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RESEARCH ARTICLE :

# Role of morphological characters offering resistance/ susceptibility of pigeonpea genotypes to pod borer complex

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**SUMMARY :** Investigation on "Studies on morphological and biochemical basis of resistance against pod borer complex in pigeonpea (*Cajanus cajan* L.)" was conducted, at the Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Kharif - Rabi* 2012-13 and 2013-14, respectively.In the genotype screening against pod borer complex *viz. M. vitrata*, *H. armigera* and *M. obtusa,* it was found that the germplasm ICP 6996 showed minimum larval population, minimum pod damage, minimum grain damage, least pest susceptibility rating and gave maximum yield. The second least susceptible germplasm was ICP 7374, followed by ICP 7005, ICP 7406, ICP 7392, ICP 7404, ICP 7003, ICP 6994, ICP 7405, ICP 6999, ICP 7373, ICP 7391, ICP 7387, ICP 7393, Rajeevlochan, ICP 7398, ICP 7004, ICPL 87119, ICP 7379 and ICP 7409. Among the morphological parameters, it was observed that the pod wall thickness (r = -0.96**), calyx trichome's length(r = -0.65**), pod trichomes length(r = -0.90**), calyx trichome's density (r = -0.94**), pod trichomes density (r = -0.94**) and seed yield (r = -0.83**) showed highly significant negative correlation with per cent pod damage by pod borer complex.

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## BACKGROUND AND OBJECTIVES

Pigeonpea, *Cajanus cajan* (L.) Millsp is one of the most important legume crop of India. It belong to the genus *Cajanus* of family Fabaceae and it is commonly known as red gram, tur, arhar. It is an important legume food crop of the semi-arid tropical and sub-tropical farming systems under varied agro-ecological environments. Pigeonpea is the second most important pulse crop of India after chickpea. India is the largest producer and also the largest consumer of pulses in the world. It accounts for 33 per cent of the world areas and 25 per cent share in global production (Srivastava *et al*., 2010). Globally, the area and production of pigeonpea has increased from 4.43 million hectares (mha) and 3.16 million tonnes (mt) in 2002 to 5.32 mha and 4.32 mt in 2012, respectively (FAOSTAT

2012). India is largest producer of pigeonpea, contributing more than 90 per cent of the worlds production, the productivity has always been a concern. Pigeonpea yields have remained stagnant for the past 3 to 4 decades largely due to damage inflicted by insect pests (Sharma *et al*., 2010 and Basandrai *et al*., 2011).

Since pigeonpea growers have to spend much on input like pesticides, it was considered viable to search the available germplasm for sources of resistance against pod borer complex to be used in breeding. Screening of more than 14,000 pigeonpea accessions for resistance to *H. armigera* has revealed low to moderate levels of resistance to this pest (Reed and Lateef, 1990). ICRISAT identified 11 germplasm (ICP 7, ICP 655, ICP 772, ICP 1071, ICP 3046, ICP 4575, ICP 6128, ICP 8860, ICP 12142, ICP 14471 and ICP 14701) reported moderately resistant to pod borer (damage rating 5 as compared to 9 in ICPL 87) under unprotected conditions (Anonymous, 2010). Several plant characters offer resistance to the pod borers. However, data on the role of plant characters that provides resistance to *M. vitrata* are inconclusive. Management of pigeonpea pests is complicated as the crop is affected by three group of insects with different biology and variable population dynamics throughout the year across wider geographical areas. So there is need to study their effect on this species Tayo (1988).

Several numbers of insect pests were reported to attack this crop among which the pod borer complex including *H. armigera*, *E. atomosa* and *M. obtusa* cause considerable losses in grain yield ranging from 30 to 100% by attacking the reproductive parts of the plant. The loss due to *H. armigera* alone contributes upto 50% in pigeonpea crop (Thakare, 2001).Thus, the present investigation is an effort in this direction to facilitate the development of resistant cultivars, understanding the underlining mechanism of resistance against pod borer complex to avoid direct loss in grain yield.

