

| <b>Sr. No.</b> | <b>Title</b>   | <b>Between pages</b> |
|----------------|--|----------------------|
| 1.             | Seed characteristics of different pigeonpea genotypes  | 34-35                |
| 2.             | Orientation of pulse beetle to seeds of pigeonpea genotypes under “ free choice” method                                | 36-37                |
| 3.             | Biological parameters of pulse beetle reared on seeds of different pigeonpea genotypes                                 | 41-42                |
| 4.             | Growth and development of pulse beetle on seeds of different pigeonpea genotypes                                       | 44-45                |
| 5.             | Grain infestation (number and weight basis) and grain weight loss due to pulse beetle in different pigeonpea genotypes | 47-48                |
| 6.             | Biochemical reaction to pulse beetle in seeds of pigeonpea genotypes   | 51-52                |

## LIST OF PLATES

| <b>Sr. No.</b> | <b>Title</b>  | <b>Between pages</b> |
|----------------|---|----------------------|
| 1.             | Seeds of different genotypes of pigeonpea                                       | 22-23                |
| 2.             | Experiment conducted in “Free choice” test                                      | 24-25                |
| 3.             | Experiment conducted in “No choice” test  | 24-25                |
| 4.             | Biology of pulse beetle, <i>Callosobruchus maculatus</i>                        | 26-27                |
| 5.             | NIR- Spectrometer equipment used for biochemical analysis of seeds of pigeonpea | 29-30                |
| 6.             | Healthy seeds and damaged seeds caused by pulse beetle                          | 45-46                |

## LIST OF ABBREVIATIONS

|               |   |                               |
|---------------|---|-------------------------------|
| %             | : | Per cent                      |
| /             | : | Per                           |
| @             | : | at the rate of                |
| +             | : | Plus                          |
| -             | : | Minus                         |
| >             | : | Greater than                  |
| °C            | : | Degree Celsius / Centigrade   |
| Av.           | : | Average                       |
| C.D.          | : | Critical difference           |
| cc            | : | Cubic centimeter              |
| cm            | : | Centimetre (s)                |
| <i>et al.</i> | : | and others ( <i>et alli</i> ) |
| etc.          | : | etcetera                      |
| Fig.          | : | Figure                        |
| g             | : | Gram (s)                      |
| Hr            | : | Hour (s)                      |
| i.e.          | : | <i>Id est</i> , That is       |
| Kg            | : | Kilogram (s)                  |
| Kgf           | : | Force in kiligram             |
| mg            | : | Milligram (s)                 |
| ml            | : | Milliliter (s)                |
| N. S.         | : | Non significant               |
| No.           | : | Number                        |
| r             | : | Correlation coefficient       |
| S.E.          | : | Standard error                |
| <i>viz.</i> , | : | <i>Videlicet</i> (Namely)     |
| Wt.           | : | Weight                        |

# ABSTRACT

## “RELATIVE SUSCEPTIBILITY OF PIGEONPEA GENOTYPES TO PULSE BEETLE IN STORAGE”

by

**Ms. Holay Priyanka Pandharinath**

A candidate for the degree  
of

**MASTER OF SCIENCE (AGRICULTURE)**  
**in**  
**AGRICULTURAL ENTOMOLOGY**

Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722

**2016**

---

|                       |   |                         |
|-----------------------|---|-------------------------|
| <b>Research Guide</b> | : | Dr. S. K. Patil         |
| <b>Department</b>     | : | Agricultural Entomology |

---

The present investigation was undertaken to study the relative susceptibility of pigeonpea genotypes to pulse beetle, *Callosobruchus maculatus* (Fabricius) in storage at Department of Agricultural Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722 during *Kharif* 2015-16.

The seeds of twenty five different pigeonpea genotypes were evaluated under “Free choice” and “No choice” test with their physical characters and chemical constituents imparting resistance / susceptibility to pulse beetle.

In “free choice” test, adults of pulse beetle were oriented in the range of 1 to 9 adults towards the seeds of different pigeonpea genotypes. There was no any significant difference of was noticed in orientation of adults towards the seed having size of seed in small, medium and bold seeds with red, light brown and white colour seed.

In “No choice” test, out of the 25 genotypes, PKV-TARA, BSMR-736 and Vipula was found to be comparatively less ovipositional preference, larval-pupal period, adult emergence, adult longevity, growth and development period of pulse beetle, *C. maculatus* and also having low growth index. Among the genotypes, there was no any strong relationship recorded with ovipositional period, incubation period, hatching percentage and larval-pupal period with seed characters such as seed colour and seed size.

On the basis grain infestation, PKV-TARA, BSMR-736, Vipula and PT-03-142 were observed to be less susceptible to pulse beetle having minimum grain infestation (on number and weight basis) and loss in weight grain in he ranged of 2.08 to 10.00 per cent on number basis and 76.86 to 79.92 per cent on weight basis and 2.22 to 4.30 percent , respectively.

The observations on growth indices revealed that the genotype which were more susceptible had higher growth indices as compared to the less susceptible types indicating that the susceptible genotype were more nutritious to pulse beetle.

Irrespective of physical and biological parameters, ICPL-980098, PKV-TARA, BSMR-736 and Vipula having less protein , carbohydrate and fat content and higher in ash content in seeds said to less preferred by pulse beetle. Whereas, ICPL-87 and PT-04-12-1-1 having higher content of protein, carbohydrates, fat with lesser content of ash in seed was said to be most susceptible to attack of pulse beetle.

# 1. INTRODUCTION

Pulses are the cheapest source of proteins and essential amino acids in vegetarian human diet. They also provide nutritious fodder to the livestock and nitrogen to the soil. In India, pulses are grown over 25.21 million hectares per year with annual production of around 19.78 million tonnes and productivity of 785 kg/ha (Anonymous, 2015). More than 80 per cent Indian population being vegetarian, pulses form an important source of protein.

Pigeonpea [ *Cajanus cajan* (Linnaeus) Millsp.] is one of the most important rainfed and drought tolerant pulse crop. It has diversified uses and grown in a wide range of soils and climatic zones of India. Millions of the people in India are living below poverty line and their livelihood mostly depends on rainfed agriculture. India has the distinction of being the top producer and consumer of pigeonpea in the world accounting for 78 per cent of the global output (Patel *et al.*, 2005).

It is grown approximately 50 countries in Asia, Africa and America. In Central and North India, pigeonpea is locally known as Arhar, whereas in Maharashtra it called 'Tur'. Also commonly known as Pigeonpea, Redgram, Tuvarica, Congobean, Thogari or Gandul in India. Economically, it is the second most important pulse crop after chickpea. In India, it is cultivated in Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu (Tabu *et al.*, 1995).

Though India is leading producer of pigeonpea, its productivity has not been improved significantly during the last decade due to its susceptibility to insect pests and narrow genetic base. Productivity of pigeonpea in world is 4.90 million

tonnes. In world, pigeonpea is grown on nearly 5.22 million hectares. Productivity of pigeonpea in India is 813 kg/ha. In India, pigeonpea is grown on nearly 3.90 million hectares with production of 3.17 million tonnes. The total area in Maharashtra state was 1.037 million hectares with production of 0.661 million tonnes and productivity of 637 kg/ha during 2014-15 (Anonymous, 2015).

Pigeonpea contains 19-23 per cent proteins, 1-2 per cent fat, 45-55 per cent carbohydrates, 1-5 per cent fibers and energy 16-18 per cent (Lawn and Troedson, 1990). Protein content of the pigeonpea seeds is about 2-3 times more than the cereals. The proteins of pigeonpea are nutritionally superior and important. It contains B-complex vitamins. It also contains minerals like calcium, iron, phosphorus, etc. Seeds of pigeonpea are highly nutritious and used as food and fodder.

It is used commonly for making curry and in fact is the main source of proteins for vegetarian people. It is staple diet in most parts of India and is consumed as green pods as well as dry seeds (Tabu *et al.*, 1995). The per capita consumption of pulses in India is dismally low. Efforts should be streamlined to increase production. However, growing more pulses alone is not enough, but checking the losses both quantitatively and qualitatively from the attack of pests during storage is also equally important.

Among the several important insect pests of stored grains, bruchids i.e. pulse beetles, *Callosobruchus chinensis* (Linnaeus), *Callosobruchus maculatus* (Fabricius), *Callosobruchus analis* (Fabricius) and *Callosobruchus phaseoli* (Gall) (Coleoptera : Bruchidae) are commonly occurring and considered to be the most serious insect pests of stored pulses *viz.*, Arhar, black

gram, green gram, horse gram, Bengal gram, peas, cowpea, soybean, mothbean, etc. ( Raina, 1970)

Bruchids attack the legumous pods in the field from where they are carried to store godowns also. Ovipositing females glue each egg to the seed coat. On hatching, grub chews its way in the seed directly beneath the ovipositoin site while the upper surface of egg chorion remains intact on the seed. Grub destroys completely the endospermic portion of the seed leaving only seed coat. Pulse beetle is an internal feeder which multiplies very rapidly under storage conditions. As many as 8-10 or more grubs can complete their development within a single seed. The heavily damaged legume seeds are riddled with emergence holes and defaced with egg covers. The pulse beetle is not only causing quantitative losses but also qualitative losses in nutrition and germination that makes most pulses unfit for marketing as well as human consumption. Nearly 8.5 per cent of the total production of the pulses in India is lost during post harvest and storage (Agarwal *et al.*, 1988). Pulse beetles do not attack all kinds of pulses to the same extent and the average per cent damage has been found to be highest in green gram (55.4%) followed by black gram (35.3%), pigeonpea (22.1%), cowpea (16.8%), gram (11.1%) and pea (8.8%) (Bhaduria and Jakhmola, 2006). It also caused 30.20 to 55.70 per cent loss in seed weight and 17.00 to 53.50 per cent loss in protein content (Gujar and Yadav, 1978).

The fumigants which are commonly used in exterminating the storage pests are deadly poisonous to the warm blooded animals and some are highly inflammable and need to be applied under expert supervision. Due to the limitations associated with the use of pesticides, the Entomologists are in search of other avenues of pest control. Use

of pest resistance varieties of crops is one such avenue which has been attracting the attention of Entomologists in reducing the pest infestation in field as well as in storage.

Developing countries are adopting the use of resistant grain varieties to control stored grain weevils as a popular alternative to the use of chemicals (Garib, 2004). Development of improved varieties through genetic methods plays a major role in protecting the seeds from post harvest damage (Karthikeyan *et al.*, 2008). Screening of resistant cultivars is a major component of IPM and is a continuous process. Various workers (Manohar and Yadava, 1990, Chavan *et al.*, 1997a and 1997b, Umrao and Verma, 2002 and Jha *et al.*, 2008) have reported varietal preference of different species of bruchids in pulses. From time to time new genotypes were evolved and these genotypes were used in developing new varieties and hybrids. It is essential to screen these genotypes for resistant to pulse beetle.

Although, lot of work is being carried out on evolving varieties of pulses resistant to storage against pulse beetle. In view of the nutritive value of pulses in the present era of protein deficiency, it was felt necessary to undertake the studies on relative susceptibility of different genotypes of pigeonpea, *Cajanus cajan* to the attack of pulse beetle, *C. maculatus* in storage

The present studies were undertaken with the following objectives.

1. To evaluate susceptibility of pigeonpea genotypes to pulse beetle under free choice and no choice test in storage
2. To study the physical characters and biochemical constituents imparting resistance / susceptibility in certain pigeonpea genotypes

## 2. REVIEW OF LITERATURE

The literature pertaining to the various aspects of the present studies on “Relative susceptibility of pigeonpea genotypes to pulse beetle in storage” have been thoroughly reviewed and presented in this chapter.

### 2.1 Susceptibility of pulse crops to pulse beetle under “Free choice” and “No choice” test in storage

Adults oriented for ovipositional preference, incubation period, per cent egg hatch, larval-pupal period, per cent adult emergence, adult longevity, oviposition period, fecundity, development rate, growth index, per cent grain damage, per cent grain infestation and per cent grain weight loss were taken as criterion for the assessment of susceptibility of different varieties of pigeonpea and other pulse crops in storage are presented below.

Mukherjee *et al.* (1970) studied the incidence and extent of damage due to insect pests in stored legumes in different parts of the Indian Union and observed that the maximum damage of (32.64%) due to bruchids was noticed by them in case of pigeonpea.

Raina (1970) conducted an experiment on the comparative study of the biology of the three species of *Callosobruchus* reared on mungbean at 30°C and 70% RH. He revealed that the adults of all three bruchids species emerged by cutting open the ‘window’ in the seed testa. The entire development from egg to adult stage takes on average of 22.3, 24.0 and 28.5 days for *C. chinensis*, *C. maculatus* and *C. analis*,

respectively and also reported egg hatching of *C. chinensis* ranged from 94 to 99 per cent and larval-pupal period of 18.8 days on mung bean.

Gokhale (1973) reported that adult emergence of *C. maculatus* to the extent of 77.47 to 86.44 per cent when reared on Bengal gram and the sex ratio was observed to be 1: 0.93 and 1:1.00. The growth index of *C. maculatus* ranged from 2.67 to 3.14 when reared on Bengal gram.

Girish *et al.* (1974) carried out trials on oviposition and development of *C. maculatus* on six different pulses where in bruchids showed a considerable ovipositional preference for soyabean followed by Bengal gram, pea, black gram, green gram and red gram.

Singh (1976) studied the relative resistance of important pulses to *C. maculatus* and *C. chinensis*. He observed that the two beetle species reacted differently to various food plants on no choice test. *C. chinensis* preferred cowpea followed by lentil, red gram, green gram, Bengal gram, pea and black gram, while *C. maculatus* preferred green gram followed by cowpea, red gram, Bengal gram, black gram, pea and lentil.

Wadnerkar *et al.* (1978) studied the preference of pulse beetle, *C. maculatus* to four varieties of arhar and three varieties of gram. They also reported that the variety having maximum growth index are more suitable for pulse beetle.

Yadav and Pant (1978) studied the developmental response of *C. maculatus* on different pulses and observed that the pea (44.0 days), Bengal gram (33.9 days), pigeonpea (29.7 days) and green gram (26.9 days) served as host.

Redden and McGuire (1983) reported that the development period and per cent adult emergence are the two most discriminating indicators for evaluation of bruchid susceptibility.

Mensah (1986) categorised accessions ICPL-87119 as moderately resistance, shows high egg deposition and supported high grain damage and mass loss and ICPL-87 as resistance, being unsuitable for egg deposition and mass loss due to hard seed coat with thicker testa.

Khokhar and Singh (1987) reported that the number of egg laid by the beetle on pigeonpea varieties varied from 34.7 to as high as 238.0 eggs and stated that ICPL-143, ICPL-148 were least preferred by beetle and ICPL-289 which was more preferred for egg laying provided conditions for better development and successful adult emergence.

Patnaik and Samalo (1987) studied the susceptibility of pigeonpea varieties to *C. maculatus* and reported the seed infestation of pigeonpea varieties by the bruchid in the range of 7.0 to 28.7 per cent and 5.2 to 88.7 per cent, respectively.

Manohar and Yadav (1990) reported that eggs laid by females of *C. maculatus* ranged from 104 to 170 on different pulses. The maximum adult emergence of *C. chinensis* was found to the extend of 72.00 to 96.00 per cent on cowpea. They observed the growth index of *C. chinensis* and *C. maculatus* ranging from 2.67 to 5.15 and 2.54 to 4.11, respectively on different pulses.

Thanthianga and Mitchell (1990) conducted the laboratory experiments at ambient light and 22 to 24°C temperature. According to them, the fecundity of the South Indian

strain of *C. maculatus* was 73 eggs per female developed in 31 days and increased to 94 eggs per female emerged after 41 days.

Kitch and Shade (1993) suggested that ovipositional non-preference could be a practical form of resistance to *C. maculatus* and observed the incubation period of *C. maculatus* was in the range of 6.33 to 12.0 days

Khairnar *et al.* (1996) released ten freshly emerged pairs of *C. chinensis* in jars containing 500 g pigeonpea seeds. They observed that the number of exit holes and eggs laid were highest and germination percentage was lowest in seeds after five months storage with the pest.

Chavan *et al.* (1997a) evaluated various cowpea lines for their effect on growth and development of *C. chinensis*. Significant effect of these lines was observed on growth indices, larval-pupal duration and the per cent adult emergence in different lines. On the basis of growth index, the lines HLD-1, 258/85, EC-340-10088, EC-59321, 597185, V-70-3-3-1 and 109493/30 formed the less susceptible group where growth index ranged from 1.656 to 2.112.

