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Inheritance Study for *Fusarium* Wilt Resistance in Pigeonpea (*Cajanus cajan* L. Millspaugh)

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Abstract

Wilt caused by *Fusarium udum* Butler, is one of the most important limiting factors for pigeonpea production. In order to incorporate *Fusarium* wilt resistance into adapted, popular, high yielding but susceptible variety PRG-100, the inheritance of resistance to *Fusarium* wilt in pigeonpea was studied using ICP-8863 and ICPL-87119 as resistant parents and PRG-100 as susceptible parent. Analysis of F_2 progenies of the cross PRG-100 x ICP-8863 showed a digenic epistatic interaction mechanism of resistance with a 13 (resistant): 3 (susceptible) segregation ratio. Similarly, evaluation of F_2's of the cross PRG-100 x ICPL-87119 also showed digenic epistatic interaction which segregated in 9 (resistant): 7 (susceptible) ratio, indicating a complementary gene action. Study of progenies back crossed to resistant parents indicated the segregation of resistant and susceptible progeny in the ratio of 3R:1S in both the crosses. The allelic test between ICP-8863 and ICPL-87119 confirmed the independence of genes governing resistance.

1. Introduction

Pigeonpea is one of the major pulse crops of the tropics and sub-tropics. *Fusarium* wilt of pigeonpea is soil borne disease of considerable importance in India. The yield loss due to this disease depends on the stage at which the plants wilt and it can approach 100% when wilt occurs at the pre-pod stage (Okiror, 2002). The annual loss of the crop due to wilt in India alone has been estimated to US $71 million (Reddy et al., 1993). *Fusarium* wilt causes economic loss in pigeonpea of about 470,000 t of grain in India (Joshi et al., 2001). Adoption of certain management practices such as, crop rotation and mixed cropping with sorghum are partially effective in minimizing the losses due to wilt. Similarly, uses of chemicals for soil treatment or soil solarization are not economical. Therefore, breeding of varieties resistant to *Fusarium* wilt seems to be the most efficient and economical approach. Although the search for sources of resistance to *Fusarium* wilt in pigeonpea was initiated following the identification of the causal organism in India (Butler, 1906), conflicting reports have been made on the inheritance of resistance to *Fusarium* wilt in pigeonpea. Earlier studies revealed that resistance to wilt is under the control of two complementary genes (Parmita et al., 2005), single dominant gene (Pawar and Mayee, 1986; Pandey et al., 1996; Singh et al., 1998; Karimi et al., 2010), two genes (Okiror, 2002), major genes (Sharma, 1986; Parmita et al., 2005), duplicate genes and even multiple factors (Mehrotra and Ashok, 2007) and a single recessive gene (Jain and Reddy, 1995). Apart from dominant, recessive and complementary gene, action on the control of *Fusarium* wilt (Kimani, 1991; Kotresh et al., 2006) has been reported. Dominant epistatic gene interaction and a single dominant gene play a significant role in controlling resistance to wilt (Parmita et al., 2005). Digenic and quantitative genes that are resistant to *Fusarium* wilt have also been observed (Odeny, 2001). These results show that inheritance of resistance depends on nature of resistance genes and parental background and emphasizes need for further study to obtain information on the inheritance of wilt resistance. The present study has been undertaken to study the inheritance of *Fusarium* wilt resistance and to incorporate it in a popular, high yielding but susceptible pigeonpea variety, PRG-100 utilizing two resistant parents, viz. ICP-8863 and ICPL-87119.

2. Materials and Methods

2.1. Experimental site and plant materials

The study was conducted at Regional Agricultural Research Station, Palem under Acharya N. G. Ranga Agricultural University, Hyderabad. The genetic materials were developed using two ICRISAT lines, ICP-8863 and ICPL-87119 as

Fusarium wilt resistant parents and PRG-100 as susceptible parent (Table 1).

The resistant parents, ICP-8863 and ICPL-87119, both are medium duration maturing of 160-165 days with 155-170 cm plant height and are highly resistant to wilt. However, both have brown small seed with 11.6 and 8.5 g 100 seed weight hence, are not popular in local markets in Andhra Pradesh. The variety PRG-100, very popular in Andhra Pradesh, is highly susceptible to wilt. This variety matures in 155-160 days having bold seed size with 12.4 - 13.6 g 100 seed weight.

2.2. Evaluation for resistance

During *kharif* 2009 crosses were made between the resistant and susceptible parents and between the resistant parents. At flowering, the lines were hand pollinated to make two crosses each cross involving a susceptible and a resistant line. Tightly closed buds of the female parent were emasculated by removing anthers from the staminal column with fine forceps one day before they were due to open. About 2-10 buds were emasculated branch^{-1} and all smaller buds removed to prevent competition within the inflorescence. Pollination was done immediately after emasculation using unopened buds of the male parent for which the anthers would dehisce on the same day. Both emasculation and pollination were done in the morning before 10.00 a.m. to avoid heat, which would otherwise rapture the stigma of the emasculated flower. At maturity, the pods were harvested and F_1 seeds were divided into three lots. In *Kharif* 2010 the first lot was planted and allowed to self into F_2. The second lot was planted and backcrossed to both the resistant (BC_1) and susceptible parents (BC_2). The remaining seeds were kept in store.