## RESOURCES AND METHODS

### Observations recorded :

*Plant height (cm) :*

Plant height was measured in centimeter, from the base to tip of the plant at maturity and correlated with the per cent pod damage.

*Growth habit :*

Growth habit of the tested pigeonpea genotypes ***i.e.*** determinate or indeterminate type was recorded and correlated with the per cent pod damage.

*Pod wall thickness :*

Hand cut cross sections of pods of twenty germplasm of pigeonpea germplasm were taken and the thickness of the outer peel portion of four sections of 5 pods from each entry was measured with the help of Vernier Calipers. The thickness was measured in millimeter and correlated with the per cent pod damage.

*Trichomes length and density :*

For measuring the trichomes length and density of twenty pigeonpea genotypes, uniformly developed flower calyx and pods were selected from three replications of twenty pigeonpea genotypes and for each replication five flower calyx and pods were selected and trichomes density and length were measured in accordance with Jackai and Oghiakhe (1989).

For measuring the trichomes density, the pod walls were cut into bits of 9 $mm^2$ (3 x 3) and number of trichomes present on the epidermis of the bits (flower calyx and pods) were counted under a trinocular microscope (10x100x) and similarly trichomes length on flowers calyx was also measured with the aid of the above instrument. Trichomes length on pods was measured by gently pressing the sticky transparent tape to the pod surface and the trichomes adhered to the sticky surface were then fixed to a glass slide and trichomes length was measured under binocular microscope and correlated with the per cent pod damage.

*Pod length and breadth :*

The length and breadth of the pods of each genotype were observed with the help of graph paper. Three replications were maintained for each genotype and in each replication five pods were observed. It was measured in centimeter and correlated with the per cent pod damage.

*Podding habit :*

Podding habit of each genotype *i.e.* cluster or non cluster type was observed in each genotype and correlated with the per cent pod damage.

*Days of maturity :*

Days of maturity were observed in term of day from the sowing to 50% pod cracking in each line and correlated with the per cent pod damage.

*Flower colour :*

Colours of flowers *i.e.* yellow and yellow with red lines of tested genotypes from various groups were recorded by visual observations at the time of blooming period and correlation with the per cent pod damage.

*Seed yield per plot (kg) :*

Weight of healthy seeds per plot was recorded in kilograms with the help of an Electronic balance and correlated with the per cent pod damage.

The degrees of associations among the different characters were calculated by the correlated on the basis of following formula:

$$r = \frac{\sum XY - n\bar{x}\bar{y}}{\sqrt{\sum X^2 - n\bar{X}^2} \times \sqrt{\sum Y^2 - n\bar{Y}^2}}$$

where,

X = Mean of first factor

Y= Mean of second factor

n = Total number of observations

r = Correlation co-efficient

After correlating significant and non-significant findings, t-test value n-2 degrees of freedom were calculated on the following formula:

$$t = \frac{r\sqrt{n - 2}}{\sqrt{1 - r^2}} \quad \sim t \quad \text{with} \quad (N - 2)\text{d.f}$$

## OBSERVATIONS AND ANALYSIS

On the basis of field screening of twenty pigeonpea genotypes against pod borer complex *viz. Maruca vitrata*, *Helicoverpa armigera* and *Melanagromyza obtusa* infestation, it was observed that the genotype ICP 6996 showed minimum larval population, minimum pod damage and least pest susceptibility rating followed by ICP 7374. These twenty genotypes were further analysed to look out for the resistance mechanism involved. Under these, various morphological parameters *viz.* plant height, growth habit, pod wall thickness, trichomes length and density, pod length and breadth, podding habit, days to maturity, flower color and seed yield (Table 1 and 2) were selected and correlated with percentage pod damage due to pod borer complex (Table 3).

**Plant height :**

Study of plant height (two year mean) indicated that mean plant height (Table 1) showed significant differences among the tested genotype which varied from 138.10 cm (ICP 7405) to 179.10 cm (Rajeevlochan) but there was no significant role of plant height for preference and non preference of pod borers as the correlation of plant height with pod borer complex *viz. Maruca vitrata*, *Helicoverpa armigera* and *Melanagromyza obtusa* infestation was found non-significant (Table 3).