Gill and Ramzan (1998) reported that egg hatching of *C. maculatus* varied from 57.9 per cent in November and 93.1 per cent in September on green gram. Also, larval and pupal period ranged from  $10.60 \pm 0.06$  and  $5.02 \pm 0.66$  days, respectively, while the life span of *C. maculatus* to the tune of 19.00 days during June to July and 35.35 days during October to November in Punjab.

Singal (1998) observed that *C. chinensis* completed its life cycle from egg laying to adult emergence in an average period of 35.5 days under laboratory conditions in cowpea.

Singal and Borah (2001) observed that larval and pupal period of *C. chinensis* was  $16.2 \pm 0.16$  and  $7.2 \pm 0.18$  days, respectively and also studied biology of *C. chinensis* on pods of pigeonpea and they reported that an average adult longevity of male and female was  $6.2 \pm 0.36$  and  $6.8 \pm 0.25$  days. They also observed average total development period of  $30.4 \pm 0.62$  days.

Patel *et al.* (2005) studied the biology of pulse beetle *C. chinensis* on different pulses revealed that all the biological parameters like incubation period, larval- pupal period, total development period and adult longevity varied significantly among different pulses. Pigeonpea were found to be the least preferred host among the different pulses. Incubation period of 4.48 days was recorded on pigeonpea. Average total larval-pupal period and longevity of pulse beetle were 20.15 days and 12.07 days, respectively. The duration of life cycle was 36.70 days.

Bhaduria and Jakhmola (2006) studied the effect of intensity of infestation caused by pulse beetle on the extent of losses and seed germination in different pulses and concluded that cowpea was found to be the most preferred for oviposition (171.6 eggs) and survival (78.4%) followed by green gram.

Nagaraja (2006) observed the lowest per cent adult emergence, germination, weight loss, lowest growth index value, highest developmental period genotypes of pigeonpea *viz.*, ICPL 2008-1, PG-12, GS-1, DEPS-3, DEPS-9 and showed relative resistance to *C. maculatus* compared to the other susceptible genotypes *viz.*, ICPL-2009-1, GPS-2003, PG-44 and ICPL-87119. He also observed that in cowpea genotypes *viz.*, KM-1, Goa local T-1 and TV X 944 showed least susceptible to *C. chinensis* and these having lowest per cent adult emergence, germination, weight loss, growth index value, highest developmental period.

Swella and Mushobozy (2009) studied the comparative susceptibility of seeds of ten legumes to infestation by *C. maculatus* in free choice and no choice experiments. The developmental period of *C. chinensis* was maximum 34 days in chickpea and other common beans.

Gopalswamy *et al.* (2010) reported more number of eggs in small seeded varieties of urdbean. The less fecundity of test insect in seeds of urdbean having large seed size can be attributed to the dark brown colour varieties.

Obopile Motshwari *et al.* (2011) conducted study on ten Botswana cowpea land races to evaluate their resistance to the cowpea weevil, *C. maculatus*. The land races B339, B383, B013-F and B261-B had significant lower percentage adult emergence and oviposition than the land races B001-B, B055, B109-C and B154. The land races B339, B383, B013-F and B261-B also significantly prolonged development period of beetles. The reduction in oviposition, adult emergence and prolonged development period by these land races indicate inherent level of resistance against pulse beetles.

Rawat and Srivastava (2011) observed that the quantitative (seed damage and weight losses) and quantitative (biochemical) losses in three pulses showed a maximum seed damage of 96.15 per cent in cowpea (*Vigna radiata*) followed by 88.44 per cent in green gram (*V. unguiculata*) and 74.22 per cent in moth bean (*Phaseolus aconitifolius*).

Shivanna *et al.* (2011a) evaluated different cowpea varieties for their susceptibility to *C. maculatus* and *C. analis*. Among them, CP-17 was comparatively less preferred host with lesser oviposition (81.33 eggs/100 g seeds), prolonged development period (34.67 days), least adult survival (84.67%)

and weight loss of grains (0.96%) followed by IT-38956 to *C. maculatus*. C-152 and local variety was recorded most preferred host for egg laying, development period, per cent adult survival and per cent weight loss. This is because physical properties of grains like *viz.*, bigger size, smooth skin and seed coat surface.

Shivanna *et al.* (2011b) conducted experiment on the host preference of pulse beetle, *C. maculatus* on pigeonpea and seed pulses under laboratory conditions. The results revealed that number of egg laid, developmental period, adult survival and weight loss of grain was 88.00 and 100.33 eggs / 100 seeds, 36.00 and 33.33 days, 77.67 and 78.00 per cent and 1.82 and 1.80 per cent in *C. maculatus* and *C. analis* in pigeonpea, respectively.

Chandel *et al.* (2012) studied the varietal resistance in pigeonpea genotypes against pulse beetle in storage. They indicated the weight loss and infestation increased on pigeonpea varieties with the increase in egg laying and adult emergence.

Jaggal, M. *et al.* (2012) indicated that per cent adult emergence, mean time of adult emergence and per cent weight loss were most important parameters which helped in categorizing the genotypes into susceptible or resistant.

Rosemond and Khan (2013) conducted an experiment to compare the oviposition preference on *C. maculatus* on 18 pigeonpea cultivars. Cultivars i.e. B9, B35, B26PL2, B52 and B59 appear to be more resistance to attack by *C. maculatus* than the other cultivars tested. Duration from adult parent ovipositioning to F1 adult emergence was longest in cultivar B35 (33 days) and shortest in cultivar B59 and B200.

Amusa *et al.* (2014) showed that delay in bruchid emergence with mean development period for successful adult emergence ranging from 32-47 days. Nine varieties of cowpea showed percentage seed damage above 80% and percentage pest tolerance below 50%. Susceptibility index indicates that seven of the studied varieties to be moderately resistance and the remaining three to be resistance to the bruchid infestation with TVu 11953 being the most resistance of all with index 1.78.

Radha and Susheela (2014) conducted an investigation on the life history and ovipositional preference of *C. maculatus* reared on cowpea, green gram, black gram, horse gram and green peas. The adults exhibited a marked preference for smooth and well filled seeds for oviposition and degree of infestation varied among the pulses. This is due to varied response of the insect to different host seeds for oviposition and their appropriateness for the successful completion of the life cycle.

Soumia *et al.* (2015) studied the susceptibility of eighty five green gram accessions against pulse beetle, *C. analis* under laboratory conditions. Accessions which exhibited lesser susceptibility index during the preliminary free choice tests were further subjected to force choice tests for confirmation of bruchid resistance. Correlation between growth index and other growth parameters of pulse beetle, indicated that growth index had positive relationship with adult emergence, weight loss and egg laid.

Chakraborty and Mondal (2016) conducted test for susceptibility done through the egg laying preference of *C. chinensis* in five different stored pulses under “free choice” test in the laboratory conditions. A combination of several factors such as texture, seed size, seed weight, volume of seed and seed

colour have been suggested to be responsible for ovipositional preference of bruchids to different pulses. Dark and brown coloured seeds were preferred most for oviposition over white seeds in “ free choice” situation.

## **2.2 Seed characteristics of pulse crops for the host preference of pulse beetle**

Teotia and Singh (1966) studied the effect of host species on oviposition, fecundity and development of *Callasobruchus chinensis* and observed that the oviposition was positively correlated with the seed surface and seed volume. They further indicated that ovipositional preference did not have any relationship with the suitability of the seed for development of the insect, as seeds of French bean and field pea although preferred for oviposition, were wholly unsuitable for the development of beetles. The best growth was observed on *Vigna unguiculata* and *Cajanus cajan*.

Booker (1967) carried out studies on biology of *C. maculatus* associated with cowpea in Nigeria. He reported that there was a definite preference for oviposition on seeds with smooth testa but there seemed to be no colour preference. He also reported that one insect could cause a loss in weight of cowpea seed to the extent of 3 to 5 per cent.

Gupta and Mishra (1970) reported that relative resistance of varieties of Bengal gram to pulse beetle, *C. chinensis* was not associated with the grain size but some physical factors of seed particularly: the seed surface and thickness of the seed coat appeared to be the important reasons for different preference by the beetle.

Regupathy and Rathnaswamy (1970) studied the comparative susceptibility of seeds of certain redgram varieties to pulse beetle and observed no association of seed colour, seed volume and hardness of seed.

Nwanze *et al.* (1975) observed that a combination of several factors such as seed texture, seed size and shape, weight and volume of the seed and the seed colour have been suggested to be responsible for the ovipositional preference of bruchids to different pulses.

Dabi *et al.* (1979) studied the relative susceptibility of ten varieties of cowpea to *C. maculatus*. They reported that the variety RS-9 was least susceptible while varieties RS-118, RS-42, NO-5-19-4-1 were the most susceptible. They also indicated that the weight, volume, hardness and colour of the seed had no effect on the resistance of the susceptibility of the varieties.

Satyavir (1981) screened 24 promising varieties of cowpea under cultivations against *C. maculatus* and reported that all varieties were not equally susceptible to *C. maculatus*. He also indicated that seed volume; 100 grain weight and seed colour of seed had no effect on the susceptibility of different varieties of cowpea.

Redden and McGuire (1983) observed that the development period and per cent adult emergence are the two most discriminating indicators for evaluation of bruchid susceptibility.

Dharmasena and Subhasinghe (1986) reported that seed size of mung bean has been shown to influence the oviposition and infestation of grain legumes by the pulse beetle.

Semple (1992) reported that the rate of insect population increase could be adversely affected when a resistant variety is used which causes reduction in oviposition rate through physical or mechanical barrier. The barrier is said to either deter access into the grains or make it unsuitable for oviposition.

Ahmed *et al.* (1993) reported that cultivars with hard seed coat showed non preference by pulse beetle. Coefficients of phenotypic and genotypic variations were highly positively correlated with damaged seeds and emergence holes.

Chavan *et al.* (1997b) tested ovipositional preference of *C. chinensis* for cowpea lines. The pulse beetle showed a definite intravarietal response for oviposition. The lines with brown, black grey and red colour seeds are more preferred for oviposition over the white coloured seeds.

Wajenayake and Karunaratne (1999) studied the ovipositional preference and developmental response of the cowpea beetle, *C. chinensis* on six pulses. The most preferred seeds for oviposition were mung and soyabean whereas chickpea was least preferred due to rough seed coat. The study revealed that ovipositional preference was not an indication of suitability for the larval development. Development was comparatively faster in mung and the black and white varieties of cowpea followed by chickpea. On the basis of ovipositional preference, growth index and fecundity, mung bean and white and black varieties of cowpea proved to be most suitable for the development of the cowpea beetle.

Umrao and Verma (2002) tested twenty pea varieties against *C. chinensis* for their physical characters hardness, moisture and damaged grains, fecundity, F1 progeny and index

susceptibility. According to them, increased hardness decreases the growth and development and *vice-versa*. The moisture content of grain had significant positive correlation with fecundity and index susceptibility. The loss in weight and damaged grain showed significant positive correlation with F<sub>1</sub> progeny and index susceptibility.

Dasbak *et al.* (2009) evaluated physical traits and correlation for their relative influence on the susceptibility of six pigeonpea genotypes to *C. maculatus*. The results showed that the physical traits of seed was recorded in the range of 13.6 to 17.9 kgf, 5.8 to 6.4mm, 4.2 to 5.1 mm, 7.89 to 11.31g seed hardness, length, breadth and 100 grain weight respectively. They also reported ovipositional count, grain damage, grain loss and susceptibility index in the range between 47 to 84 per 20 grains, 26.9 to 41.4 per cent, 24.7 to 38.5 per cent and 1.8 to 4.2 respectively. Out of six genotypes i.e. ICPL 87 and ICPL 161 had low susceptibility indices characterized by low oviposition count, grain damage and grain mass loss and were classified as having moderate levels of resistance. They also reported correlation that testa thickness was the only physical character having strong correlation with susceptibility index of  $r = -0.753$ ,  $P < 0.01$ .

Sarwar (2012) studied the relative resistance of 12 chickpea genotypes to the attack of *C. maculatus* during storage. The tolerant genotypes exhibited hard and wrinkled seed coat, dark brown colour and small size grain. These characteristics demonstrated a significant harmful effect to pest appearance and grain damage. The vulnerable genotypes had soft and smooth seed coat, while seed colour and bigger grain size that caused vulnerability to *C. maculatus*.

Shams Fawki *et al.* (2012) screened four varieties of cowpea seeds (Local, Dokki 331, Kareem 7 and Aswany) for their resistance to the bruchid, *C. maculatus*, a serious pest of stored pulses. Morphological characters like seed coat texture, volume and weight were not found to be responsible for offering resistance to *C. maculatus*. The results also showed that Aswany was found to reduce the growth and development of *C. maculatus* which were indicated by different parameters, adult emergence %, total development time, growth index. A negative correlation was indicated between the seed total protein content and susceptibility index.

Chandel and Bhaduria (2015) studied the impact of physical characteristics of promising varieties of pigeonpea, *Cajanus cajan* Linn. on infestation of pulse beetle. The results indicated that TYPE-7 (13.1 kg/grain) had significantly more hardness. The adults emergence was observed minimum (43.36%) on TYPE-7, closely followed by UPAS-120 (42.61%) and ICPL-151(40.78%) and higher adults emergence were (75.30%) on BAHAR, (61.59%) on MANAK. The emergence of adults found to be positively governed by the test weight and seed hardness.

Vishwamithra *et al.* (2015) studied the performance of 16 pigeonpea genotypes to *C. chinensis* was assessed under laboratory conditions based on the development of the insect, seed damage and the various morphological parameters of the test varieties. Significant variation was observed among the varieties with respect to pest development and seed damage. The oviposition of test insect was found to be more influenced by the physical parameters like 100 grain weight and seed size.

### **2.3 Effect of biochemical constituents imparting resistance/ susceptibility in seeds of pulse crops to pulse beetle**

Gujar and Yadav (1978) conducted an experiment on feeding of *C. maculatus* and *C. chinensis* in green gram and reported 44.5 to 66.3 per cent loss in protein due to feeding of *C. maculatus* and 17 to 53.5 per cent loss in protein due to *C. chinensis* in green gram.

Ramanamurthy (1981) studied the physical and chemical characters of certain pulse varieties to pulse beetle and reported that the chickpea varieties with less protein content were not preferred for development of *C. chinensis*

Satyavir (1981) screened 24 promising varieties of cowpea under cultivations against *C. maculatus* and all varieties are not equally susceptible to *C. maculatus*. A positive and significant correlation was observed between adult emergence of test insect and protein content.

Vimla and Pushpamma (1983) asserted changes in carbohydrate contents of seed of red gram, green gram, black gram and Bengal gram by feeding of pulse beetles (*Callosobruchus* spp.) in three agro-climatic zones.

Gupta (1985) studied the losses of stored grains due to insects in Andaman and reported that the minimum damage caused by pests was because the food was stored for not more than 2 months but moisture played important role.

Khattak *et al.* (1991) studied on the response of chickpea cultivars to *C. chinensis* and they reported that high ash content of varieties of chickpea significantly reduced the insect infestation.

Dharne *et al.* (1984) studied the susceptibility of pigeonpea (*Cajanus cajan* L.) varieties of pulse beetle, *C. chinensis* and found that the variety ICPL-95 of pigeonpea had maximum nutritious value which tends to emergence of high amount of beetles.

Singh *et al.* (1995) studied the relative resistance to some gram varieties to *C. chinensis* in storage. It revealed that the fecundity and index susceptibility were comparatively lesser for the varieties with characteristics such as high protein and oil content.

Dwivedi and Sharma (1996) reported that the cowpea and soyabean were the most and preferred hosts to *C. chinensis*. They also reported a decrease in preference by the bruchid with increasing protein and fat content.

Sandhya Rani (1998) assessed the chickpea varieties to pulse beetle and reported a significant negative relationship of ash content of chickpea varieties with *C. chinensis* infestation.

Venugopal *et al.* (2000) revealed the strongly confirmed the positive correlation of protein to *C. maculatus* infestation.

Ashfaque *et al.* (2001) studied the oviposition and development of pulse beetle on seed of chickpea varieties. The varieties with high protein contents were highly preferred for oviposition by *C. chinensis* and susceptible to pulse beetle. While varieties with low contents was least preferred for oviposition.

Singh and Sharma (2001) observed that longest period for incubation can be attributed to the variety content with high amount of protein.

Umrao and Verma (2002) tested twenty pea varieties against *C. chinensis* for their index susceptibility. Accordingly the moisture content of grain had significant positive correlation with fecundity and index susceptibility.

Nagaraja (2006) observed the lowest protein content, highest trypsin content and phenol content in the genotypes of pigeonpea *viz.*, ICPL 2008-1, PG-12, GS-1, DEPS-3, DEPS-9 and showed relative resistance to *C. maculatus* compared to the other susceptible genotypes *viz.*, ICPL-2009-1, GPS-2003, PG-44 and ICPL-87119.

