



## Identification of *Fusarium* wilt-resistant sources of long-duration pigeonpea (*Cajanus cajan*)

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### ABSTRACT

Present investigation was carried out during 2000–10 to identify and develop the wilt resistant donors of long duration pigeonpea [*Cajanus cajan* (L.) Millsp.]. Four long duration pigeonpea genotypes, viz IPA 16 F, IPA 8 F, IPA 9 F and IPA 12 F possessing acceptable yield levels were evaluated for their reaction to wilt disease in wilt sick plots continuously for three to five years at hot spots in north east plain zone, central zone and south zone of the country. All the four genotypes showed resistant to moderately resistant reaction to wilt over the years at all the hot spots. The consistency in the reaction (resistant to moderately resistant) to wilt disease indicated that genotypes IPA 16 F, IPA 8 F, IPA 9 F and IPA 12 F are very good source of resistance to all the five variants of *Fusarium udum* prevalent in India causing wilt and can be used as resistant donors in pigeonpea wilt resistance breeding programme.

**Key words:** *Cajanus cajan*, *Fusarium udum*, Resistant donor, Wilt

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the major grain legume (pulse) crops. Disease caused by the fungus *Fusarium udum* is the most devastating disease of pigeonpea in the tropics and sub-tropics and ranks second after chickpea in India. *Fusarium* wilt a soil borne.

Almost all pigeonpea growing states of India (Ahlawat *et al.* 2005) that affects the plant at all stages of development resulting in up to 100% yield loss (Reddy *et al.* 1990). The yield loss due to this disease also depends upon the stage at which the plants wilt and it can approach over 50% and even up to 100% when wilt occurs at the pre-pod stage ( Okiror 2002). Since satisfactory control measures for this disease have not been developed so far, development and adoption of resistant varieties is important for management of this disease. However, in long duration pigeonpea none of the varieties under cultivation is resistant to wilt disease. Therefore, it is the need of hour to develop and release wilt-resistant varieties of long duration pigeonpea through breeding programme in order to stabilize the pigeonpea production for which identification of reliable wilt resistant donors is important. Indian Institute of Pulses Research, Kanpur has

got the largest collection of long duration pigeonpea germplasm lines. Many of these collections are promising with regard to yield and other qualitative traits. Studies are underway to locate the sources of resistance to important diseases of pigeonpea with acceptable yield level from this collection through conventional approach. So the present study was taken up to exploit the high degree of variability present in long duration germplasm lines to locate the reliable sources of resistance to *Fusarium udum* through multilocal testing over the years.

### MATERIALS AND METHODS

Four long duration pigeonpea germplasm lines, viz IPA 16 F, IPA 8 F, IPA 9 F and IPA 12 F were selected on the basis of yield superiority over best check Bahar and resistance to *Fusarium* wilt at different locations of north east plains zone (NEPZ) during 2000–03. Keeping this performance in view, these germplasm lines were evaluated for resistance to wilt at locations of wilt hot spots of pigeonpea-growing areas, viz Dholi, Faizabad and Kanpur in north-east plains zone; Rahuri, Badnapur, Akola, Khargone and Sehore in central zone and ICRISAT, Bangalore and Gulbarga in south zone of the country. IPA 16 F and IPA 8 F were evaluated for three and five years during 2004–07 (at 1, 5 and 6 locations) and 2005–10 (at 4, 5, 3, 5 and 5 locations) respectively and IPA 9 F and IPA 12 F were evaluated for four years during 2006–10 at 9, 4, 5 and 7 locations and 8, 4, 4 and 5 locations, respectively.