**Growth habit :**

Study of growth habit indicated that there was no difference among the tested genotypes all the genotypes showed non-determinate type of growth habit (Table 1). Thus, growth habit did not offer resistance/susceptibility of tested pigeonpea genotypes against pod borer complex.

**Flower colour :**

Flower colour of pigeonpea genotypes was observed by visual observation. They were grouped in to two *i.e.* yellow and yellow with red lines (Table 1). Out of the twenty genotypes sixteen had yellow colour and rest four genotypes *viz.*, ICP 6994, ICP 6999, ICP 7409 and Rajeevlochan had yellow flowers with red lines. These pigeonpea genotypes were susceptible to pod borer complex.

**Podding habit :**

Podding habit of pigeonpea genotypes was observed to be non-significant difference among the tested genotypes. All the genotypes had cluster type of podding habit (Table 1). Thus, podding habit did not play any role in the tested pigeonpea genotypes against pod borer complex infestation and making the plant resistance or susceptible.

**Pod length :**

Study of pod length (two year mean) indicated that mean pod length (Table 1) showed non-significant differences among the tested genotype which varied from 4.7 cm (ICP 7398) to 5.6 cm (ICP 6996, ICP7393, ICP 7409). Pod length of tested genotypes showed no significant role for preference and non preference to pod borers as the correlation of pod length with pod borer complex *viz. M. vitrata*, *H. armigera* and *M. obtusa* infestation was found to be positively non-significant. (Table 3).

**Pod breadth :**

The pod breadth (two year mean) indicated that mean pod breadth (Table 1) also showed non significant difference among the tested genotype which varied from 7.3 mm (ICP 7004) to 8.1 mm (ICP 7387, ICP7392). Pod breadth of tested genotypes did not play any role for offering resistance or susceptibility as the correlation of pod breadth with pod borer complex *viz.M. vitrata*, *H.armigera* and *M. obtusa* infestation was found to be negatively non significant,(Table 3).

**Pod wall thickness :**

On the basis of data recorded pod wall thickness (two year mean) showed non significant difference among the tested genotype varying from 0.58 mm to 0.72 mm. Maximum pod wall thickness was recorded in resistant genotype ICP6996 (0.72 mm) and lowest was observed in the susceptible genotype ICP 7409 (0.58 mm) with the per cent pod damage by pod borer complex 12.66 to 22.43 per cent, respectively. The correlation studies showed highly significant negative correlation between pod wall thickness and per cent pod damage by pod borer complex with a correlation value (r) of - 0.96** (Table 3). These findings justifies that the increase in pod wall thickness is not favorable for the pod borers and the pod infestation decreased with increase in pod wall thickness. Thus, the pod wall thickness played an important role in tested pigeonpea genotypes against pod borer complex infestation and making the plant resistance.

**Trichome density :**

The trichome density was observed on flower calyx and surface of the pod and the results are presented in (Table 2)

The glandular trichomes density of calyx (two year mean) showed non significant differences among the tested genotypes which varied from 1.10 to 3.03 trichomes per sq millimeter (Table 2). The maximum density was recorded in resistance genotype ICP 6996 (3.03 trichomes per sq millimeter) and lowest was observed in susceptible ICP 7409 (1.01 trichomes per sq