Gawade (2010) reported increase in hardness of seed, decrease in the per cent weight loss and increase in moisture content, increase in the per cent weight loss and *vice-versa*. He also reported seed volume and 100 grain weight showed no any correlation with per cent loss in grain weight.

Radha and Susheela (2014) revealed that white cowpea IT97K499-38 has more energy with the highest level of protein, fat and sugar with a thin tegument proved to be more favourable to the development of the beetles on pulses.

Chandel and Bhaduria (2015) studied the impact of promising varieties of pigeonpea. *Cajanus cajan* Linn. on infestation of pulse beetle and reported that average moisture content in pigeonpea varieties was found to be 12.39 per cent. The mean protein content was 22.99 per cent in pigeonpea varieties. It was concluded that TYPE-7 variety of pigeonpea showed the least weight loss (15.52%) and contained 110.13 g test weight, 12.5 per cent moisture and 21.80 per cent protein. The infestation and losses were found to be positively associated with the test weight and moisture content.

Vishwamithra *et. al.* (2015) assessed the performance of 16 pigeonpea genotypes to *C. chinensis* under laboratory conditions based on the development of the insect, seed damage and the chemical parameters of the test varieties. Significant variation was observed among the genotypes with respect to pest development and seed damage. The chemical parameters like high ash of test varieties were detrimental to the growth and development of test insect while protein content of the test varieties favoured the successful development of bruchids and high infestation.

### 3. MATERIAL AND METHODS

The studies on “Relative susceptibility of pigeonpea genotypes to pulse beetle in storage” were carried out during *Kharif* 2015-16 at laboratory of Department of Agricultural Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722, Dist. Ahmednagar (M.S.) under the ambient conditions.

The details of materials used and methods adopted for the conduct of experiments are presented in this chapter.

#### 3.1 Material

##### 3.1.1 Seed

Five hundred grams seed of each 25 elite genotypes of pigeonpea obtained from Pulses Improvement Project, MPKV, Rahuri were dried in bright sunlight for three days to bring down moisture content to less <10 per cent for conducting this study. The list of the various genotypes is given below.

| <b>Sr.No.</b> | <b>Name of genotypes</b> | <b>Sr.No.</b> | <b>Name of genotypes</b> |
|---------------|--------------------------|---------------|--------------------------|
| 1             | PT-00-1-25-1             | 14            | BSMR-736                 |
| 2             | PT-04-12-1-1             | 15            | PT-00-12                 |
| 3             | PT-04-24-2               | 16            | PT-03-142                |
| 4             | PT-04-31                 | 17            | Vipula                   |
| 5             | PT-01-24-1-1             | 18            | BDN-2010-12              |
| 6             | PT-00-5-7-4-1            | 19            | BDN-2001-6               |
| 7             | PT-00-16-4-2             | 20            | ICPL-87                  |
| 8             | PT-00-4-16-2             | 21            | ICPL-332                 |
| 9             | PT-04-257                | 22            | ICPL-87119               |
| 10            | PT-2001-11-2             | 23            | ICPL-98008               |
| 11            | PT-417-7-1-14            | 24            | ICPL-88039               |
| 12            | PKV-TARA                 | 25            | BSMR-853                 |
| 13            | PT-17-12-2               |               |                          |

### **3.1.2 Pulse beetle culture**

The initial culture of pulse beetle, *Callosobruchus maculatus* (Fabricius) was obtained from the storage godown of Central Store, Seed Cell and Seed Technology Research Unit, MPKV, Rahuri. The identification key of *Callosobruchus* spp. given by Raina (1970) was used.

For initial culture, healthy seed of pigeonpea was kept in to 32×22.5 cm size cylindrical jar and 10 pairs of adult beetles were isolated and released into jar. The top of the jar was covered with muslin cloth secured firmly by rubber band. After emergence of new adults, the beetles were introduced into pigeonpea seed kept in a series of cylindrical jars for building up a homogenous population. Density of population per jar was standardized to prevent overcrowding which was reported to give rise to less reproductive active forms (Sano, 1967). A permanent colony was maintained as per procedure described by Strong *et al.* (1968). Adults of uniform age were used from this colony for the experiment. These studies were conducted at room temperature and relative humidity under ambient conditions.

### **3.1.3 Other material**

The materials and the facilities available from Department of Entomology, MPKV, Rahuri and STRU, MPKV, Rahuri for mass culturing of pulse beetle, *C. maculatus* and investigations on reaction of seeds of different pigeonpea genotypes to *C. maculatus* were used.

## **3.2 Methodology**

### **3.2.1 Experimental detail**

The experiment on seeds of 25 genotypes of pigeonpea for their reaction to pulse beetle, *C. maculatus* was conducted under laboratory conditions. The details of the experiments are given below.

### **3.2.1.1 Free choice test and No choice test**

The experiment on screening of 25 pigeonpea genotype against pulse beetle was conducted in the laboratory of Department of Agril. Entomology, PGI, MPKV, Rahuri. The experiment was replicated 4 times with completely randomised design.

#### **a) Free choice test**

Under “Free choice” test, 100 grains of each genotype was kept in open specimen tubes (5 x 3 cm) and arranged horizontally in circular manner in the trough (40 x 5 cm) at equidistance from centre. Hundred pairs of 10 days-old adults were released in centre of trough giving free choice to the adults for orientation and then the trough was covered with muslin cloth. The experiment was replicated four times. The number of adults oriented in each genotype was counted 48 hours after their release.

#### **b) No choice test**

Under “No choice” test 50 g grain of each genotype was kept in plastic container and 5 pairs of 10 days-old adults were released in each container and 48 hours after released all adults were removed. The experiment was replicated 4 times. The grains were observed daily and after 15 days onward to record the total number of adults emerged. After completion of one generation, developmental period (egg to adult), adult emergence, per cent grain damage and loss in grain weight in each genotype was computed. The data was subjected to statistical analysis. The weight of 100 grains, seed volume and seed hardness of each genotype was recorded. The correlation of grain weight, volume and density with infestation was also worked out.

### **3.2.1.2 Methods of recording observations**

The following observations were recorded as per the experiments earlier mentioned.

#### **3.2.1.2.1 Physical characters of seed**

For screening all the genotypes were categorised into different groups on physical bases of resistance as per the standard methods.

**a. Seed coat colour**

Seed coat colour was recorded with the help of Methuen Handbook of colour (Kornerup Wanscher, 1978).

**b. Seed size**

Seed size was categorised into small, medium and bold category by visual observations.

**c. Seed volume**

The seed volume was determined by counting the number of seed per 10 cc volume of measuring cylinder (Regupathy and Rathnaswamy, 1970).

**d. Seed length and breadth**

The seed length and breadth was determined by using digital micrometer.

**e. Hundred grains weight**

The samples of hundred seeds was taken from each genotype and weighed out with the help of mono pan micro analytical balance (Mettler).

**f. Seed hardness**

The hardness of seed was recorded with the help of Tablet Hardness Tester developed in Indian Equipment Corporation.

### 3.2.1.2.2 Biological study of pulse beetle, *C. maculatus*

#### a. Oviposition

An initially released adult beetle was removed after seven days of release from each genotype. The forty seeds were taken randomly from each genotype and number of eggs laid were counted. The counter part of seeds was kept undisturbed in the jar till the emergence of beetle. The mean of egg laying per 10 seed was calculated and also oviposition period in days, incubation period in days, hatching per cent and total larval-pupal were recorded upto adult emergence and adult longevity.

#### b. Adult emergence

Total number of adult insects emerged was recorded on the basis of number of seeds with exist holes and counted on each alternate day from the date of emergence of adult up to 20 days.

#### c. Growth and development

To study the effect of different pigeonpea genotypes on the growth and development of *C. maculatus*, the set of plastic containers used for oviposition and adult emergence as well as for per cent loss in grain weight and per cent grain infestation was used while taking the daily observations on adult emergence and average development period of *C. maculatus* in each genotype was also calculated.

$$\text{Growth index} = \frac{\text{Log Per cent adult emergence}}{\text{Average developmental period in days (from egg to adult stage)}}$$

Based on the growth index, genotypes were categorised on resistant (<2.50), moderately resistance (2.51-2.75), moderately susceptible (2.51-3.00), susceptible (3.01-3.25) and highly susceptible (<3.26) as per standard procedure, suggested by (Howe, 1971 and Suleherie *et. al.*, 2003).

**d. Per cent grain infestation, per cent weight loss and per cent grain damage**

The sample of each genotype (10 seed) was weighed out with the help of mono pan micro analytical balance. The samples were kept in plastic containers and 5 pair of adults *C. maculatus* was released in each of them. The containers were covered with the help of Muslin cloth, fastened with rubber bands and kept at room temperature.

Newly emerged beetles were removed daily from the 25<sup>th</sup> day after the release of beetles and counted for further period of 15 days till there was no further emergence of beetles. Finally the samples were weighed with the help of same balance after removing hatched and unhatched egg along with dough and the per cent of loss in weight of different genotypes was worked out after adjusting any increase or decrease in the weight of the control. Per cent weight loss was calculated using the formula given by Adams (1976).

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{Final weight of sound and damaged grains}}{\text{Initial weight}} \times 100$$

The number of grains infested by *C. maculatus* was counted and per cent infestation was worked out on the basis of grains with characteristics holes made by beetles. The grain infestation was calculated by following formula.

$$\text{Grain infestation (\%)} = \frac{\text{Total No. of grains} - \text{No. of damaged grains}}{\text{Total No. of grains}} \times 100$$

The damage was computed by subtracting the sound grains from the already counted total number of grains. The amount of damage was converted into percentage with the help of following formula.

$$\text{Seed damage (\%)} = \frac{\text{Initial weight} - \text{Weight of sound grains}}{\text{Initial weight}} \times 100$$

### **3.2.1.2.3 Biochemical constituents**

#### **a. Moisture content**

Moisture content of grains was determined by following Hot Air Oven method (Chalam *et al.*, 1967). Ten gm of ground sample was taken. The weight of pan with its lid was taken. The sample was placed in the pan and dried in the oven at  $130 \pm 1^\circ\text{C}$  for 60 min. After drying, the sample was taken out and the dish was covered immediately and placed in a desiccator to cool for 30 to 45 min. The weight of pan with sample and lid was noted.

$$\text{Moisture content (\%)} = \frac{(M_2 - M_3)}{(M_2 - M_1)} \times 100$$

Where,

$M_1$  = Weight of pan with lid (g)

$M_2$  = Weight of pan with lid and sample before drying (g)

$M_3$  = Weight of pan with lid and sample after drying (g)

**b. Biochemical constituents**

Biochemical constituents *viz.*, protein, carbohydrate, fat and ash was analyzed on the equipment i.e. NIR-Spectrometer which was provided by the Department of Agricultural Botany, PGI, MPKV, Rahuri.

**3.2.1.2.4 Correlation coefficient 'r'****a. Correlation coefficient (r) between physical characters and ovipositional preference**

The observations on ovipositional preference was studied to correlate them with the physical characters of each genotype *viz.*, seed volume, seed hardness, 100 grain weight, seed length and breadth of the seed. These physical parameters of seed were correlated by applying simple correlation coefficient method.

**b. Correlation coefficient (r) between physical characters and per cent weight loss**

The observations on per cent weight loss were correlated with the physical characters of seed of each genotype *viz.*, seed volume, seed length, seed breadth, seed hardness, 100 grain weight of seed and seed hardness by applying simple correlation coefficient method.

**c. Correlation coefficient (r) between physical and biological characters and biochemical constituents**

The observations on development period, growth index, per cent grain infestation, per cent weight loss of each genotype correlated with the biochemical constituents *viz.*, protein, carbohydrate, fat, ash and moisture content by applying simple correlation coefficient method.

### **3.2 Statistical analysis**

The data obtained from different aspects were analyzed by using complete randomized block design method as per the statistical guidelines given by Gomez and Gomez (1984). The data was transformed to arc sin values wherever necessary. The different parameters *viz.*, biological, morphological, physical and biochemical constituents were correlated with each other by applying the method of simple correlation coefficient (r) suggested by Snedecor and Cochran (1967) and Rangaswamy (2007). Wherever the results were significant, the critical difference at 5 and 1 per cent level of significance was calculated.

## 4. RESULTS AND DISCUSSION

The present investigation was carried out on “Relative susceptibility of pigeonpea genotypes to pulse beetle in storage” with the objectives to screen the pigeonpea genotypes under “free choice” and “no choice” test and to study on resistance/susceptibility in certain pigeonpea genotypes to pulse beetle, *C. maculatus* under laboratory conditions.

The results of the studies are presented and discussed in the light available pertinent literature in this chapter.

### 4.1 Studies on seed characteristics of different pigeonpea genotypes

The morphological characteristics of seeds of 25 different pigeonpea genotypes were categorized into seed colour and seed size and recorded seed volume, seed length and breadth, 100 grain weight and seed hardness of each genotypes. The data on seed characters are presented in Table 1 and depicted in Fig. 1.

#### 4.1.1 Seed colour

Seed colour of genotypes was grouped into three categories i.e. red, light brown and white. Out of 25 genotypes, 17 had red colour *viz.*, PT-00-1-25-1, PT-04-12-1-1, PT-04-24-2, PT-04-31, PT-01-24-1-1, PT-00-5-7-4-1, PT-0016-4-2, PT-00-4-16-2, PT-04-257, PT-2001-11-2, PT-417-7-1-14, PKV-TARA, PT-17-12-2, BSMR-736, PT-00-12, PT-03-142 and Vipula. Seven genotypes *viz.*, BDN-2010-12, BDN-2001-6, ICPL-87, ICPL-332, ICPL-87119, ICPL-98008 and ICPL-88039 displayed light brown colour and BSMR-853 had only one genotype which was white colour.

#### **4.1.2 Seed size**

The red, light brown and white colour seeds were grouped into three categories on the basis of seed size i.e. small, medium and bold seed. The genotype *viz.*, PT-00-1-25-1, PT-04-12-1-1, PT-04-24-2, PT-04-31, PT-01-24-1-1, BDN-2010-12, BDN-2001-6, ICPL-87 and BSMR-853 showed small size seeds. Medium seed size was observed in genotypes of PT-00-5-7-4-1, PT-00-16-4-2, PT-00-4-16-2, PT-04-257, PT-2001-11-2, PT-417-7-1-14 and ICPL-332. The genotypes *viz.*, PKV-TARA, PT-17-12-2, BSMR-736, PT-00-12, PT-03-142, Vipula, ICPL-87119, ICPL-98008 and ICPL-88039 had shown bold seeds.

#### **4.1.3 Seed volume**

Seed volume of each genotype was recorded on number of seeds per 10 cc of measuring cylinder. The seed volume of given genotypes of pigeonpea ranged from 82.1 to 116.0 seeds per 10 cc. The genotype PT-01-24-1-1 showed significantly highest seed volume (116.0) indicating smallness in seed size, whereas, ICPL-88039 shown less seed volume (82.1) indicating boldness of seed and which was at par with ICPL-87119 (84.3), PT-00-12 (84.4) and BSMR-736 (85.7).

#### **4.1.4 Seed length**

From the data, it revealed that the seed length was observed in the range of 6.00 to 6.88 mm. The maximum (6.88 mm) length of seed was noticed in small sized seeds of PT-01-24-1 and minimum length (6.00 mm) in PKV-TARA, ICPL-98008 and ICPL-88039 which was bold seeded genotypes. There were no any relation was observed in seed length with seed size.

#### **4.1.5 Seed breadth**

The seed breadth of different pigeonpea genotypes ranged from 4.72 and 5.86 mm. The minimum seed breadth (4.72 mm) recorded in bold size ICPL-88039, while the maximum (5.86 mm) was observed in medium size genotype ICPL-332. Also there was no any relation was noticed in seed size with seed breadth.

#### **4.1.6 Hundred grain weight**

The hundred grain weight of different pigeonpea genotypes ranged from 9.25 to 11.29 g. The maximum (11.29 g) hundred grain weight was observed in PKV-TARA indicating boldness of seed with minimum seed length. The minimum (9.25 g) hundred grain weight of seed was observed in ICPL-87 indicating small size of seeds.

#### **4.1.7 Seed hardness**

The seed hardness of different genotypes was in the range from 8.80 to 21.94 kg/grain. The maximum hardness was recorded in the genotype PKV-TARA (21.94 kg/grain). The genotype ICPL-87 noted less hardness (8.80 kg/ grain) which was found statistically at par with ICPL-98008 (9.00 kg/grain), PT-01-24-1-1 (10.61 kg/grain).