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Randomized block design was used to evaluate these genotypes in wilt sick plot. Each of the four lines was evaluated in three replications each of five rows at all the locations. The row length was 5 m and row-to-row and plant-to-plant spacing were 75 and 20 cm, respectively. After five rows of test materials one of the susceptible checks like ICP 2376, Bahar, TTB 7 and PT 221 was replicated. The cause of mortality was confirmed after dividing the stem of affected plants vertically into two equal halves and observing the typical blackening of xylem vessels in the middle of the stem. The number of plants wilted due to *Fusarium* wilt was recorded at flowering, podding and maturity stages and after each observation the wilted plants were removed from the plot. The sum of total wilted plants at all the three stages (flowering, podding and maturity) was added and recorded as total number of wilted plants. The lines were categorized as resistant (0–10 % plant mortality), moderately resistant (10.1–30 % plant mortality) and susceptible (30.1–100 % plant mortality) as per the criterion followed in All-India Coordinated Research Project on Improvement of pigeonpea for screening the wilt-resistant pigeonpea lines in wilt-sick plot. Local susceptibility Index (LSI) was also recorded by averaging the per cent infection of all the lines including checks and test material. Same method of data recording was followed at all the locations over years.

## RESULTS AND DISCUSSION

Qualitative and quantitative traits including yield potential of all the four genotypes used in the present investigation has been mentioned in Table 1. Reaction of all the four genotypes to *Fusarium* wilt at different locations (hot spots) over the years has been summarized in Table 1. Genotype IPA 16 F was screened against *Fusarium* wilt continuously for three years (2004–07). In 2004–05 it showed moderately resistant reaction with 13.2% infection to wilt disease at Dholi. In 2005–06, this genotype showed resistant

reaction to wilt disease at all locations except Gulbarga, where moderately resistant reaction was recorded. In third year, i.e. 2006–07 this was screened at Dholi, Rahuri, Gulbarga, Akola, ICRISAT and Bangalore and showed moderately resistant, resistant, moderately resistant, resistant, resistant and moderately resistant reactions, respectively. Thus it is obvious that per cent plant mortality due to wilt in genotype IPA 16 F ranged from 4.2 (resistant reaction) at Rahuri in 2006–07 to 25.7 (moderately resistant reaction) at Gulbarga in 2005–06 and wilt reaction varied from resistant to moderately resistant in north-east plains zone (Dholi and Faizabad), central zone (Rahuri, Badnapur and Akola) and south zone (Gulbarga, Bangalore and ICRISAT). Least susceptibility index (LSI) and per cent mortality of IPA 16 F at different locations indicates that this genotype has shown best performance in the locations (Rahuri, Badnapur and Akola) of central zone. From the reactions of IPA 16 F to wilt over the years and locations it can be concluded that this genotype can be used as resistant donor in wilt resistance breeding programme of pigeonpea.

Reaction of genotype IPA 8 F to wilt disease at different locations (hot spots) of country was recorded continuously for five years (2005–2010). During 2005–06 reaction to wilt at Dholi, Badnapur, Gulbarga and Faizabad was moderately resistant, moderately resistant, moderately resistant and resistant, respectively. During 2006–07 this genotype showed resistant, resistant, moderately resistant, moderately resistant and moderately resistant reaction at Dholi, Khargone, Gulbarga, Akola and ICRISAT respectively. During 2007–08 this genotype showed resistant, moderately resistant and resistant reaction at Dholi, Badnapur and ICRISAT respectively. Moderately resistant, moderately resistant, resistant, resistant and moderately resistant reaction were recorded at Dholi, Rahuri, Badnapur, Gulbarga and ICRISAT respectively during 2008–09. Reaction of this genotype to wilt during 2009–10 was resistant, moderately resistant,

Table 1 Qualitative and quantitative traits recorded for IPA 16 F, IPA 8 F, IPA 9 F and IPA 12 F

| Trait                   | IPA 16 F      | IPA 8 F          | IPA 9 F          | IPA 12 F      |
|-------------------------|---------------|------------------|------------------|---------------|
| Days to 50% flowering   | 159           | 157              | 158              | 144           |
| Base flower colour      | Yellow        | Yellowish orange | Yellowish orange | Yellow        |
| Pattern of streak       | Medium        | Medium           | Medium           | Sparse        |
| Flowering pattern       | Indeterminate | Indeterminate    | Indeterminate    | Indeterminate |
| Growth habit            | Spreading     | Spreading        | Compact          | Compact       |
| Stem colour             | Green         | Green            | Green            | Green         |
| Days to 75% maturity    | 256           | 264              | 263              | 256           |
| Plant height (cm)       | 181           | 213              | 220              | 227           |
| No. of primary branches | 11            | 12               | 16               | 11            |
| Pod colour              | Mixed         | Dark purple      | Mixed            | Green         |
| No. of seed/pod         | 3.5           | 3.5              | 4.0              | 4.0           |
| Pod length (cm)         | 4.7           | 5.1              | 5.1              | 5.2           |
| 100 seed weight (g)     | 11            | 12               | 10               | 11            |
| Yield (kg/ha)           | 1 763         | 2 315            | 1 929            | 2 367         |