**Table 1: Morphological characters of pigeonpea genotypes (Mean of *Kharif*, 2012-13 and 2013-14)**

| Genotypes | Plant height (cm) | Growth habit | Flower colour | Podding habit | Pod length (cm) | Pod breadth (mm) | Pod wall thickness (mm) | Days to maturity (Days) | Seed yield (Kg/ 9.6m$^2$) |
|---|---|---|---|---|---|---|---|---|---|
| ICPL 87119 | 164.30 | Non determinate | Yellow | Cluster | 5.3 | 7.5 | 0.59 | 193.70 | 1.100 |
| Rajeevlochan | 179.10 | Non determinate | Yellow with red lines | Cluster | 4.9 | 7.8 | 0.62 | 191.60 | 0.800 |
| ICP 6994 | 152.70 | Non determinate | Yellow with red lines | Cluster | 5.5 | 7.6 | 0.65 | 187.70 | 0.900 |
| ICP 6996 | 172.20 | Non determinate | Yellow | Cluster | 5.6 | 8.0 | 0.72 | 190.70 | 1.200 |
| ICP 6999 | 151.50 | Non determinate | Yellow with red lines | Cluster | 5.4 | 7.4 | 0.64 | 186.70 | 0.800 |
| ICP 7003 | 156.10 | Non determinate | Yellow | Cluster | 5.3 | 7.8 | 0.65 | 186.90 | 0.900 |
| ICP 7004 | 147.90 | Non determinate | Yellow | Cluster | 5.3 | 7.3 | 0.60 | 184.70 | 0.700 |
| ICP 7005 | 148.20 | Non determinate | Yellow | Cluster | 4.8 | 7.4 | 0.70 | 184.80 | 1.000 |
| ICP 7373 | 176.60 | Non determinate | Yellow | Cluster | 5.4 | 7.5 | 0.64 | 192.90 | 0.800 |
| ICP 7374 | 170.90 | Non determinate | Yellow | Cluster | 5.1 | 7.6 | 0.71 | 182.80 | 1.100 |
| ICP 7379 | 159.50 | Non determinate | Yellow | Cluster | 5.4 | 7.4 | 0.59 | 190.70 | 0.600 |
| ICP 7387 | 164.60 | Non determinate | Yellow | Cluster | 5.1 | 8.1 | 0.64 | 191.70 | 0.800 |
| ICP 7391 | 144.30 | Non determinate | Yellow | Cluster | 5.1 | 7.4 | 0.64 | 191.70 | 0.800 |
| ICP 7392 | 147.30 | Non determinate | Yellow | Cluster | 5.4 | 8.1 | 0.67 | 186.80 | 1.000 |
| ICP7393 | 168.10 | Non determinate | Yellow | Cluster | 5.6 | 7.9 | 0.64 | 196.70 | 0.800 |
| ICP 7398 | 170.70 | Non determinate | Yellow | Cluster | 4.7 | 7.4 | 0.61 | 196.70 | 0.700 |
| ICP 7404 | 173.10 | Non determinate | Yellow | Cluster | 5.6 | 7.8 | 0.65 | 194.70 | 0.900 |
| ICP 7405 | 138.10 | Non determinate | Yellow | Cluster | 5.2 | 7.5 | 0.65 | 186.70 | 0.900 |
| ICP 7406 | 160.50 | Non determinate | Yellow | Cluster | 5.2 | 7.5 | 0.69 | 184.70 | 1.000 |
| ICP 7409 | 154.90 | Non determinate | Yellow with red lines | Cluster | 5.6 | 7.6 | 0.58 | 184.70 | 0.600 |
| C.D. (P=0.05) | 17.20 | - | - | - | NS | NS | NS | NS | NS |

NS=Non-significant

millimeter) with the per cent pod damage by pod borer complex 12.66 to 22.43 per cent, respectively. The correlation studies exhibited highly significant negative correlation between calyx glandular trichomes density and per cent pod damage by pod borer complex with a correlation value (r) of -0.94** (Table 3). The findings revealed that the increasing in the calyx glandular trichome density is not favorable for pod borers for damage and the pod infestation decreased with increase in the calyx glandular trichomes density. Thus, calyx glandular trichomes density played important role in the tested pigeonpea genotypes against pod borer complex infestation offering plant resistance. Trichome density on green pods was maximum in HDM 04-1 (35.39/mm$^2$) and minimum in Pusa-992 (21.85/mm$^2$); trichome length was maximum in HDM 04-1 (0.63 mm) and minimum in Pusa 992 (0.53 mm) (Yadav and Rohillar, 2010).