The seed hardness and seed volume in different genotypes was recorded in relation with the small, medium and bold size seed in range from 8.80 to 18.30, 12.00 to 17.10 and 9.00 to 21.94 kg/grain and 90.4 to 116.0, 90.6 to 98.7 and 82.1 to 97.0 seeds per 10 ml, respectively.

During the present studies, seed categorization on the basis of average of different morphological characters such as

**Table 1. Seed characteristics of different pigeonpea genotypes**

| <b>Sr. No</b>     | <b>Genotypes</b> | <b>Seed colour</b> | <b>Seed size</b> | <b>Seed volume/<br/>10 cc</b> | <b>Seed length<br/>(mm)</b> | <b>Seed breadth<br/>(mm)</b> | <b>100 grain<br/>weight<br/>(g)</b> | <b>Seed<br/>hardness<br/>(kg/grain)</b> |
|-------------------|------------------|--------------------|------------------|-------------------------------|-----------------------------|------------------------------|-------------------------------------|---|
| 1                 | PT-00-1-25-1     | Red                | Small            | 100.7                         | 6.59                        | 5.20                         | 10.97                               | 15.20                                   |
| 2                 | PT-04-12-1-1     | Red                | Small            | 90.4                          | 6.43                        | 5.07                         | 9.73                                | 18.30                                   |
| 3                 | PT-04-24-2       | Red                | Small            | 101.2                         | 6.46                        | 5.23                         | 10.20                               | 14.17                                   |
| 4                 | PT-04-31         | Red                | Small            | 102.8                         | 6.48                        | 5.22                         | 10.90                               | 17.87                                   |
| 5                 | PT-01-24-1-1     | Red                | Small            | 116.0                         | 6.88                        | 5.48                         | 10.45                               | 10.61                                   |
| 6                 | PT-00-5-7-4-1    | Red                | Medium           | 92.9                          | 6.33                        | 5.06                         | 10.45                               | 12.00                                   |
| 7                 | PT-00-16-4-2     | Red                | Medium           | 93.1                          | 6.18                        | 5.14                         | 9.86                                | 13.30                                   |
| 8                 | PT-00-4-16-2     | Red                | Medium           | 94.0                          | 6.25                        | 5.07                         | 10.25                               | 17.10                                   |
| 9                 | PT-04-257        | Red                | Medium           | 90.6                          | 6.27                        | 5.00                         | 10.41                               | 14.27                                   |
| 10                | PT-2001-11-2     | Red                | Medium           | 92.2                          | 6.32                        | 5.09                         | 11.14                               | 16.44                                   |
| 11                | PT-417-7-1-14    | Red                | Medium           | 96.5                          | 6.16                        | 5.22                         | 10.52                               | 13.48                                   |
| 12                | PKV-TARA         | Red                | Bold             | 87.6                          | 6.00                        | 4.99                         | 11.29                               | 21.94                                   |
| 13                | PT-17-12-2       | Red                | Bold             | 97.0                          | 6.39                        | 5.07                         | 11.00                               | 11.00                                   |
| 14                | BSMR-736         | Red                | Bold             | 85.7                          | 6.23                        | 4.86                         | 9.92                                | 19.33                                   |
| 15                | PT-00-12         | Red                | Bold             | 84.4                          | 6.07                        | 4.97                         | 10.00                               | 19.87                                   |
| 16                | PT-03-142        | Red                | Bold             | 89.2                          | 6.09                        | 5.04                         | 10.00                               | 15.29                                   |
| 17                | Vipula           | Red                | Bold             | 88.1                          | 6.11                        | 5.07                         | 9.82                                | 17.72                                   |
| 18                | BDN-2010-12      | Light brown        | Small            | 99.8                          | 6.42                        | 5.26                         | 10.89                               | 11.88                                   |
| 19                | BDN-2001-6       | Light brown        | Small            | 99.5                          | 6.41                        | 5.29                         | 11.06                               | 15.60                                   |
| 20                | ICPL-87          | Light brown        | Small            | 102.8                         | 6.36                        | 5.26                         | 9.25                                | 8.80                                    |
| 21                | ICPL-332         | Light brown        | Medium           | 98.7                          | 6.38                        | 5.86                         | 10.48                               | 13.86                                   |
| 22                | ICPL-87119       | Light brown        | Bold             | 84.3                          | 6.07                        | 4.89                         | 10.19                               | 11.87                                   |
| 23                | ICPL-98008       | Light brown        | Bold             | 85.8                          | 6.00                        | 4.96                         | 9.61                                | 9.00                                    |
| 24                | ICPL-88039       | Light brown        | Bold             | 82.1                          | 6.00                        | 4.72                         | 10.69                               | 17.26                                   |
| 25                | BSMR-853         | White              | Small            | 102.4                         | 6.26                        | 5.35                         | 10.05                               | 12.00                                   |
| <b>S.E.±</b>      |                  |                    |                  | <b>1.29</b>                   | <b>0.008</b>                | <b>0.007</b>                 | <b>0.33</b>                         | <b>0.70</b>                             |
| <b>C.D. at 5%</b> |                  |                    |                  | <b>3.64</b>                   | <b>0.022</b>                | <b>0.020</b>                 | <b>0.93</b>                         | <b>1.96</b>                             |

seed volume, 100 grain weight and seed hardness was observed with seed size of 90.4 – 116.0/cc, 9.25 – 11.06 g and 8.86 – 18.30 kg/grain in small size seeded genotypes, 90.6 – 98.7/ 10 cc, 9.80 – 11.14 g and 12.00 – 17.10 kg/grain in medium size seeded genotypes and 82.1 – 97.0/10cc, 9.61 – 11.29 g, and 9.00 – 21.94 kg/ grain bold size seeds of genotypes, respectively. There was no any association was observed in individual genotype with different seed morphological characters. The present findings are in agreement with the results reported by Regupathy and Rathnaswamy (1970) who observed no association of seed colour, seed volume and hardness of seed.

#### **4.2 Orientation of pulse beetle adults to seeds of pigeonpea genotypes under “Free choice” test**

In free choice method, 100 pairs of adults of pulses beetle, *C. maculatus* released for their orientation towards the seed in 25 different genotypes of pigeonpea having 100 seed of each genotype and the data are presented in Table 2 and depicted in Fig. 2.

Out of two hundred adults, 137.75 adults beetle oriented to different genotypes during 48 hours and it was ranged from 1.00 (BSMR-853) to 9.00 (PT-04-12-1-1 and ICPL-87). From the results, it indicted that red colour with small, medium and bold size seeded genotypes attracted in the range of 2.00 to 9.00, 3.50 to 7.50 and 1.50 to 6.00, respectively. Whereas, in light brown colour with small, medium and bold seeds adults oriented between 4.50 to 9.00, 7.75 and 6.00 to 8.00, respectively. There was a single genotype of white colour with small seed to which minimum number of adult was oriented i.e.1.00.

**Table 2. Reaction of pulse beetle adults oriented to different seeds of pigeonpea genotypes under “Free choice”test**

| <b>Sr. No.</b> | <b>Genotypes</b> | <b>Seed colour</b> | <b>Seed size</b> | <b>Average no. of adults oriented</b> |
|----------------|------------------|--------------------|------------------|---------------------------------------|
| 1              | PT-00-1-25-1     | Red                | Small            | 8.25                                  |
| 2              | PT-04-12-1-1     | Red                | Small            | 9.00                                  |
| 3              | PT-04-24-2       | Red                | Small            | 3.50                                  |
| 4              | PT-04-31         | Red                | Small            | 6.25                                  |
| 5              | PT-01-24-1-1     | Red                | Small            | 2.00                                  |
| 6              | PT-00-5-7-4-1    | Red                | Medium           | 7.50                                  |
| 7              | PT-00-16-4-2     | Red                | Medium           | 5.25                                  |
| 8              | PT-00-4-16-2     | Red                | Medium           | 7.50                                  |
| 9              | PT-04-257        | Red                | Medium           | 7.50                                  |
| 10             | PT-2001-11-2     | Red                | Medium           | 3.50                                  |
| 11             | PT-417-7-1-14    | Red                | Medium           | 7.00                                  |
| 12             | PKV-TARA         | Red                | Bold             | 3.00                                  |
| 13             | PT-17-12-2       | Red                | Bold             | 4.75                                  |
| 14             | BSMR-736         | Red                | Bold             | 3.00                                  |
| 15             | PT-00-12         | Red                | Bold             | 6.00                                  |
| 16             | PT-03-142        | Red                | Bold             | 3.75                                  |
| 17             | Vipula           | Red                | Bold             | 1.50                                  |
| 18             | BDN-2010-12      | Light brown        | Small            | 4.50                                  |
| 19             | BDN-2001-6       | Light brown        | Small            | 5.00                                  |
| 20             | ICPL-87          | Light brown        | Small            | 9.00                                  |
| 21             | ICPL-332         | Light brown        | Medium           | 7.75                                  |
| 22             | ICPL-87119       | Light brown        | Bold             | 7.25                                  |
| 23             | ICPL-98008       | Light brown        | Bold             | 8.00                                  |
| 24             | ICPL-88039       | Light brown        | Bold             | 6.00                                  |
| 25             | BSMR-853         | White              | Small            | 1.00                                  |
| <b>Total</b>   |                  |                    |                  | <b>137.75</b>                         |

Nwanze *et al.* (1975) and Chakraborty and Mondal (2016) suggested a combination of several factors such as texture, seed size, seed weight, volume of seed and seed colour have been responsible for ovipositional preference of bruchids to different pulses. Dark and brown coloured seeds were preferred most for oviposition over white seeds in “free choice” situation. These results are supported with the present findings.

### **4.3 Influence of pulse beetle reared on seeds of pigeonpea genotypes under “No choice” test**

Adults of pulse beetle, *C. maculatus* when reared on different seed size and seed colour of pigeonpea genotypes for their host preference and the observations were recorded on number of egg laid/10 seeds, incubation period, hatching percentage, total larval pupal period, adult emergence, adult longevity and ovipositional period. The results are presented in Table 3 and depicted in Fig. 3.

#### **4.3.1 Ovipositional preference**

The data on the ovipositional preference indicated that, the beetles showed marked variation for oviposition on all pigeonpea genotypes. The adult female laid eggs on different genotypes recorded in the range of 10.25 – 14.00 eggs /10 seeds. However, among the genotypes tested, PKV-TARA and BSMR-736 was less preferred (10.25 eggs/10 seeds) for oviposition and found statistically at par with all genotypes except PT-00-12-1-1 (12.75 eggs), PT-04-31 (13 eggs), PT-417-7-1-14 (14.00 eggs) and ICPL-87. Whereas, genotypes ICPL-87 and PT-417-7-1-14 recorded significantly highest number of eggs (14.00 eggs). The mean ovipositional period was observed in range of 5.75 to 7.50

days in all genotypes. There was only one genotype PKV-TARA noticed in relation of less (5.75 days) ovipositional period with less number of egg laid (10.25 eggs/10 seeds). There was no any relationship noticed in seed colour, seed volume, seed size and ovipositional period.

These present findings are also in agreement with the results reported by following workers.

Khokhar and Singh (1987) reported the number of eggs laid by the beetle on pigeonpea varieties varied from 34.7 to as high as 238.0 eggs/20 seeds and also stated that ICPL-143 and ICPL-148 were least preferred by beetle and ICPL-289 which was more preferred for egg laying provided conditions for better development and successful adult emergence.

Dasback *et al.* (2009) also suggested that 1000 grain mass and testa thickness were considered the most important factor for resistance to bruchid attack in pigeonpea.

Shivanna *et al.* (2011a) reported the CP-17 was comparatively less preferred host with lesser oviposition (81.33 eggs/100 g seeds) of *C. maculatus* in cowpea.

Rosemond and Khan (2013) reported ovipositioning to F<sub>1</sub> adult emergence of *C. maculatus* was longest in pigeonpea cultivar B35 (33 days) and shortest in cultivar B59 and B200.

Chandel and Bhadauria (2015) reported that the preference of the variety for egg laying was not varying much even up to 10 days after initiation of egg laying.

Semple (1992) reported the rate of insect population increase could be adversely affected when a resistant variety is used which causes reduction in oviposition rate through physical or mechanical barrier. The barrier is said to either deter access into the grains or make it unsuitable for oviposition.

When adults of *C. maculatus* reared on different seed characters for ovipositional preference, the results revealed that there was no any relationship noticed in seed colour, seed size, seed volume with ovipositional preference and oviposition period. These present findings are in agreement with Satyavir (1982) indicating no relationship of seed character of different varieties of moth bean with oviposition of *C. maculatus*. Teotia and Singh (1966) indicated that ovipositional preference did not have any relationship with the suitability of the seed for development of the insect. However, Gopalswamy *et al.* (2010) reported more number of eggs in small seeded varieties of Urdbean and Vishwamithra *et al.*, (2015) revealed that the oviposition of *C. chinensis* on pigeonpea genotypes was found to be more influenced by the physical parameters like 100 grain weight and seed size.

#### **4.3.2 Incubation period, hatching per cent and total larval-pupal period**

The results on incubation period, hatching per cent and total larval-pupal period of *C. maculatus* in different genotypes of pigeonpea ranged from 3 to 5 days, 90.64 to 95.45 per cent and 18.25 to 20.50 days, respectively. There was no relationship observed in between morphological characters with the biological parameters of *C. maculatus*. However, present findings are corrugated with the results reported by Kitch and Shade (1993) who observed the incubation period of *C. maculatus* was in the range of 6.33 to 12.0 days in cowpea. Raina (1970) reported egg hatching of *C. chinensis* ranged from 94 to 99 per cent on mung bean and larval-pupal period 18.8 days on mung bean. Gill and

Ramzan (1998) reported egg hatching of *C. maculatus* varied from 93.1 per cent in September on green gram and also larval and pupal period ranges from  $10.60 \pm 0.06$  and  $5.02 \pm 0.66$  days, respectively. Patel *et al.* (2005) observed larval-pupal period of pulse beetle completed within 17.19 to 21.05 days in different pulses.

#### **4.3.3 Adult emergence and longevity**

The data on per cent adult emergence indicated that there was also marked variation (71.01 to 91.38 %) in adult emergence of *C. maculatus* in different pigeonpea genotypes. The significantly highest per cent adult emergence was displayed in PT-00-12-1-1 (91.38 %) followed by BDN-2001-6 (90.68 %). The significant less per cent adult emergence was observed in PKV-TARA (71.01 %), which was found statistically at par with Vipula (72.66 %), ICPL-332 (74.91 %), BSMR-736 (78.14 %), PT-04-257 (78.65 %) and ICPL-88039 (79.09 %).

Irrespective of adult emergence, the adult longevity ranged from 7.50 to 12.25 days. The less (7.50 days) adult longevity was recorded in Vipula and PKV-TARA genotypes and the highest adult longevity noticed in BSMR-853 (12.25 days).