Table 2 Reaction of IPA 16 F, IPA 8 F, IPA 9 F and IPA 12 F to *Fusarium* wilt in wilt-screening nursery at different locations over the years

| Year            | Location | Per cent infection (genotype) | Per cent infection (check) | LSI  | Reaction of IPA 16 F |
|-----------------|----------|-------------------------------|----------------------------|------|----------------------|
| <i>IPA 16 F</i> |          |                               |                            |      |                      |
| 2004-05         | Dholi    | 13.2                          | 66.2 (Bahar)               | 40.7 | Moderately resistant |
| 2005-06         | Dholi    | 8.3                           | 91.8 (Bahar)               | 44.2 | Resistant            |
|                 | Rahuri   | 8.1                           | 75.1 (Bahar)               | 59.4 | Resistant            |
|                 | Badnapur | 8.3                           | 88.5 (Bahar)               | 45.0 | Resistant            |
|                 | Gulbarga | 25.7                          | 77.5 (Bahar)               | 51.2 | Moderately resistant |
|                 | Faizabad | 5.0                           | 86.0 (Bahar)               | 19.2 | Resistant            |
| 2006-07         | Dholi    | 14.0                          | 90.0 (Bahar)               | 49.1 | Moderately resistant |
|                 | Rahuri   | 4.2                           | 100 (ICP 2376)             | 74.7 | Resistant            |
|                 | Gulbarga | 15.8                          | 100 (PT 221)               | 63.2 | Moderately resistant |
|                 | Akola    | 4.3                           | 85.0 (ICP 2376)            | 44.3 | Resistant            |
|                 | ICRISAT  | 8.8                           | 100 (ICP 2376)             | 60.8 | Resistant            |
|                 | Banglore | 18.7                          | 66.7 (TTB 7)               | 16.4 | Moderately resistant |
| <i>IPA 8 F</i>  |          |                               |                            |      |                      |
| 2005-06         | Dholi    | 13.2                          | 91.8 (Bahar)               | 44.2 | Moderately resistant |
|                 | Badnapur | 20.5                          | 88.5 (Bahar)               | 45.0 | Moderately resistant |
|                 | Gulbarga | 17.6                          | 77.5 (Bahar)               | 51.2 | Moderately resistant |
|                 | Faizabad | 5.0                           | 86.0 (Bahar)               | 49.2 | Resistant            |
| 2006-07         | Dholi    | 8.0                           | 90.0 (Bahar)               | 49.1 | Resistant            |
|                 | Khargone | 8.3                           | 67.0 (ICP 2376)            | 25.0 | Resistant            |
|                 | Gulbarga | 14.5                          | 100 (PT 221)               | 63.2 | Moderately resistant |