The study on pod glandular trichome density(two year mean)showed non significantly difference among the tested genotype which varied from 2.60 to 4.57 trichomes per sq millimeter (Table 2). The maximum density was recorded in resistance genotype ICP 6996 (4.57 trichomes per sq millimeter.) and lowest was observed in susceptible ICP 7409 (2.60 trichomes per sq millimeter) with the per cent pod damage by pod borer complex 12.66 to 22.43 per cent, respectively. The correlation studies showed highly significant negative correlation between Pod glandular trichomes density and per cent pod damage by pod borer complex with correlation value (r) of -0.94** (Table 3). The findings revealed that the increase in pod glandular trichome density is not favorable for the pod borer to damage the pods and the infestation decreased with increase in pod glandular trichome density. Thus, pod glandular trichome density played an important role in the tested pigeonpea genotypes against pod borer complex infestation making the plant resistant.

## Trichome length :

The trichome length was observed on flower calyx and surface of the pod and the results are presented in (Table 2).

The length of the trichomes on flower calyx (two year mean) indicated that mean flower calyx glandular trichomes length (Table 2) showed significantly difference among the tested genotype which varied from 1.08 mm to 1.19 mm. The results revealed highest flower calyx glandular trichomes length on ICP 6996 (1.19 mrn). Lowest flower calyx glandular trichomes length was recorded on ICP 7409 (1.08 mm). Length of calyx glandular trichomes tested genotypes was observed to play an important role for offering resistance as the correlation of calyx glandular trichomes length with pod borer complex *viz. M. vitrata*, *H. armigera* and *M. obtusa* infestation was found to be highly significant negatively with a correlation value (r) of -0.65** (Table 3). Thus, it is clear from the above studies that as the calyx glandular trichome length decreases the level of infestation due to pod borer complex. The present findings are in agreement with Jackai and Oghiakhe (1989) who also demonstrated the trichomes and phyto chemicals were responsible for resistance in wild cowpea TVNU-72 and TVNU-73.

Length of the trichomes on pod (two year mean) indicated that mean calyx glandular trichome length (Table 2) showed significant differences among the tested

**Table 2 : Trichome length and density on flower calyx and pod of pigeonpea genotypes (Mean of year *Kharif*, 2012-13 and 2013-14)**

| Genotypes | Glandular trichomes density (No. of trichomes/mm$^2$) | | Glandular trichomes length (mm) | |
|---|---|---|---|---|
| | Flower calyx | Pod | Flower calyx | Pod |
| ICPL 87119 | 1.33 | 2.83 | 1.09 | 3.09 |
| Rajeevlochan | 1.53 | 3.03 | 1.09 | 3.10 |
| ICP 6994 | 1.70 | 3.20 | 1.10 | 3.13 |
| ICP 6996 | 3.03 | 4.53 | 1.19 | 3.37 |
| ICP 6999 | 1.64 | 3.14 | 1.16 | 3.13 |
| ICP 7003 | 1.70 | 3.20 | 1.11 | 3.15 |
| ICP 7004 | 1.40 | 2.90 | 1.16 | 3.10 |
| ICP 7005 | 2.33 | 3.83 | 1.15 | 3.19 |
| ICP 7373 | 1.60 | 3.10 | 1.10 | 3.13 |
| ICP 7374 | 2.80 | 4.30 | 1.11 | 3.33 |
| ICP 7379 | 1.24 | 2.74 | 1.13 | 3.07 |
| ICP 7387 | 1.60 | 3.10 | 1.12 | 3.11 |
| ICP 7391 | 1.60 | 3.10 | 1.11 | 3.11 |
| ICP 7392 | 1.80 | 3.30 | 1.13 | 3.17 |
| ICP7393 | 1.60 | 3.10 | 1.09 | 3.11 |
| ICP 7398 | 1.43 | 2.93 | 1.14 | 3.10 |
| ICP 7404 | 1.73 | 3.23 | 1.14 | 3.15 |
| ICP 7405 | 1.64 | 3.14 | 1.14 | 3.13 |
| ICP 7406 | 2.23 | 3.73 | 1.15 | 3.17 |
| ICP7409 | 1.10 | 2.60 | 1.08 | 3.07 |
| C.D. (P=0.05) | NS | NS | 0.06 | 0.07 |