The results of present investigation are supported with the findings by Gokhale (1973) who reported adult emergence of *C. maculatus* to the extent of 77.47 to 86.44 per cent when reared on Bengal gram and the minimum (43.36 to 61.59%) adult emergence of *C. chinensis* on different pigeonpea genotypes. Nagaraja (2006) observed the lowest per cent adult emergence in genotypes of pigeonpea *viz.*, ICPL. 2008-1, PG-12, GS-1, DEPS-3 and DEPS-9 and showed relative resistance to

**Table 3. Biological parameters of pulse beetle reared on seeds of different pigeonpea genotypes**

| <b>Sr. No.</b> | <b>Genotypes</b>  | <b>No. of eggs laid/10 seeds</b> | <b>Oviposition period (Days)</b> | <b>Incubation period (Days)</b> | <b>Hatching (%)</b> | <b>Total larval-pupal period ( Days)</b> | <b>Adult emergence (%)</b> | <b>Adult longevity (Days)</b> |
|----------------|-------------------|----------------------------------|----------------------------------|---------------------------------|---------------------|--|----------------------------|-------------------------------|
| 1              | PT-00-1-25-1      | 11.50                            | 7.25                             | 4.75                            | 93.30               | 20.00                                    | 85.68                      | 10.75                         |
| 2              | PT-00-12-1-1      | 12.75                            | 7.50                             | 4.00                            | 95.00               | 18.75                                    | 91.38                      | 8.25                          |
| 3              | PT-04-24-2        | 11.00                            | 7.25                             | 4.00                            | 95.23               | 19.50                                    | 90.23                      | 11.75                         |
| 4              | PT-04-31          | 13.00                            | 6.00                             | 3.25                            | 94.20               | 19.50                                    | 88.46                      | 9.50                          |
| 5              | PT-01-24-1-1      | 11.00                            | 6.75                             | 3.50                            | 93.14               | 20.25                                    | 87.95                      | 11.00                         |
| 6              | PT-005-7-4-1      | 10.50                            | 6.25                             | 3.50                            | 92.72               | 19.50                                    | 82.73                      | 9.25                          |
| 7              | PT-00-16-4-2      | 10.75                            | 6.75                             | 4.50                            | 92.95               | 20.00                                    | 85.90                      | 10.25                         |
| 8              | PT-00-4-16-2      | 11.25                            | 6.50                             | 3.50                            | 95.45               | 20.75                                    | 84.66                      | 9.00                          |
| 9              | PT-04-257         | 10.75                            | 6.75                             | 3.00                            | 90.99               | 18.50                                    | 78.65                      | 8.75                          |
| 10             | PT-2001-11-2      | 10.50                            | 7.00                             | 4.50                            | 90.87               | 19.25                                    | 83.18                      | 9.75                          |
| 11             | PT-417-7-1-14     | 14.00                            | 6.50                             | 3.00                            | 90.80               | 20.25                                    | 86.29                      | 8.75                          |
| 12             | PKV-TARA          | 10.25                            | 5.75                             | 4.50                            | 92.92               | 20.25                                    | 71.01                      | 7.50                          |
| 13             | PT-17-12-2        | 10.50                            | 6.50                             | 5.00                            | 91.98               | 20.50                                    | 82.01                      | 9.25                          |
| 14             | BSMR-736          | 10.25                            | 6.75                             | 5.00                            | 92.73               | 18.50                                    | 78.14                      | 7.75                          |
| 15             | PT-00-12          | 11.00                            | 6.50                             | 3.00                            | 91.17               | 18.75                                    | 81.97                      | 9.75                          |
| 16             | PT-03-142         | 11.75                            | 6.75                             | 3.00                            | 91.38               | 19.75                                    | 83.29                      | 8.50                          |
| 17             | Vipula            | 11.25                            | 6.50                             | 3.75                            | 92.12               | 18.25                                    | 72.66                      | 7.50                          |
| 18             | BDN-2010-12       | 10.50                            | 6.50                             | 5.00                            | 92.73               | 19.50                                    | 88.18                      | 11.00                         |
| 19             | BDN-2001-6        | 11.00                            | 7.00                             | 3.50                            | 90.64               | 19.75                                    | 90.68                      | 10.75                         |
| 20             | ICPL-87           | 14.00                            | 6.75                             | 5.00                            | 92.12               | 19.75                                    | 90.00                      | 10.25                         |
| 21             | ICPL-332          | 11.00                            | 6.00                             | 3.25                            | 93.08               | 20.50                                    | 74.91                      | 10.50                         |
| 22             | ICPL-87119        | 10.75                            | 6.50                             | 3.25                            | 93.18               | 18.50                                    | 83.41                      | 8.25                          |
| 23             | ICPL-98008        | 10.50                            | 7.25                             | 5.00                            | 94.07               | 19.25                                    | 84.13                      | 9.50                          |
| 24             | ICPL-88039        | 10.75                            | 7.25                             | 4.00                            | 92.95               | 19.50                                    | 79.09                      | 8.75                          |
| 25             | BSMR-853          | 12.00                            | 6.25                             | 3.25                            | 90.99               | 19.50                                    | 89.07                      | 12.25                         |
|                | <b>S.E. ±</b>     | <b>0.62</b>                      | <b>0.45</b>                      | <b>0.45</b>                     | <b>2.05</b>         | <b>0.44</b>                              | <b>3.34</b>                | <b>0.44</b>                   |
|                | <b>C.D. at 5%</b> | <b>1.76</b>                      | <b>1.26</b>                      | <b>1.26</b>                     | <b>5.77</b>         | <b>1.25</b>                              | <b>9.41</b>                | <b>1.23</b>                   |

*C. maculatus* compared to the other susceptible genotypes *viz.*, ICPL-2009-1, GPS-2003, PG-44 and ICPL-87119. Patel *et al.* (2005) observed more longevity in pea 14.83 days followed by Bengal gram (12.53 days) and red gram (12.07 days).

#### **4.3.4 Development period**

The results indicated that the significantly less development period was observed in Vipula (26.00 days) with closely followed by BSMR-736 (26.25 days). The highest development period noted in BSMR-853 (31.75 days).

The bold seeded genotypes with red and light brown colour seeds were recorded less development period of 26.00 – 29.75 days followed by medium (27.75 - 31.00 days) size seeds and small seeds (27.00 – 31.25 days). The maximum total number of days required to complete the life cycle of *C. maculatus* recorded in the range at 26.00 to 31.75 days in different genotypes.

The present findings are in line with the results reported by Jaggal *et al.* (2012) who observed the development period of *C. chinensis* in between 18.33 and 27.17 days in different genotypes of pigeonpea. The maximum (30-36 days) development period of *C. maculatus* on red gram was reported by Shivanna *et al.* (2011). Singal (1998) and Swella and Mushobozy (2009) also recorded developmental period of *C. chinensis* of 35.5 and 34 days in pigeonpea and chickpea.

#### **4.3.5 Growth index**

The growth index ranged from 2.56 to 3.38 in different pigeonpea genotypes. PT-00-12-1-1 proved to be most nutritious to *C. maculatus* recording high growth index of 3.38. The least

nutritious genotypes was PKV-TARA which recorded 2.56 growth index and it was at par with BSMR-853 (2.61).

In respect of genotypes based on resistance/susceptibility, none of the genotype was found to be resistance to *C. maculatus*. However two genotypes i.e. PKV-TARA and ICPL 332 was observed moderately resistance, four genotypes (PT 04-24-2, Pt-04-31, Vipula and ICPL-87119) was susceptible and one genotype (PT-00-12-1-1) recorded highly susceptible category. The rest of the genotypes comes under moderately susceptible to *C. maculatus*.

The results of present investigations are in agreement with the results reported Wadnerkar *et al.* (1978) reported the varieties having maximum growth index are more suitable for pulse beetle in arhar and gram. Ghokhale (1973) observed the growth index of *C. maculatus* ranged from 2.67 – 3.14 recorded on Bengal gram and Vishwamitra *et al.* (2015) also observed the growth index of *C. chinensis* in between 0.00 to 6.00 in different varieties of pigeonpea.

#### **4.4 Grain infestation due by pulse beetle in pigeonpea**

##### **4.1.1 Grain infestation ( Number and weight basis)**

The data on per cent grain infestation caused by pulse beetle, *C. maculatus* adults on different pigeonpea genotypes are presented in Table 5 and depicted in Fig. 5.

The grain infestation on number and weight basis ranged between 2.08 – 25.09 and 76.86 – 95.58 per cent, respectively. The minimum grain infestation on number and weight basis was noticed in the genotype PKV-TARA (2.08 %) and (76.86 %) which was found statistically at par with BSMR-736 (5.77%) and (78.00%, respectively). The maximum grain infestation on number basis was exhibited in PT-00-12-1-1

**Table 4. Growth and development of pulse beetle in different pigeonpea genotypes**

| <b>Sr. No.</b> | <b>Genotypes</b> | <b>Adult emergence (%)</b> | <b>Development period (Days)</b> | <b>Growth index</b> | <b>Category</b> |
|----------------|------------------|----------------------------|----------------------------------|---------------------|-----------------|
| 1              | PT-00-1-25-1     | 85.68                      | 30.75                            | 2.79                | MS              |
| 2              | PT-00-12-1-1     | 91.38                      | 27.00                            | 3.38                | HS              |
| 3              | PT-04-24-2       | 90.23                      | 31.25                            | 3.03                | S               |
| 4              | PT-04-31         | 88.46                      | 29.00                            | 3.05                | S               |
| 5              | PT-01-24-1-1     | 87.95                      | 31.25                            | 2.81                | MS              |
| 6              | PT-005-7-4-1     | 82.73                      | 28.75                            | 2.88                | MS              |
| 7              | PT-00-16-4-2     | 85.90                      | 30.25                            | 2.84                | MS              |
| 8              | PT-00-4-16-2     | 84.66                      | 29.75                            | 2.85                | MS              |
| 9              | PT-04-257        | 78.65                      | 27.25                            | 2.89                | MS              |
| 10             | PT-2001-11-2     | 83.18                      | 29.00                            | 2.89                | MS              |
| 11             | PT-417-7-1-14    | 86.29                      | 29.00                            | 2.98                | MS              |
| 12             | PKV-TARA         | 71.01                      | 27.75                            | 2.56                | MR              |
| 13             | PT-17-12-2       | 82.01                      | 29.75                            | 2.76                | MS              |
| 14             | BSMR-736         | 78.14                      | 26.25                            | 2.98                | MS              |
| 15             | PT-00-12         | 81.97                      | 28.50                            | 2.88                | MS              |
| 16             | PT-03-142        | 83.29                      | 28.25                            | 2.95                | MS              |
| 17             | Vipula           | 72.66                      | 26.00                            | 3.10                | S               |
| 18             | BDN-2010-12      | 88.18                      | 30.50                            | 2.89                | MS              |
| 19             | BDN-2001-6       | 90.68                      | 30.25                            | 2.97                | MS              |
| 20             | ICPL-87          | 90.00                      | 30.00                            | 3.00                | MS              |
| 21             | ICPL-332         | 74.91                      | 31.00                            | 2.62                | MR              |
| 22             | ICPL-87119       | 83.41                      | 26.75                            | 3.12                | S               |
| 23             | ICPL-98008       | 84.13                      | 28.75                            | 2.93                | MS              |
| 24             | ICPL-88039       | 79.09                      | 28.25                            | 2.80                | MS              |
| 25             | BSMR-853         | 89.07                      | 31.75                            | 2.81                | MS              |

MR= Moderately Resistance,  
S = Susceptible,

MS = Moderately Susceptible  
HS = Highly Susceptible

(25.09 %) and it was at par with ICPL-87 (24.82 %), PT-04-31 (22.85 %), PT-00-25-1-1 (21.86 %) and BSMR-853 (21.35 %). While, ICPL-87 genotype recorded significantly maximum per cent grain damage against rest of the genotypes. ICPL-87 was found to be highly susceptible genotype to *C. maculatus* on number and weight basis.

The minimum infested seed on number and weight basis was recorded in bold size seed of 2.08 – 18.49 and 76.86 – 90.00 per cent and 11.82-15.87 and 85.17 – 88.32 per cent in red and light brown coloured seeds, respectively. The small size seed recorded maximum seed infestation on number as well as weight basis in the range from 14.32 – 25.09 and 85.50 – 92.63 per cent in red colour and 18.03 – 24.82 and 79.89 – 95.58 per cent in light brown colour seeds, respectively.

These present findings are supported with the results recorded by Patnaik and Samalo (1987), Dasbak *et al.* (2009) Mukherjee *et al.* (1970) and Khokhar and Singh (1987) reported the seed infestation of pigeonpea genotypes by *C. maculatus* in the range of 7.0 to 28.7, 24.7 to 38.5, 32.64 and 5.2 to 88.7 per cent, respectively.

#### **4.4.2 Seed weight loss**

The statistical analysis of the data in Table 5 indicated that most of the genotypes tested suffered grain weight loss due to feeding of *C. maculatus*. The significant difference was found in per cent grain weight loss on weight basis which ranged from 2.22 to 22.81 per cent. The minimum per cent grain weight loss of 2.22 % was recorded in the genotype PKV-TARA and it was found statistically at par with BSMR-736 (2.55 %). The maximum grain weight loss 22.81 % was observed in PT-00-12-1-1 (22.81 %) which was found statistically at par with ICPL-87 (21.15 %).

In the present investigation, it indicated that the seed weight loss (11.60 – 22.81, 9.51 – 15.79 and 2.53- 7.37 per cent) was increased in pigeonpea genotype with increase in egg laying (11.00- 12.75, 10.50-14.00 and 10.50-11.75 eggs/10 seed) and adult emergence (85.68-91.38, 78.65-86.29 and 71.01-83.29 per cent) of *C. maculatus* in small, medium and bold size seeds, respectively.

In respect of seed colour, red colour seed genotypes were found to be slightly resistance by recording 2.55 - 22.81 per cent compared to light brown colour (9.27 - 21.15%). Only one genotype was evaluated daily, the per cent infestation, it was not considered for comparing the grain damage and seed weight loss. The findings are in agreement with Chandel *et al.* (2012) who indicated the weight loss and infestation increased on pigeonpea varieties with the increase in egg laying and adult emergence of pulse beetle. Sarwar (2012) reported the tolerant varieties of chickpea showed the least loss in weight due to *C. maculatus* which could be attributed to small and presence of well texture layer of seed.

However, the earlier research on another germplasm, Mukharjee *et al.* (1970), Patnaik and Samalo (1987), Khairnar *et al.* (1996), Dasback *et al.* (2009), Rosemond and Khan (2013) and Shivanna *et al.* (2011b) observed in varying degree in seed weight loss in pigeonpea due to pulse beetle.

#### **4.5 Reaction of biochemical constituents of seeds of pigeonpea genotypes to pulse beetle**

The results on the reaction of biochemical contents in seeds of different pigeonpea genotypes to pulse beetle, *C. maculatus* are presented in Table 6 and depicted in Fig.6.

**Table 5. Grain infestation caused by pulse beetle in different pigeonpea genotypes**

| <b>Sr. No.</b>    | <b>Genotypes</b> | <b>% Grain infestation (No.basis)</b> | <b>% Damage of grain (Wt. basis)</b> | <b>% Grain weight loss (Wt. basis)</b> |
|-------------------|------------------|---------------------------------------|--------------------------------------|--|
| 1                 | PT-00-1-25-1     | 21.86 (27.73) *                       | 85.50 (67.62)                        | 19.37 (26.11)                          |
| 2                 | PT-00-12-1-1     | 25.09 (29.99)                         | 92.63 (74.25)                        | 22.81 (28.52)                          |
| 3                 | PT-04-24-2       | 14.32 (21.70)                         | 88.18 (69.89)                        | 11.85 (20.13)                          |
| 4                 | PT-04-31         | 22.85 (28.30)                         | 88.31 (70.01)                        | 11.60 (19.90)                          |
| 5                 | PT-01-24-1-1     | 20.91 (27.13)                         | 85.85 (67.91)                        | 14.05 (22.00)                          |
| 6                 | PT-005-7-4-1     | 17.27 (24.31)                         | 85.73 (67.81)                        | 15.79 (23.41)                          |
| 7                 | PT-00-16-4-2     | 14.09 (21.72)                         | 79.05 (62.75)                        | 10.23 (18.64)                          |
| 8                 | PT-00-4-16-2     | 13.07 (20.66)                         | 84.27 (66.63)                        | 15.76 (23.38)                          |
| 9                 | PT-04-257        | 13.71 (18.98)                         | 79.03 (62.75)                        | 16.64 (24.07)                          |
| 10                | PT-2001-11-2     | 19.46 (26.12)                         | 88.63 (70.29)                        | 11.39 (19.72)                          |
| 11                | PT-417-7-1-14    | 12.37 (17.66)                         | 86.43 (68.39)                        | 14.17 (22.09)                          |
| 12                | PKV-TARA         | 2.08 (4.19)                           | 76.86 (61.25)                        | 2.22 (8.23)                            |
| 13                | PT-17-12-2       | 18.11 (25.07)                         | 90.00 (71.56)                        | 20.47 (26.90)                          |
| 14                | BSMR-736         | 5.77 (9.80)                           | 78.00 (62.02)                        | 2.55 (9.07)                            |
| 15                | PT-00-12         | 15.34 (19.76)                         | 80.00 (63.43)                        | 7.37 (15.74)                           |
| 16                | PT-03-142        | 18.49 (25.02)                         | 79.92 (63.38)                        | 4.30 (11.53)                           |
| 17                | Vipula           | 10.00 (18.43)                         | 78.00 (62.03)                        | 4.01 (11.39)                           |
| 18                | BDN-2010-12      | 18.86 (25.43)                         | 90.50 (72.05)                        | 15.80 (23.42)                          |
| 19                | BDN-2001-6       | 18.03 (24.97)                         | 79.89 (63.36)                        | 11.67 (19.98)                          |
| 20                | ICPL-87          | 24.82 (29.62)                         | 95.58 (77.87)                        | 21.15 (27.37)                          |
| 21                | ICPL-332         | 14.32 (21.70)                         | 90.73 (72.27)                        | 9.51 (17.95)                           |
| 22                | ICPL-87119       | 11.82 (19.91)                         | 85.17 (67.35)                        | 15.20 (22.94)                          |
| 23                | ICPL-98008       | 15.87 (23.17)                         | 88.32 (70.01)                        | 9.27 (17.68)                           |
| 24                | ICPL-88039       | 13.94 (21.66)                         | 86.22 (68.21)                        | 14.38 (22.28)                          |
| 25                | BSMR-853         | 21.35 (27.36)                         | 84.00 (66.42)                        | 14.87 (22.67)                          |
| <b>S.E.±</b>      |                  | <b>1.34</b>                           | <b>0.14</b>                          | <b>0.45</b>                            |
| <b>C.D. at 5%</b> |                  | <b>3.76</b>                           | <b>0.39</b>                          | <b>1.27</b>                            |

\* Figures in parenthesis are arc sine transformed values.