|                 | Akola    | 18.6                          | 85.0 (ICP 2376)            | 44.3 | Moderately resistant |
|                 | ICRISAT  | 18.6                          | 100 (ICP 2376)             | 60.8 | Moderately resistant |
| 2007-08         | Dholi    | 2.0                           | 90.0 (ICP 2376)            | 29.4 | Resistant            |
|                 | Badnapur | 29.7                          | 93.5 (ICP 2376)            | 30.7 | Moderately resistant |
|                 | ICRISAT  | 8.6                           | 95.8 (ICP 2376)            | 29.7 | Resistant            |
| 2008-09         | Dholi    | 20.9                          | 70.0 (ICP 2376)            | 22.8 | Moderately resistant |
|                 | Rahuri   | 20.9                          | 100 (ICP 2376)             | 34.4 | Moderately resistant |
|                 | Badnapur | 6.3                           | 100 (ICP 2376)             | 16.3 | Resistant            |
|                 | Gulbarga | 4.3                           | 92.7 (ICP 2376)            | 17.7 | Resistant            |
|                 | ICRISAT  | 20.5                          | 100 (ICP 2376)             | 33.4 | Moderately resistant |
| 2009-10         | Dholi    | 5.2                           | 83.5 (ICP 2376)            | 20.6 | Resistant            |
|                 | Badnapur | 20.8                          | 100 (ICP 2376)             | 21.8 | Moderately resistant |
|                 | Gulbarga | 4.6                           | 78.9 (ICP 2376)            | 19.3 | Resistant            |
|                 | ICRISAT  | 13.1                          | 92.9 (ICP 2376)            | 22.1 | Moderately resistant |
|                 | Banglore | 0.0                           | 75.7 (ICP 2376)            | 18.0 | Resistant            |
| <i>IPA 9 F</i>  |          |                               |                            |      |                      |
| 2006-07         | Dholi    | 14.0                          | 90.0 (Bahar)               | 49.1 | Moderately resistant |
|                 | Khargone | 3.5                           | 67.0 (ICP 2376)            | 25.0 | Resistant            |
|                 | Gulbarga | 23.1                          | 100 (PT 221)               | 63.2 | Moderately resistant |
|                 | Akola    | 8.8                           | 85.0 (ICP 2376)            | 44.3 | Resistant            |
|                 | ICRISAT  | 11.2                          | 100 (ICP 2376)             | 60.8 | Moderately resistant |
|                 | Rahuri   | 21.2                          | 100(TTB 7)                 | 74.7 | Moderately resistant |
|                 | Faizabad | 2.9                           | 100 (Bahar)                | 41.6 | Resistant            |
|                 | Sehore   | 3.1                           | 60.3 (ICP 2376)            | 10.2 | Resistant            |
|                 | Badnapur | 12.5                          | 100 (ICP 2376)             | 45.4 | Moderately resistant |