NS=Non-significant

**Table 3: Correlation co-efficients between morphological characters of pigeonpea genotypes and percent pod damage by pod borer complex *viz.*, *Helicoverpa armigera*, *Marucavitrata* and *Melangromyza obtusa* (Mean of *Kharif*, 2012-13and 2013-14)**

| Sr. No. | Morphological characters | (%) Pod damage by | | | |
|---|---|---|---|---|---|
| | | *Marucavitrata* | *Helicoverpa armigera* | *Melangromyza obtusa* | Pod borer Complex |
| 1. | Plant height | -0.07 | -0.05 | -0.07 | -0.12 |
| 2. | Pod length | 0.29 | 0.29 | 0.32 | 0.33 |
| 3. | Pod breadth | -0.34 | -0.31 | -0.24 | -0.31 |
| 4. | Pod wall thickness | -0.97** | -0.96** | -0.97** | -0.96** |
| 5. | Days to maturity | 0.26 | 0.28 | 0.26 | 0.29 |
| 6. | Seed yield | -0.74** | -0.77** | -0.74** | -0.83** |
| 7. | Trichomes length of flower calyx | -0.63** | -0.73** | -0.63** | -0.65** |
| 8. | Trichomes length of pod | -0.84** | -0.85** | -0.84** | -0.90** |
| 9. | Trichomes density of flower calyx | -0.90** | -0.90** | -0.90** | -0.94** |
| 10. | Trichomes density of pod | -0.90** | -0.90** | -0.89** | -0.94** |

* indicates significant of value at P=0.05 and **indicates highly significant at P=0.01

genotypes which varied from 3.07 mm to 3.37 mm. The results revealed highest pod glandular trichome length on ICP 6996 (3.37 mrn) while lowest was recorded on ICP 7409 (3.07 mm). Pod glandular trichome length of tested genotypes was observed to play an important role for offering resistance as the correlation of pod glandular trichome length with pod borer complex *viz. M. vitrata*, *H. armigera* and *M. obtusa* infestation was found negatively highly significant with a correlation value (r) of -0.90** (Table 3), expressing that, as the calyx glandular trichome length increases the infestation of pod borer complex decreases.Sharma *et al*. (2009) The present findings are in concurrence with who also concluded that the glandular trichomes (type A) on the calyxes and pods were associated with susceptibility to *H. armigera*, while the non-glandular trichomes (trichome type C and D) were associated with resistance to this insect on twenty genotypes of pigeonpea, *Cajanus cajan* (L.) for field resistance against podfly, *Melanagromyza obtusa* (Malloch) and correlated with morphological plant characteristics. The lowest mean pod damage was recorded in HDM 04-1 (2.77%) whereas maximum was in Pusa 992 (15.16%) with a Pest Susceptibility Rating of 3 and 9, respectively.

### Days to maturity :

On the basis of data recorded days to maturity (two year mean) showed non significant differences among the tested genotype which varied from 182.80 days to 196.70 days (Table 1). Maximum days to maturity was recorded in the genotype ICP 7393 (196.70 days) and lowest in ICP 7374 (182.80 mm). Days to maturity of tested genotypes did not play any role for offering resistance or susceptibility as the correlation of days to maturity with pod borer complex *viz. M. vitrata*, *H. armigera* and *M. obtusa* infestation was found to be non significant and positively correlated (Table 3).

### Seed yield :

On the basis of data recorded seed yield (two year mean) showed non significant difference between the tested genotypes varying from 0.600 to 1.200kg/ 9.6 sq meter. The maximum seed yield was recorded in resistant genotype ICP 6996 (1.200kg/9.6 sq meter) and lowest was observed in susceptible ICP 7409 (0.600kg/ 9.6 sq meter) with the per cent pod damage by pod borer complex 12.66 to 22.43 per cent, respectively. The correlation studies exhibited highly significant negative correlation between seed yield and per cent pod damage by pod borer complex with a correlation value (r) of -0.83** (Table 3). These findings revealed that the increase in seed yield is not favorable for the pod borer and the pod infestation decreased with increase in seed yield. Thus, seed yield played an important role in the tested pigeonpea genotypes against pod borer complex infestation for building resistance in pigeonpea genotypes.

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