#### **4.5.1 Protein content**

The protein content in seeds of different pigeonpea genotypes range from 17.32 to 20.18 per cent. The highest per cent protein content was found in ICPL-87 (20.18 %) followed by PT-00-5-7-4-1 (19.30 %). The less protein content was observed in ICPL-98008 (17.32 %).

The red and light brown coloured seed recorded protein content in the ranged from 17.56 to 19.30 and 17.32 to 20.18 per cent, respectively. White colour genotype BSMR-853 recorded protein of 18.32 per cent.

#### **4.5.2 Carbohydrate content**

The carbohydrate content was in the range of 57.63 to 69.49 per cent in seeds of different genotypes. The highest per cent carbohydrate was found in PT-2001-11-2 (69.49 %), followed by ICPL-87 (67.63 %). The less carbohydrate content was observed in PKV-TARA (57.63 %).

The red and light brown seed coat coloured genotype of pigeonpea recorded carbohydrate in the range between 57.63 to 69.49 and 60.46 to 67.63 per cent, respectively. Whereas, carbohydrate in white seed colour of BSMR-853 genotype was 63.25 per cent.

#### **4.5.3 Fat content**

The fat content in seeds of different pigeonpea genotypes ranged from 0.93 to 1.40 per cent. The highest per cent fat was found in PT-04-12-1-1 (1.40 ), whereas, the less per cent fat was observed in PKV-TARA (0.93 %) followed by PT-2001-11-2 (0.95 %).

The red and brown seed coat coloured genotypes recorded fat content in the range of 0.93 to 1.40 and 0.97 to 1.21 per cent, respectively and 1.25 per cent in white colour genotype of pigeonpea.

#### **4.5.4 Ash content**

The ash per cent ranged from 2.58 to 4.02 in seeds of different genotypes. Highest ash content was recorded in Vipula (4.02 %) followed by PKV-TARA (3.80 %). The less ash content was recorded in PT-04-12-1-1 (2.58 %) followed by ICPL-332 (2.60 %).

The red and brown seed coat coloured genotypes of pigeonpea recorded ash content in the range between 2.58 and 4.02 and 2.60 to 3.47 per cent, respectively. White colour seed recorded 3.52 per cent fat.

#### **4.5.5 Moisture content**

The moisture content in seeds of different genotypes was recorded in between the range of 8.67 to 9.32 per cent. The highest moisture content was recorded in BDN-2001-6 (9.32 %). The less moisture content was recorded in PT-04-31 (8.67 %).

The findings of present investigations are in conformity with the results reported by Singh *et al.* (1995) who reported fecundity and index susceptibility were comparatively lesser for the varieties with characteristics of high protein content. Singh and Sharma (2001) observed that longest period for incubation can be attributed to the variety containing high amount of protein. Nagaraja (2006) observed the lowest protein content in the genotypes of pigeonpea *viz.*, ICPL 2008-1, PG-12, GS-1, DEPS-3, DEPS-9 and showed relative resistance to *C. maculatus* compared to the other susceptible genotypes *viz.*, ICPL-2009-1, GPS-2003, PG-44 and ICPL-87119. Gujar and Yadav (1978) recorded 44.5 to 66.3 per cent loss in protein due to feeding of *C. maculatus* and 17 to 53.5 per cent loss in protein due to *C. chinensis* in green gram. Khattak *et al.* (1991) reported

high ash content of varieties of chickpea significantly reduced the insect infestation and Sandhya Rani (1998) also reported a significant negative relationship of ash content of chickpea varieties with *C. chinensis* infestation. Dwivedi and Sharma (1996) reported a decrease in preference by the bruchid, *C. chinensis* with increasing protein and fat content.

Vimla and Pushpamma (1983) asserted changes in carbohydrate contents of seed of red gram, green gram, black gram and Bengal gram by feeding of pulse beetles (*C. chinensis*.) in three agro-climatic zones.

Gupta (1985) reported that the minimum damage caused by pests because the food was stored for not more than 2 months but moisture played important role.

Dharne *et al.* (1984) found that the variety of ICPL-95 of pigeonpea had maximum nutritious value which tends to emergence of high amount of beetles.

All these results lend supports with the present findings.

#### **4.6 Correlation coefficient 'r' between pulse beetle and seeds of pigeonpea genotypes**

##### **a. Correlation coefficient between pulse beetle adults oriented to seeds for host preference in different genotypes pigeonpea**

The results presented in Table 7 showed all the morphological characters *viz.*, seed volume, seed length, seed breadth, 100 grain weight and seed hardness were negative and non significantly correlated with orientation of *C. maculatus* adults towards the seeds for host preference in pigeonpea.

**Table 6. Biochemical reaction to pulse beetle in seeds of pigeonpea genotypes**

| <b>Sr. No.</b> | <b>Genotypes</b> | <b>Protein content (%)</b> | <b>Carbohydrate content (%)</b> | <b>Fat content (%)</b> | <b>Ash content (%)</b> | <b>Moisture content (%)</b> |
|----------------|------------------|----------------------------|---------------------------------|------------------------|------------------------|-----------------------------|
| 1              | PT-00-1-25-1     | 19.10                      | 66.83                           | 1.20                   | 3.50                   | 9.05                        |
| 2              | PT-00-12-1-1     | 19.06                      | 62.72                           | 1.40                   | 2.58                   | 9.12                        |
| 3              | PT-04-24-2       | 18.60                      | 62.28                           | 1.22                   | 3.49                   | 9.05                        |
| 4              | PT-04-31         | 18.92                      | 62.59                           | 1.24                   | 3.22                   | 8.67                        |
| 5              | PT-01-24-1-1     | 19.18                      | 65.15                           | 1.23                   | 3.45                   | 8.90                        |
| 6              | PT-005-7-4-1     | 19.30                      | 62.64                           | 1.21                   | 2.96                   | 9.00                        |
| 7              | PT-00-16-4-2     | 18.15                      | 64.90                           | 1.06                   | 3.21                   | 9.03                        |
| 8              | PT-00-4-16-2     | 18.32                      | 63.23                           | 1.22                   | 3.44                   | 9.27                        |
| 9              | PT-04-257        | 18.36                      | 62.62                           | 1.15                   | 3.18                   | 9.12                        |
| 10             | PT-2001-11-2     | 17.56                      | 69.49                           | 0.95                   | 3.34                   | 8.87                        |
| 11             | PT-417-7-1-14    | 18.34                      | 66.60                           | 1.17                   | 3.35                   | 9.05                        |
| 12             | PKV-TARA         | 17.83                      | 57.63                           | 0.93                   | 3.80                   | 9.12                        |
| 13             | PT-17-12-2       | 18.51                      | 63.38                           | 1.19                   | 3.41                   | 9.05                        |
| 14             | BSMR-736         | 18.37                      | 59.15                           | 1.19                   | 3.49                   | 8.90                        |
| 15             | PT-00-12         | 18.64                      | 62.48                           | 1.18                   | 3.30                   | 9.20                        |
| 16             | PT-03-142        | 18.62                      | 59.28                           | 1.16                   | 3.76                   | 8.85                        |
| 17             | Vipula           | 17.95                      | 61.95                           | 0.96                   | 4.02                   | 9.02                        |
| 18             | BDN-2010-12      | 18.98                      | 63.01                           | 1.20                   | 3.38                   | 9.10                        |
| 19             | BDN-2001-6       | 18.96                      | 62.83                           | 1.21                   | 3.26                   | 9.32                        |
| 20             | ICPL-87          | 20.18                      | 67.63                           | 1.17                   | 3.07                   | 8.97                        |
| 21             | ICPL-332         | 18.13                      | 65.35                           | 1.00                   | 2.60                   | 8.85                        |
| 22             | ICPL-87119       | 18.04                      | 60.46                           | 1.17                   | 3.40                   | 9.00                        |
| 23             | ICPL-98008       | 17.32                      | 62.30                           | 0.97                   | 3.25                   | 9.07                        |
| 24             | ICPL-88039       | 18.31                      | 62.94                           | 1.11                   | 3.40                   | 9.17                        |
| 25             | BSMR-853         | 18.82                      | 63.25                           | 1.21                   | 3.52                   | 9.15                        |

These findings are in agreement with the results reported by Dabi *et al.* (1979) and Satyavir (1981) who indicated seed weight, volume, hardness and colour and 100 grain weight of the seed had no effect on the resistance to *C. maculatus* on cowpea. Regupathy and Rathanswamy (1970) who observed no association of seed colour, seed volume and hardness of seed and Ahmed *et al.* (1993) also reported seed coat showed non-preference by pulse beetle.

**b. Correlation coefficient 'r' between seed characters and grain weight loss**

The data presented in Table 8, it indicated that the seed length was found to be significantly positive correlation with the per cent grain weight loss ( $r=0.468$ ). Seed volume, seed breadth, 100 grain weight and moisture content was recorded non significant and positive correlation with per cent grain weight loss. Whereas, the seed hardness was significant and negatively correlated with the per cent grain weight loss ( $r = -0.493$ ). It means increase in hardness of seed decreased the per cent weight loss and increase in moisture content increase the per cent weight loss and *vice-versa*.

The results confirming negative correlation of seed hardness and positive correlation of moisture content with per cent grain weight loss were in agreement with results of Umrao and Verma (2002), Gawade (2010) who reported increase in hardness of seed decrease the per cent weight loss and increase in moisture content increase the per cent weight loss and *vice-versa*. He also reported seed volume and 100 grain weight showed no any correlation with per cent loss in grain weight. Chakraborty and Mondal (2016) suggested a combination of several factors such as texture, seed size, seed weight, volume of

**Table 7. Correlation coefficient 'r' between pulse beetle adults oriented to host preference in different pigeonpea genotypes**

| <b>Sr. No.</b> | <b>Seed characters</b>   | <b>Correlation coefficient 'r'</b> |
|----------------|--------------------------|------------------------------------|
| 1              | Seed volume (cc)         | -0.149                             |
| 2              | Seed length (mm)         | -0.027                             |
| 3              | Seed breadth(mm)         | -0.035                             |
| 4              | 100 grain weight (g)     | -0.179                             |
| 5              | Seed hardness (kg/grain) | -0.195                             |
| 6              | Moisture content (%)     | 0.090                              |

\* Significant at 5% = 0.396

\*\* Significant at 1% = 0.505

**Table 8. Correlation coefficient 'r' between seed characteristics of pigeonpea genotypes with grain weight loss caused by pulse beetle**

| Particulars                        | Correlation coefficient 'r' of <i>C. maculatus</i> |                  |                   |                      |                          |                                |                      |
|------------------------------------|--|------------------|-------------------|----------------------|--------------------------|--------------------------------|----------------------|
|                                    | Seed volume (10 cc)                                | Seed length (mm) | Seed breadth (mm) | 100 grain weight (g) | Seed hardness (kg/grain) | % Grain weight loss (Wt.basis) | Moisture content (%) |
| Seed volume (10 cc)                | 1.000  | 0.866**          | 0.765**           | 0.178                | -0.444*                  | 0.380                          | -0.230               |
| Seed length (mm)                   |  | 1.000            | 0.609**           | 0.230                | -0.278                   | 0.468*                         | -0.257               |
| Seed breadth (mm)                  |  |                  | 1.000             | 0.096                | -0.334                   | 0.133                          | 0.258                |
| 100 grain weight (g)               |  |                  |                   | 1.000                | 0.260                    | 0.007                          | 0.0170               |
| Seed hardness (kg/grain)           |  |                  |                   |                      | 1.000                    | -0.493*                        | 0.107                |
| % Grain weight loss (Weight basis) |  |                  |                   |                      |                          | 1.000                          | -0.229               |
| Moisture content (%)               |  |                  |                   |                      |                          |                                | 1.000                |

\* Significant at 5%=0.396

\*\* Significant at 1%=0.505

seed and seed colour have been responsible for ovipositional preference of bruchids to different pulses. Dark and brown coloured seeds were preferred most for oviposition over white seeds in “ free choice” situation. However, Dabi *et al.* (1979) and Satyavir (1981) indicated that seed volume; 100 grain weight and seed colour of seed had no effect on the susceptibility of different varieties of cowpea to *C. maculatus*.

**c. Correlation coefficient ‘r’ between biological parameters of pulse beetle and grain weight loss**

The present findings of biological parameters of pulse beetle, *C. maculatus* and per cent grain infestation are presented in Table 9, it indicated that all the biological parameters of *C. maculatus* were found to be positively correlated with the per cent grain loss on weight basis. Adult emergence was strong significant and positively correlated with per cent grain weight loss ( $r=0.585$ ). While, the number of eggs laid on 10 seeds, incubation period, hatching per cent, total larval-pupal period, adult longevity and ovipositional period was positively correlated and responsible to increase grain weight loss.

The present results are supported with the results reported by Chandel *et al.* (2012) who reported the tolerant varieties showed the lesser loss in weight due to *C. maculatus* which could be attributed to small and presence of seed texture layer of seed in chickpea. Chavan *et al.* (1997b) confirmed the correlation between egg laying and seed colour i.e. dark colour seed with more number of egg laid. The correlation between seed volume and egg laying was as per the results obtained by Teotia and Singh (1966).

**d. Correlation coefficient 'r' between seed characters and biological characters of pulse beetle**

It was observed from the data presented in Table 10, the number of eggs laid recorded positively correlation with development period of pulse beetle, *C. maculatus* and negatively significant correlation with seed hardness ( $r=-0.478$ ). The growth index was significant and positively correlated with seed hardness. Whereas, the grain damage on number ( $r=-0.439$ ) and weight ( $r = -0.515$ ) basis and grain weight loss ( $r=-0.493$ ) were significant and negatively correlated with seed hardness. Development period and grain weight loss was positively correlated with number of eggs laid by the *C. maculatus*. The growth index ( $r = 0.426$ ), per cent grain infestation on number ( $r = 0.482$ ) and weight ( $r = 0.413$ ) basis recorded significantly positive correlation with eggs laid ( $r=-0.430$ ) on seed.

These findings are corrugated with the results of Gawade (2010) who reported increase in hardness, 100 grain weight and seed size, the number of eggs of *C. maculatus* on cowpea decreased. Similar indication about correlation between hardness and egg laying was observed earlier by Booker (1967), Raina (1970), Chavan *et al.* (1997a) and Umrao and Verma (2002).

Wadnerkar *et al.* (1978) reported that the varieties having maximum growth index are more suitable for pulse beetle. Dasback (2009) also reported grain hardness and breadth had a moderate direct effect on the susceptibility index.

Redden and McGuire (1983) observed that the development period and per cent adult emergence are the two most discriminating indicators for evaluation of bruchid susceptibility. All these results lend supports to the present findings.