Continued

Table 2 *Concluded*

| Year            | Location | Per cent infection (genotype) | Per cent infection (check) | LSI  | Reaction of IPA 16 F |
|-----------------|----------|-------------------------------|----------------------------|------|----------------------|
| 2007-08         | Dholi    | 10.5                          | 90.0 (ICP 2376)            | 29.4 | Moderately resistant |
|                 | ICRISAT  | 11.3                          | 95.8 (ICP 2376)            | 29.7 | Moderately resistant |
|                 | Rahuri   | 11.9                          | 100 (ICP 2376)             | 46.4 | Moderately resistant |
|                 | Gulbarga | 2.9                           | 100 (ICP 2376)             | 39.2 | Resistant            |
| 2008-09         | Dholi    | 17.5                          | 80.7 (ICP 2376)            | 20.8 | Moderately resistant |
|                 | Kanpur   | 17.6                          | 91.8 (ICP 2376)            | 21.8 | Moderately resistant |
|                 | Badnapur | 20.5                          | 100 (ICP 2376)             | 18.5 | Moderately resistant |
|                 | Gulbarga | 4.6                           | 96.7 (ICP 2376)            | 17.1 | Resistant            |
|                 | ICRISAT  | 27.3                          | 100 (ICP 2376)             | 25.6 | Moderately resistant |
| 2009-10         | Dholi    | 18.4                          | 90.4 (ICP 2376)            | 18.0 | Moderately resistant |
|                 | Badnapur | 0.0                           | 100 (ICP 2376)             | 17.1 | Resistant            |
|                 | Gulbarga | 4.4                           | 84.7 (ICP 2376)            | 18.4 | Resistant            |
|                 | ICRISAT  | 3.9                           | 85.9 (ICP 2376)            | 17.2 | Resistant            |
|                 | Banglore | 0.0                           | 78.3 (ICP 2376)            | 34.4 | Resistant            |
|                 | Rahuri   | 6.1                           | 100 (ICP 2376)             | 26.4 | Resistant            |
|                 | Kanpur   | 14.6                          | 91.8 (ICP 2376)            | 48.5 | Moderately resistant |
| <i>IPA 12 F</i> |          |                               |                            |      |                      |
| 2006-07         | Dholi    | 4.0                           | 90.0 (Bahar)               | 49.1 | Resistant            |
|                 | Khargone | 10.0                          | 67.0 (ICP 2376)            | 25.0 | Moderately resistant |
|                 | Gulbarga | 15.2                          | 100 (PT 221)               | 63.2 | Moderately resistant |
|                 | ICRISAT  | 20.7                          | 100 (ICP 2376)             | 60.8 | Moderately resistant |
|                 | Rahuri   | 24.3                          | 100(TTB 7)                 | 74.7 | Moderately resistant |
|                 | Sehore   | 0.0                           | 60.3 (ICP 2376)            | 10.2 | Resistant            |
|                 | Badnapur | 16.7                          | 100 (ICP 2376)             | 45.4 | Moderately resistant |
|                 | Banglore | 4.5                           | 66.7 (TTB 7)               | 16.4 | Resistant            |
| 2007-08         | Dholi    | 20.0                          | 90.0 (ICP 2376)            | 29.4 | Moderately resistant |
|                 | ICRISAT  | 19.9                          | 95.8 (ICP 2376)            | 29.7 | Moderately resistant |
|                 | Badnapur | 11.8                          | 93.5 (ICP 2376)            | 30.7 | Moderately resistant |
|                 | Gulbarga | 25.3                          | 100 (ICP 2376)             | 39.2 | Moderately resistant |
| 2008-09         | Dholi    | 13.0                          | 80.7 (ICP 2376)            | 20.8 | Moderately resistant |
|                 | Badnapur | 18.6                          | 100 (ICP 2376)             | 18.5 | Moderately resistant |
|                 | Gulbarga | 13.3                          | 96.7 (ICP 2376)            | 17.1 | Moderately resistant |
|                 | ICRISAT  | 16.1                          | 100 (ICP 2376)             | 25.6 | Moderately resistant |
| 2009-10         | Dholi    | 8.4                           | 90.4 (ICP 2376)            | 18.0 | Resistant            |
|                 | Badnapur | 5.0                           | 100 (ICP 2376)             | 17.1 | Resistant            |
|                 | Gulbarga | 12.5                          | 84.7 (ICP 2376)            | 18.4 | Moderately resistant |
|                 | ICRISAT  | 10.6                          | 85.9 (ICP 2376)            | 17.2 | Moderately resistant |
|                 | Rahuri   | 5.7                           | 100 (ICP 2376)             | 26.4 | Resistant            |

resistant, moderately resistant and resistant at Dholi, Badnapur, Gulberga, ICRISAT and Bangalore respectively. Thus it can be summarized that during 2005-10 minimum per cent infection (plant mortality) in IPA 8 F due to wilt was 0.0 (resistant reaction) during 2009-10 at Bangalore and maximum was 29.7 (moderately resistant reaction) during 2007-08 at Badnapur. On the basis of least susceptibility index (LSI) and per cent mortality of this genotype at different

locations it is evident that IPA 8 F has shown best performance in the locations (Dholi and Faizabad) of north-east plains zone. Since this genotype has never shown per cent infection 30 or >30 (susceptible reaction) continuously for five years therefore, it is confirmed that IPA 8 F is a very good source of resistance to wilt disease of pigeonpea for all zones of the country.

Reaction of genotype IPA 9 F to wilt disease at different

locations of north-east plains zone, central zone and south zone has been mentioned for the four years (2006–10). During 2006–07 this genotype was evaluated at Dholi, Khargone, Gulbarga, Akola, ICRISAT, Rahuri, Faizabad, Sehore and Badnapur where it showed moderately resistant, resistant, moderately resistant, resistant, moderately resistant, moderately resistant, resistant, resistant and moderately resistant reaction, respectively to wilt. In the crop season of 2007–08, IPA 9 F showed moderately resistant, moderately resistant, moderately resistant and resistant reaction to wilt at Dholi, ICRISAT, Rahuri and Gulbarga, respectively. Resistant, moderately resistant and resistant reaction to wilt disease was recorded at Dholi, Badnapur and ICRISAT, respectively during 2008–09. IPA 9 F was evaluated at Dholi, Badnapur, Gulbarga, ICRISAT, Bangalore, Rahuri and Kanpur during 2009–10 where it gave moderately resistant, resistant, resistant, resistant, resistant and moderately resistant reaction to wilt. Thus it can be concluded that during 2006–10 per cent infection (per cent plant mortality) ranged from 0.0 (resistant reaction) during 2009–10 at Bangalore to 27.3 (moderately resistant reaction) in 2008–09 at ICRISAT and IPA 9 F showed resistant/moderately resistant reaction at all the locations during 2006–10. But, a comparison of performances as per least susceptibility index (LSI) and per cent mortality at different locations shown by IPA 9 F clearly indicates that this genotype has shown best performance in the locations (Rahuri, Badnapur, Sehore, Khargone and Akola) of central zone. The consistent resistant reaction of IPA 9 F confirms that it can be used as a wilt-resistant donor for transferring wilt resistance to a pigeonpea genotype, which is agronomically superior but susceptible to wilt.

Reaction of genotype IPA 12 F to wilt disease at different locations (hot spots) of north-east plains zone, central zone and south zone was recorded continuously for four years. During 2006–07 this genotype showed resistant, resistant, moderately resistant, moderately resistant, moderately resistant, resistant, moderately resistant and resistant reaction at Dholi, Khargone, Gulbarga, ICRISAT, Rahuri, Sehore, Badnapur and Bangalore respectively. In the crop season of 2007–08 this genotype was evaluated at Dholi, ICRISAT, Badnapur and Gulbarga and it gave moderately resistant reaction to wilt at all the four locations. Moderately resistant, moderately resistant, moderately resistant, resistant and moderately resistant reaction to wilt disease were recorded at Dholi, Kanpur, Badnapur, Gulbarga and ICRISAT respectively in the crop season of 2008–09. Reaction of this genotype to wilt during 2009–10 was resistant, resistant, moderately resistant, moderately resistant and resistant at Dholi, Badnapur, Gulbarga, ICRISAT and Rahuri, respectively. Thus it can be summarized that during 2006–10 minimum per cent infection (plant mortality) due to wilt in IPA 12 F was 0.0 (resistant reaction) during 2006–07 at Sehore and maximum was 25.3 (moderately resistant reaction) during 2007–08 at Gulbarga. Least susceptibility index (LSI) and per cent mortality of IPA

12 F at different locations indicates that this genotype has shown mixed performance at the locations of different zones over the years. Since this genotype has shown resistant to moderately resistant reaction to wilt disease continuously for four years therefore, it is confirmed that IPA 12 F is a very good resistant donor for incorporating resistance to wilt in agronomically superior but wilt-susceptible genotypes.

Thus from present investigation it can be concluded that consistency in reaction (resistant to moderately resistant) shown by genotypes IPA 16 F, IPA 8 F, IPA 9 F and IPA 12 F in north-east plains zone, central zone and south zone indicated that these genotypes are resistant to all the five variants of *Fusarium udum* prevalent in India (Mishra and Vishwadhhar 2003, Mishra 2004). Out of these five variants, in north-east plains zone all the five (I, II, III, IV and V) are prevalent, whereas only three variants (I, II and III) and (I, III and V) are prevalent in south zone and central zone, respectively. From the results it has been observed that a single genotype has shown different reactions to wilt at different locations over the years. This variation may be attributed to the different climatic conditions and presence of different fungal variants at different locations. A comparison between any two genotypes for their least susceptibility index along with per cent mortality at different locations over the zones indicated that the genotype IPA 16 F is the best genotype with respect to resistance to wilt. Thus these genotypes can be used as resistant donor in resistance breeding programme for pigeonpea wilt throughout the country. Similarly, Gwata *et al.* 2006 have also reported that genotype ICEAP 00040 is useful as a good source of resistance in pigeonpea genetic improvement programs in the region of South Africa, particularly in Kenya, Malawi and Tanzania.

Therefore, it is suggested that more pigeonpea germplasm lines should be screened for their reaction to wilt either through conventional method or by using molecular markers which is a very quick method (Prasanthi *et al.* 2009) and it is possible to identify the new resistance sources in a short time and they can be utilized in breeding programme or for direct release.

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