**Table 9. Correlation coefficient 'r' between biological parameters of pulse beetle and grain weight loss**

| Particulars                   | Correlation coefficient 'r' |                          |              |                            |               |                 |                    |                                |
|-------------------------------|-----------------------------|--------------------------|--------------|----------------------------|---------------|-----------------|--------------------|--------------------------------|
|                               | No. of eggs / 10 seeds      | Incubation period (Days) | Hatching (%) | Total larval -pupal period | Adult emerged | Adult longevity | Oviposition period | % Grain weight loss (Wt.basis) |
| No. of eggs/ 10 seeds         | 1.000                       | -0.236                   | -0.041       | 0.119                      | 0.474*        | 0.067           | 0.009              | 0.366                          |
| Incubation period (Days)      |                             | 1.000                    | 0.214        | 0.071                      | 0.010         | 0.028           | 0.298              | 0.104                          |
| Hatching (%)                  |                             |                          | 1.000        | 0.132                      | 0.156         | -0.023          | 0.181              | 0.160                          |
| Total larval -pupal period    |                             |                          |              | 1.000                      | 0.127         | 0.340           | -0.253             | 0.177                          |
| Adult emerged                 |                             |                          |              |                            | 1.000         | 0.610**         | 0.426*             | 0.585**                        |
| Adult longevity               |                             |                          |              |                            |               | 1.000           | 0.122              | 0.326                          |
| Oviposition period            |                             |                          |              |                            |               |                 | 1.000              | 0.322                          |
| %Grain weight loss (Wt.basis) |                             |                          |              |                            |               |                 |                    | 1.000                          |

\* Significant at 5% = 0.396,

\*\* Significant at 1% = 0.505

**Table 10. Correlation coefficient 'r' between seeds characters of pigeonpea and biological parameters of pulse beetle**

| Particulars                         | Correlation coefficient 'r' |                       |                           |              |                                |                           |                            |                      |
|-------------------------------------|-----------------------------|-----------------------|---------------------------|--------------|--------------------------------|---------------------------|----------------------------|----------------------|
|                                     | Seed hardness (kg/grain)    | No. of eggs/ 10 seeds | Development period (days) | Growth index | % Grain infestation (No.basis) | % Damage grain (Wt.basis) | % Grain wt loss (Wt.basis) | Moisture content (%) |
| Seed hardness (kg/grain)            | 1.000                       | -0.129                | -0.478*                   | 0.017        | -0.439*                        | -0.515*                   | -0.493*                    | -0.102               |
| No. of eggs per 10 seeds            |                             | 1.000                 | 0.105                     | 0.426*       | 0.482*                         | 0.413                     | 0.366                      | 0.181                |
| Development period (Days)           |                             |                       | 1.000                     | -0.430*      | 0.464*                         | 0.383                     | 0.324                      | 0.053                |
| Growth index                        |                             |                       |                           | 1.000        | 0.315                          | 0.201                     | 0.230                      | -0.060               |
| % Grain infestation (No.basis)      |                             |                       |                           |              | 1.000                          | 0.652**                   | 0.672**                    | -0.166               |
| % Damage of grain (Wt.basis)        |                             |                       |                           |              |                                | 1.000                     | 0.686**                    | -0.229               |
| % Grain weight loss (Weight .basis) |                             |                       |                           |              |                                |                           | 1.000                      | 0.205                |
| Moisture content (%)                |                             |                       |                           |              |                                |                           |                            | 1.000                |

\* Significant at 5% = 0.396,

\*\* Significant at 1% = 0.505

**e. Correlation coefficient 'r' between biochemical constituents and grain infestation**

The results on correlation of biochemical constituents are presented in Table 11, it was observed that protein, carbohydrate, fat and moisture content indicated positive and non significant correlation with orientation of pulse beetle, *C. maculatus* adults towards seeds of pigeonpea. Whereas, ash content was noticed strong significantly negative ( $r = -0.606$ ) association with the adults oriented towards the seeds. Also the protein, carbohydrate, fat content in seed were found significant and positively correlated with per cent weight loss ( $r=0.538$ ,  $0.519$  and  $0.586$ , respectively), Whereas, ash content was significant and negatively correlated with per cent grain weight loss ( $r = -0.427$ ).

These present findings are agreement with the results reported by following earlier workers.

Ramanamurthy (1981) reported that the chickpea varieties with less protein content were not preferred for development of *C. chinensis*. Whereas, Venugopal *et al.* (2000) reported strongly confirmed the positive correlation of protein to *C. maculatus* infestation. Shams Fawki *et al.* (2012) indicated a negative correlation between the seed total protein content and susceptibility index. Singh *et al.* (1995) revealed that the fecundity and index susceptibility were comparatively lesser for the varieties with characteristics such as high protein content. Ashfaque *et al.* (2001) reported the varieties with high protein content are highly preferred for oviposition by *C. chinensis*. Satyavir (1981) observed a positive and significant correlation between adult emergence of test insect and protein content.

Vishwamithra *et al.* (2015) observed that the chemical parameters like high ash of test varieties were detrimental to the growth and development of test insect, while protein content of the test varieties favoured the successful development of bruchids and high infestation. Khattak *et al.* (1991) founded that the high ash content of varieties of chickpea significantly reduced the insect infestation. Sandhya Rani (1998) also reported a significant negative relationship of ash content of chickpea varieties with *C. chinensis* infestation.

Chandel and Bhaduria (2015) reported the infestation and losses were found to be positively associated with the test weight and moisture content. Umrao and Verma (2002) observed that the moisture content of grain had significant positive correlation with fecundity and index susceptibility. The loss in weight and damaged grain showed significant positive correlation with F<sub>1</sub> progeny and index susceptibility. They also reported the moisture content of grain had significant positive correlation with fecundity and index susceptibility.

**Table 11. Correlation coefficient 'r' between biochemical reaction to pulse beetle in seeds of different pigeonpea genotypes**

| Particulars                    | Correlation coefficient 'r' |                           |              |                                |                           |                                |                     |                 |                 |                 |                      |
|--------------------------------|-----------------------------|---------------------------|--------------|--------------------------------|---------------------------|--------------------------------|---------------------|-----------------|-----------------|-----------------|----------------------|
|                                | No. of adults oriented      | Development period (Days) | Growth index | % Grain infestation (No.basis) | % Damage grain (Wt.basis) | % Grain weight loss (Wt.basis) | Protein Content (%) | CHO Content (%) | Fat content (%) | Ash content (%) | Moisture Content (%) |
| No. of adults oriented         | 1.000                       | -0.068                    | 0.204        | 0.281                          | 0.464*                    | 0.544**                        | 0.204               | 0.272           | 0.236           | -0.616**        | 0.090                |
| Development period days        |                             | 1.000                     | -0.430*      | 0.464*                         | 0.383                     | 0.324                          | 0.350               | 0.506*          | 0.152           | -0.137          | 0.053                |
| Growth index                   |                             |                           | 1.000        | 0.315                          | 0.201                     | 0.230                          | 0.200               | -0.055          | 0.489*          | -0.142          | -0.060               |
| % Grain infestation (No.basis) |                             |                           |              | 1.000                          | 0.652**                   | 0.672**                        | 0.627**             | 0.554**         | 0.523*          | -0.354          | -0.166               |
| % Damage of grain (Wt.basis)   |                             |                           |              |                                | 1.000                     | 0.686**                        | 0.364               | 0.548**         | 0.280           | -0.470*         | -0.229               |
| % Grain weight loss (Wt.basis) |                             |                           |              |                                |                           | 1.000                          | 0.538**             | 0.519*          | 0.586**         | -0.427*         | 0.205                |
| Protein Content (%)            |                             |                           |              |                                |                           |                                | 1.000               | 0.220           | 0.703**         | -0.134          | -0.018               |
| Carbohydrate content (%)       |                             |                           |              |                                |                           |                                |                     | 1.000           | -0.024          | -0.275          | -0.122               |
| Fat content (%)                |                             |                           |              |                                |                           |                                |                     |                 | 1.000           | -0.310          | 0.134                |
| Ash content (%)                |                             |                           |              |                                |                           |                                |                     |                 |                 | 1.000           | 0.046                |
| Moisture content (%)           |                             |                           |              |                                |                           |                                |                     |                 |                 |                 | 1.000                |

\* Significant at 5%=0.396 and \*\* Significant at 1%=0.505

## 5. SUMMARY AND CONCLUSIONS

### 5.1 Summary

The pulse beetle, *Callosobruchus maculatus* (Fabricius) is an important limiting factor in the storage of pigeonpea. The present study was carried out to evaluate susceptibility of different pigeonpea genotypes to pulse beetle under “Free choice” and “No choice” test and to study the physical characters and biochemical constituents imparting resistance/susceptibility in certain pigeonpea genotypes under ambient conditions. The salient features of the present studies are summarized in this chapter.

#### 5.1.1 Effect of seed characters of pigeonpea genotypes imparting resistance to pulse beetle

Seed colour and seed size of different genotypes of pigeonpea was grouped into three categories i.e. red, light brown and white colour having small, medium and bold size seeds by visual observations, respectively. The less seed volume was observed in ICPL-88039 (82.1 seeds/10 cc) and it was at par with ICPL-87119 (84.3), PT-00-12 (84.4) and BSMR-736 (85.7) and maximum seed volume recorded in PT-01-24-1-1 (116.0). The hundred grain weight ranged from 9.25 g in ICPL-87 to 11.29 g in PKV-TARA. ICPL-87 recorded less seed hardness (8.80 kg/grain) which was significantly at par with ICPL-98008 (9.00) and PT-01-24-1-1 (10.61) and highest was observed in PKV-TARA (21.94 kg/grain).

## **5.1.2 Susceptibility of seeds of pigeonpea genotypes to pulse beetle under “Free choice” and “No choice” test**

### **5.1.2.1 Orientation of adults of pulse beetle to seeds of pigeonpea genotypes under “Free choice” test**

The number of adults oriented in pigeonpea genotypes recorded in the range from 1.00 in BSMR-853 to 9.00 in PT-04-12-1-1 and ICPL-87. The results indicated that the seed characters i.e. seed colour and seed size are responsible for the orientation of adults in different pigeonpea genotypes.

### **5.1.2.2 Susceptibility of pigeonpea genotypes to pulse beetle in “No choice” test**

#### **a. Biological parameters of pulse beetle**

All genotypes were preferred by pulse beetle for oviposition. Out of 25 genotypes, maximum number of eggs were laid on ICPL-87 and PT-417-7-1-14 (14.00 eggs/10 seeds) and minimum on PKV-TARA and BSMR-736 (10.25 eggs).

The incubation period of different genotypes of pigeonpea was recorded in between 3.00 and 5.00 days. While the hatching percentage of different genotypes was observed above 90 per cent. Whereas, the total larval pupal period ranged from 18.25 to 20.50 days. There was no any relationship was noticed with oviposition period, incubation period, hatching percentage and larval-pupal period with seed characters such as seed colour and seed size.

All genotypes showed wide range of adult emergence. The per cent adults emerged was found to be less in PKV-TARA (71.01 %) which was at par with Vipula (72.66%), ICPL-332 (74.91%), BSMR-736 (78.14%), PT-04-257 (78.65%) and

ICPL-88039 (79.09%), while highest adult emergence was recorded in PT-00-12-1-1 (91.38 %) followed by BDN-2001-6 (90.68%).

The adult longevity recorded was less in PKV-TARA and Vipula (7.00 days) and highest adult longevity (12.25 days) was observed in BSMR-853.

There were little differences in the total number of days required for the growth and development of the beetles from different genotypes. The genotype Vipula showed less average development period (26.00 days) which was closely related with PKV-TARA (26.25 days). BSMR-853 showed highest average developmental period (31.75 days).

The observations on growth indices revealed that the genotype which was more susceptible had higher growth indices as compared to the less susceptible types indicating that the susceptible genotype were more nutritious to pulse beetle, *C. maculatus*.

#### **b. Grain infestation caused by pulse beetle**

The per cent grain infestation (number and weight basis) and per cent loss in grain weight was varied in the genotypes tested. The genotype PKV-TARA showed resistance against pulse beetle infestation of 2.08 per cent followed by BSMR-736 (5.77%) and also having the least (76.86 %) per cent damage of grains on weight basis. The genotypes PT-00-12-1-1 and ICPL-87 was found to be most susceptible to bruchid infestation having 25.09 and 24.82 per cent grain infestation and 92.63 and 95.58 per cent damage in grains, respectively.

In case of per cent loss in grain weight, none of the genotype tested was found resistant to attack of pulse beetle, *C. maculatus*, although they differ widely in their susceptibility. The genotypes *viz.*, PKV-TARA, BSMR-736, Vipula, PT-03-142 were observed to be less susceptible recording 2.22, 2.55, 4.01 and 4.30 per cent loss in grain weight, respectively. The maximum per cent loss in grain weight was observed in PT-00-12-1-1 (22.81%) genotype followed by ICPL-87 (21.15 %).

### **5.1.3 Reaction of biochemical constituents of seeds of pigeonpea genotypes to pulse beetle**

The biochemical constituents such as protein, carbohydrate, fat and ash were varied in tested genotypes of pigeonpea.

The maximum protein content was found in ICPL-87 (20.18 %) followed by PT-00-5-7-4-1 (19.30%), while less protein content was observed in ICPL-98008 (17.32 %).

The carbohydrate content was found maximum in PT-2001-11-2 (69.49 %) followed by ICPL-87 (67.63%) and the less carbohydrate content was observed in PKV-TARA (57.63 %).

The highest fat content was found in PT-04-12-1-1 (1.40 %) and the less fat was observed in PKV-TARA (0.93 %).

In case of ash content, maximum ash content was recorded in Vipula (4.02 %) followed by PKV-TARA (3.80 %), whereas less ash content was recorded in PT-04-12-1-1 (2.58 %) followed by ICPL-332 (3.32%).

The moisture content in seeds ranged from 8.67 to 9.32 per cent in tested different pigeonpea genotypes.

## 5.2 Conclusions

The following conclusions are drawn on the basis of the results of the present investigations.

- Among all the genotypes of pigeonpea, PKV-TARA, Vipula and BSMR-736 were found most superior, which recorded less ovipositional preference, adult emergence, longevity, development period of adult and low growth index found to be resistant to pulse beetle, *Callosobruchus maculatus*. These genotypes also recorded less per cent grain infestation and per cent loss in grain weight.
- ICPL-87 which was red colour and small seeded genotype having less seed hardness was found to be most susceptible to attack of pulse beetle. While, BSMR-853 which was white in colour and small seeded genotype having lower adult emergence and adult longevity indicated moderate susceptibility to pulse beetle.
- Amongst the genotypes, PKV-TARA, Vipula, BSMR-736 and PKV-03-142 having higher ash content with lower content of protein, carbohydrate and fat in seeds was found to be less preferred by the pulse beetle with minimum grain infestation. ICLP-87 having highest carbohydrate and protein content among all the genotypes was found to be most susceptible to attack of pulse beetle.

## 6. LITERATURE CITED

- Adams, J. M. 1976. A guide to the objective and reliable estimation of food losses in a small scale farmer storage. *Tropical Stored Prod. Inform.*, 32:5-12.
- Agarwal, A., Lal, C. P. and Gupta, K. C. 1988. Natural products a protectants of pulses against pulse beetles. *Bull. Grain Tech.*, 26(2): 154-164.
- Ahmed, K., Khalique, F., Khan, I. A., Afzal, M. and Malik, B. A. 1993. Genetic differences for susceptibility of chickpea to bruchid beetle (*Callosobruchus chinensis*) attack. *Pakistan J. Sci. and Indust. Res.*, 36(2-3): 96-98.
- Amusa, O. D., Ogunkanmi, L. A., Adetunbi, J. A., Akinyosoye, S. T., Bolarinwa, K. A. and Ogundipe, O. T. 2014. Assessment of Bruchids (*Callosobruchus maculatus*) tolerance of some elite cowpea (*Vigna unguiculata*) varieties. *J. Agric. Sustain.*, 6(2) : 164-178.
- Anonymous, 2015 .[www.indistat.com](http://www.indistat.com).
- Ashfaque, M. S., Khalil, K. and Zeb, A. 2001. Oviposition and development of pulse beetle(*Callosobruchus maculatus*) on seed of chickpea varieties. M. Sc. (Hons.) thesis, submitted to Department of Plant Protection, NWFP Agriculture University, Peshawar, Pakistan. pp.135.
- Bhaduria, N. S. and Jakhmola, S. S. 2006. Effect of intensity of infestation caused by pulse beetle on extend of losses and seed germination in different pulses. *Indian J. Ent.*, 68(1): 92-97.
- Booker, R. H. 1967. Observation on three bruchid associated with cowpea in Nigeria. *J. Stored Produ. Res.*, 3(1):1-15.

- Chakraborty, S. and Mondal, P. 2016. Physio-chemical parameters of pulses affecting the the bruchid (*C. chinensis* Linn.) infestation. *Asian J. Sci. Tech.*, 7: 2554-2560.
- Chalam, G. V., Singh, A. and Johnson, E. D. 1967. Seed testing manual, J. M. H. Press Private Limited, Delhi-6. p-249.
- Chandel, B. S., Chauhan, A. K. S. and Bhadauria, M. 2012. Varietal resistance in pigeonpea genotypes against pulse beetle. *Indian J. Ent.*, 74(3): 295-302.
- Chandel, B. S. and Bhadauria, D. S. 2015. Assessment of resistance to the attack of pulse beetle, *Callosobruchus chinensis* (Fabricius) in chickpea genotypes on the basis of various physical parameters during storage. *J. Ent. Zool. Studies*, 3(2): 160-165.
- Chavan, P. D., Singh, Y. and Singh, S. O. 1997a. Growth and development of *Callosobruchus chinensis* on cowpea lines. *Indian J. Ent.*, 59(3): 304-310.
- Chavan, P. D., Singh, Y. and Singh, S. P. 1997b. Ovipositional preference of *Callosobruchus chinensis* for cowpea lines. *Indian J. Ent.*, 59(3): 295-303.
- Dabi, R. K., Gupta, H. C. and Sharma, S. K. 1979. Relative susceptibility of some cowpea varieties to pulse beetle, *C. maculatus*. *Indian J. Agric. Sci.*, 49(1): 48-50.
- Dasbak, M. A., Echezona, B. C., and Asiegbu, J. E. 2009. Pigeonpea grain physical characteristics and resistance to attack by the bruchid storage pest. *Internal. Agrophys.*, 23:19-26.
- Dharmasena, C. M. D. and Subhasinghe, S. M. C. 1986. Resistance of mung to (*vigna radiata*) to *Callosobruchus* spp. (Coleoptera : Bruchidae). *Trop. Agric.*, 142 : 1-6.

- Dharne, P. K., Salunke, G. N. and Ajri, D. S. 1984. Studies on susceptibility of pigeonpea (*Cajanus cajan* L.) varieties of pulse beetle, *Callosobruchus chinensis* L. *Bull. Grain Tech.*, 22(3): 262-264.
- Dwivedi, S. C. and Sharma, M. K. 1996. Extend of damage caused and host preference of *Callosobruchus maculatus* Linn. *India. Bioved.*, 4(2): 249-254.
- Garib, M. C. A. 2004. Susceptibility of some wheat grain varieties to *Sitotroga cerealella* (Olivier) infestation. *Egyptian J. Agric. Res.*, 82(4): 1573-1578.
- Gawade, A. A. 2010. Screening of cowpea germplasm and evaluation of seed protectants against pulse beetle [*Callosobruchus maculatus* (F.)] M.Sc. (Ag.) thesis submitted to Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra), India.
- Gill, H. S. and Ramzan, M. 1998. Development biology of *C. maculatus* (F.) on green gram in the Punjab. *J. Insect Sci.*, 11(2): 176-177.
- Girish, G. K., Singh, K. and Krishnamurthy, K. 1974. Studies on the oviposition development of *C. maculatus* on various stored pulses. *Bull. Grain Tech.*, 12(2): 113-116.
- Gokhale, V. G. 1973. Development compatibility of several pulses in the Bruchidae-I. Growth and development of *C. maculatus* F. on host seeds. *Bull. Grain Tech.*, 11(1): 28-31.
- Gomez, A. A. and Gomez, A. A. 1984. Statistical procedures for Agriculture Research, New York, Wiley. pp. 272-356.
- Gopaldaswamy, S. V. S., Ramana, M. V. and Radha K. Y. 2010. Screening of urdbean cultivars against *Callosobruchus chinensis*. *Indian J. Pl. Protect.* 38: 53-56.

- Gujar, G. T. and Yadav, T. D. 1978. Feeding of *C. maculatus* and *C. chinensis* in green gram. *Indian J. Ent.*, 40(2) :108-112.
- Gupta, G. K. 1985. Losses to stored grains by insects in Andaman. *Bull. Grain Tech.*, 21(1): 79-82.
- Gupta, D. S. and Mishra, R. C. 1970. Further studies on the relative resistance of some important varieties of Bengal gram, *C. arientinum* to pulse beetle, *C. chinensis* (L.). *Bull. Grain Tech.*, 8(1&2): 14-17.
- Howe, R. W., 1971. A parameter for expressing the suitability of an environment for insect development. *J. Stored Prod. Res.*, 7(1): 63-65.
- Jaggal, S., Naseer. M., Bajpai, G. C., Verma, S. K. and Joshi, R. 2012. Bioassay studies for bruchid (*Callosobruchus chinensis*) resistance in F<sub>7</sub> inter-specific generation of pigeonpea. *Indian J. Agric. Sci.*, 82(3): 288-290.
- Jha, A. N., Srivastava, C. and Mishra, S. K. 2008. Weight loss in cowpea cultivars to *Callosobruchus maculatus* in storage conditions. *Indian J. Ent.*, 70(2): 181-183.
- Karthikeyan, K. A. M., Vijaykumar, I., Suresh, P. and Janarthanan, S. 2008. Susceptibility of genetically improved varieties of Indian pulses to the pulse beetle, *Callosobruchus maculatus* (Fabricus). *Indian J. Ent.*, 70(1):64-67.
- Khairnar, G. P., Adsule, V. M. and Thakur, S. G. 1996. Studies on quantitative and qualitative losses caused by *Callosobruchus chinensis* L. in pigeonpea. *Seed Res.*, 24 (1): 42-44.

- Khattak, S. U. Alam. M., Khalil, S. K. and Hussain, N. 1991. Response of chickpea cultivars to the infestation of pulse beetle, *Callosobruchus chinensis* (L.). *Pakistan J. Zool.*, 23 : 51-55.
- Khokhar, K. S. and Singh, D. 1987. Relative susceptibility of different genotypes of pigeonpea to pulse beetle, *Callosobruchus chinensis* (L.). *Bull. Grain Tech.* 25:244-251.
- Kitch, L. W. and Shade, R. E. 1993. Seed and pod resistance to *Callosobruchus maculatus* among various *vigna* species. *Insect Sci. and Applic.*, 14(3): 333-341.
- Kornerup, A. and Wanscher, J. H. 1978. *Methuen Handbook of Colour*. Eyre Methuen Ltd., pp.252.
- Lawn, R. J. and Troedson, R. J. 1990. Pigeonpea: Physiology of yield formation, Y. L. Hall, *The pigeonpea CAB International, Wallingford, UK*. P. 179-209.
- Manohar, S. S. and Yadava, S. R. S. 1990. Varietal susceptibility of cowpea varieties against *Callosobruchus maculatus*. *Indian J. Ent.*, 52: 180-183.
- Mensah, G. W. K., 1986. Infestation potential of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) on cowpea stored under subtropical conditions. *Insect Sci. Appl.*, 7(6): 181-184.
- Mukherjee, P. B., Jotwani, M. G., Yadav, T. D. and Sircar, P. 1970. Studies on incidence and extend of damage due to insect pests in stored seeds II. Leguminous and Vegetable Seeds. *Indian J. Ent.*, 32(4): 350-355.
- Nagaraja, M. 2006. Studies on evaluation of pigeonpea and cowpea genotypes for bruchid resistance (Bruchidae). M.Sc. (Agri.) thesis submitted to University of Agrcicultural Sciences, Dharwad, Karnataka, India.

- Nwanze, K. F., Horber, E. and Pitts, C. W. P. 1975. Evidence of ovipositional preference of *Callosobruchus maculatus* for cowpea varieties. *Environ. Ent.*, 4:409-412.
- Obopile Motshwari, Masiapeto Keamogetse and Gwafila Chiyapo 2011. Variation in reproductive and developmental parameters of *Callosobruchus maculatus* (F.) reared on ten Botswana cowpea landraces. *African J. Biotech.*, 10(63): 13924-13928.
- Patel, V. K., Chaudhuri, N. and Senapati, S. K. 2005. Biology of pulse beetle (*Callosobruchus chinensis* Linn.) as influenced by feeding of different grain pulses. *Agric. Sci. Digest*, 25(4): 254-256.
- Patnaik, H. P. and Samalo, A. P. 1987. Studied on the susceptiblility of pigeonpea varieties to the pulse beetle, *Callosobruchus maculatus* Fabr. *Bull. Grain Tech.*, 25: 191-193.
- Radha, R. and Susheela, P. 2014. Studies on the life history and ovipositional preference of *Callosobruchus maculatus* Reared on different Pulses. *Res. J. Animal, Veterinary and Fishery Sci.*, 2(6): 1-5
- Raina, A. K. 1970. *Callosobruchus chinensis* infesting stored pulses (grain legumes) in India and a comparative study of their biology. *Indian J. Ent.*, 32:303-310.
- Ramanamurthy, E. V. 1981. Efeect of physical chemical characters of certain pulse varieties on development of pulse beetle, *Callosobruchus chinensis* L. MSc. (Ag). thesis submitted to Andhra Pradesh Univ., Hydrabad.
- Rangaswamy, R. 2007. *A text book of Agriculture Statistics*. pp. 151-155.

- Rawat, S. and Srivastava, M. 2011. Evaluation of qualitative and quantitative losses caused by *Callosobruchus chinensis* to some pulses. *J. Ent. Res.*, 35(1): 117-120.
- Redden, R. J. and McGuire, J. 1983. The genetic evaluation of bruchid resistance in seed of cowpea (*Callosobruchus maculatus*, storage pest, Nigeria). *Australian J. Agric. Res.*, 34(6): 707-715.
- Regupathy, A. and Ratnaswamy, R. 1970. Studies of comparative susceptibility of seeds of certain red gram, *Cajanus cajan* L. *Madras Agric. J.*, 57(2):106-109.
- Rosemond, T. and Khan, A. 2013, Resistance of selected pigeonpea, *Cajanus cajan* (L.) Millsp. cultivars to *Callosobruchus maculatus* Fab. (Coleoptera : Bruchidae). *Legume Res.*, 36(6): 563-568.
- Sandhya Rani ,C. H. 1998. Reaction of chickpea varieties to pulse beetle, *Callosobruchus chinensis* L. and its control with vegetable oils. MSc. (Ag) thesis submitted to Acharya N. G. Ranga Agric. Univ., Hyderabad, India.
- Sano, I. 1967 Density effect and environmental temperature as the factor producing the active form of *C. maculatus*. *J. Stored Product Res.*, 2(3): 187-195.
- Sarwar, M. 2012. Assessment of resistance to the attack of bean beetle, *Callosobruchus maculatus* (Fabricus) in chickpea genotypes on the basis of various parameters during storage. *Songklanakarin J. Sci. Tech.*, 34(3):287-291.
- Satyavir. 1981. Note on relative susceptibility of different varieties of cowpea to *Callosobruchus maculatus* Fabricus. *Indian J. Agric. Sci.*, 51(11): 813-815.

- Semple, R. L. 1992. Studied host plant and varietal resistance to post-harvest insect attack. *In: Towards Integrated Commodity and Pests Management in Grain Storage* (Eds., R. L. Semple, P.A. Hicks, J. V. Lozare, and A. Casterman). REGNET and NAPHIRE Press, Manilla, Philippines.
- Shams Fawki, Amany S. Khaled, Hoda M. Abdel Fattah, Mohamed A. Hussein, Mona I. Mohammed and Dalia A.M.Salem, 2012. Physical and biochemical basis of resistance in some cowpea varieties against *C. maculatus* (F.) *Egyptian J. Pure and Applied Sci.* Page: 51-56.
- Shivanna, B. K., Ramamurthy, B. N., Gangadhara Naik, B., Gayathri Devi, S., Mallikarjunaiah, H. and Krishna Naik, R., 2011a. Varietal screening of cowpea against pulse beetles, *Callosobruchus maculatus* (Fab.) and *Callosobruchus analis* (Fab.) *Internal. J. Sci. and Nature*, 2(2):245-247.
- Shivanna, B. K., Ramamurthy, B. N., Gangadhara Naik, B., Gayathri Devi, S., Mallikarjunaiah, H. and Krishna Naik, R., 2011b. Host preference of pulse beetles, *Callosobruchus maculatus* (F.) and *Callosobruchus analis* (F.) on selected pulses. *Internal. J. Sci. and Nature*, 2(2):228-240.
- Singal, S. K. and Borah, R. K. 2001. Biology of pulse beetle, *Callosobruchus chinensis* (L.) on pods of *Cajanus cajan* Millsp. *Ann. Agric. Biol. Res.*, 6(1): 35-37.
- Singh, Y.1976. Studies on relative resistance of important pulses to *C. maculatus* and *C. chinensis*. *Entomologists Newsl.*, 6(2):18-19.

- Singh, S. and Sharma, G. 2001. Preference of pulse beetle to some cowpea varieties. *Indian J. Ent.*, 2: 273-276.
- Singh, V. N., Pande, N. D. and Singh, V. P. 1995. Studied relative resistance of gram varieties to *C. chinensis* on the basis of biochemical parameters. *Indian J. Ent.*, 57(2) : 77 - 82.
- Singal, S. K. 1998. Biology of pulse beetle, *Callosobruchus chinensis* (L.) on cowpea under field and laboratory conditions. *J. Insect Sci.*, 11(2): 130-132.
- Snedecor, G.W. and Cochran, W. G. 1967. Statistical methods, Oxford and IBH Publishing Company, Calcutta. p.575.
- Soumia, P. S., Srivastava, C. and Dikshit, H. K. 2015. Screening for resistance against pulse beetle, *Callosobruchus analis* (F.) in greengram (*Vigna radiate* (L.) Wilczek) accessions. *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.* DOI 10.1007/s40011-015-0635-5.
- Strong, R. G., Partida, G. J. and Warner, D. N. 1968. Rearing stored product insects for laboratory studies. *J. Econ. Ent.*, 69(4): 369-372.
- Suleherie, M. A. Q., Golob. P., Tran, B. M. D., and Farrel, G., 2003. The effects of attributes of *Vigna* spp. on the bionomics of *Callosobruchus maculatus*. *Entomologia Experimentalis et Applicata*, 106(3): 159-168.
- Swella, G. B. and Mushobozy, D. M. K. 2009. Comparative susceptibility of different legumes seeds to infestation by cowpea bruchid, *Callosobruchus maculatus* (F.) (Coleoptera : Chrysomelidae). *Pl. Protec. Sci.*, 45(1):19-24.

- Tabu, R., Ezueh, M.I., Ajaji, O., Asiegbu, J. E. and Lakman Singh. 1995. Pigeonpea production and utilization Nigeria. *ICPN*, 2:47-49.
- Teotia, T. P. S. and Singh, V. S. 1966. The effect of host species on the oviposition, fecundity and development of *C. maculatus*. *Bull. Grain Tech.*, 4(1): 3-10.
- Thanthianga, C. and Mitchell, R. 1990. The fecundity and ovipositional behaviour of a South Indian strain of *Callosobruchus maculatus*. *Entomologia-Experimentalis - et-Applicata*, 57(2): 133-142.
- Umrao, R. S. and Verma, R. A. 2002. Studies on correlation of physical factors and grain losses with infestation of the *Callosobruchus chinensis* on pea varieties. *Indian J. Ent.*, 64(3): 283-287.
- Venugopal, K. J., Janarthanan, S. and Ignacimuthu, S. 2000. Resistance of legume seeds to the bruchid, *Callosobruchus maculatus* : metabolites relationship. *Indian J. Exper. Biol.*, 38: 471-476.
- Vimla, V., and Pushpamma, P. 1983. Storage quality of pulses stored in three agroclimatic regions of Andhra Pradesh. I. Qualitative changes. *Bull. Grain Tech.*, 21(1): 54-62.
- Vishwamithra, V. Reddy, K. and Vijayalakshmi, K. 2015. Morphological and chemical parameters associated with resistance to *Callosobruchus chinensis* in pigeonpea. *Indian J. Pl. Protec.*, 43 (1): 34-39.
- Wadnerkar, D. N., Kaunsale, P. P and Pawar, V. M. 1978. Studies on preference of pulse beetle, *C. maculatus* F. to some varieties of arhar and gram. *Bull. Grain Tech.*, 16(2): 122-124.

- Wajenayake, D. U. S. and Karunaratne, M. M. S. C. 1999. Ovipositional preference and development of the cowpea beetle, *Callosobruchus chinensis* on different stored pulses. *Vidyodaya J. Sci.*, 8(1): 135-147.
- Yadav, T. D. and Pant, N. C. 1978. Developmental response of *C. maculatus* and *C. chinensis* on different pulses. *Indian J. Ent.*, 40(1): 7-15.

## 7. VITA

---

**Miss. HOLAY PRIYANKA PANDHARINATH**

A candidate for the degree

of

**MASTER OF SCIENCE (AGRICULTURE)**

in

**AGRICULTURAL ENTOMOLOGY**

**2016**

---

|                        |  |
|------------------------|--|
| <b>Title of Thesis</b> | “Relative susceptibility of pigeonpea genotypes to pulse beetle in storage”  |
| <b>Major field</b>     | Agricultural Entomology  |
| <b>Personal</b>        | Born at Loni-Masadpur, Tal. Karjat, Dist. Karjat on 31 <sup>st</sup> August, 1992.<br>Daughter of Mrs. Vimal and Mr. Pandharinath Damodhar Holay.  |
| <b>Educational</b>     | Passed S.S.C. examination from Sau. S. N. Sonmali, Kanya Vidya Mandir, Karjat.<br><br>Passed H.S.C. examination from Mahatma Ganghi Junior College, Karjat.<br><br>Passed B. Sc. (Agri.) degree from College of Agriculture, Kolhapur. Under MPKV, Rahuri. |
| <b>Others</b>          | Participated in N.S.S. during 2011-12.   |
| <b>Address</b>         | A/P.-Karjat, Tal. Karjat, Dist. Ahmednagar.<br>Email: <a href="mailto:Priyankaholay92@gmail.com">Priyankaholay92@gmail.com</a>   |