Controls of both susceptible and resistant lines were used for every batch. The controls included inoculated and non-inoculated lots. Pots were kept in the greenhouse for two months and wilting of the plants observed. The pathogen was re-isolated from the wilted plants and its pathogenicity re-confirmed. All populations-parentals, F_1, F_2, backcross progenies were screened for wilt resistance using the root dip technique suggested by Haware and Nene (1994). Roots of seven day old seedlings were dipped in the inoculum for ten minutes followed by transplanting them in 15 cm plastic pots containing autoclaved sand. For controls of both the susceptible and resistant lines, the distal end of the root system was cut, and the seedlings dipped in sterile water. Immediately after transplanting, watering was done at an interval of two days. The polythene bags were then placed in a greenhouse and maintained at about 22-32^{o}C. About 50 plants of each of the parental, F_1 and backcross populations and 150-200 plants of F_2 generation were transplanted in each replication.

Table 1: Maturity, origin and reaction to Fusarium wilt of pigeonpea cultivars used for crosses

Accession	Maturity (duration)	Origin	Response to Fusarium wilt
ICP-8863	Medium (6-8 months)	India	Resistant
ICPL-87119	Medium	India	Resistant
PRG-100	Medium	India	Susceptible

2.3. Plot design and data collection

All the experimental materials were grown in a randomised complete block design with four replicates. Data on disease expression, i.e. number of plants wilted and non-wilted were recorded every week from disease onset up to pod maturity. Plants killed by factors other than wilt were discarded and therefore not included in the analysis. Data obtained were statistically analyzed using the chi-square test to ascertain the goodness of fit to different genetic ratios (Snedcor and Cochran, 1989).

3. Results and Discussion

The results of plant reactions to *Fusarium udum* for all the generations namely the parents, F_1, F_2 and backcrosses for all the families are presented in Table 2. As expected nearly all plants of ICP-8863 and ICPL-87119 were resistant to the isolate

Table 2: Resistance to Fusarium udum, of lines ICP-8863, ICPL-87119 and PRG-100, their F1, F2 and back cross families

Parents and progeny population	Total	Reaction		Expected ratio
		Resistant	Susceptible	
ICP-8863	42	38	4	-
ICPL-87119	56	49	7	-
PRG-100	40	8	32	-
ICP-8863 x PRG-100	38	34	4	-
F_2	230	181	49	13:3
BC1 (ICP-8863 x F_1)	58	43	15	3:1
BC2 (PRG-100 x F_1)	50	28	22	1:1
ICPL-87119 x PRG-100	46	40	6	-
F_2	188	110	78	9:7
BC_1 (ICPL-87119 x F_1)	46	30	16	3:1
BC_2 (PRG-100 x F_1)	42	22	20	1:1

while all plants of PRG-100 were susceptible to it.

The F_1 plants from the crosses of PRG-100 with resistant lines ICP-8863 and ICPL-87119 were also resistant just like the resistant parents. The F_2 population of PRG-100 x ICP-8863 cross segregated in a ratio of 13R: 3S (resistant: susceptible) phenotypic ratio (p>0.05). When backcrossed to resistant parent ICP-8863, the population segregated into a 3R: 1S phenotypic ratio and to the susceptible it was a 1R: 1S phenotypic ratio. As for the PRG-100 x ICP-87119 cross, the F_2 population segregated into 9R: 7S ratio. Progenies of backcross population (BC_1) to the resistant parents segregated at 3R: 1S while those of a back cross to the susceptible (BC_2) parent were all susceptible suggesting dominance nature of genes involved in resistance.

These results are in accordance with that of some of the reported findings, namely that resistance is dominant to susceptibility. The dominant nature of this resistance is especially encouraging since its incorporation and selection should be easier than if it was recessive. In ICP-8863, the F_2 segregation of 13R: 3S indicated that its resistance is digenic (Odeny, 2001) but acting in an inhibitory manner. The segregations in the back cross populations further confirm a two-gene operating system (Okiror, 2002). As for ICPL-87119, the F_1 as well as the F_2 results showed that wilt resistance is dominant and also conferred by two genes but these genes were complementary (Parmita et al., 2005). Its backcross population (BC_1) also segregated into a 3R: 1S. However, the back cross to the susceptible parent gave all susceptible progeny. This 3: 1 ratio, as in the previous population affirms a two gene condition in ICPL-87119 as well. The results of allelic test not only demonstrated independence in these genes, but also showed existence of different genes (Odeny, 2001).

4. Conclusion

Multigenic resistance is generally accepted as more beneficial than monogenic as it is considered broader and therefore durable. The benefit is even more significant when such resistance is dominant. This is what has been found to exist in these pigeonpea lines. Based on this study, a program has been commenced already to incorporate resistance from ICP-8863 and ICPL-87119 into the adapted cultivars PRG-100 and PRG-88. It entails crossing and selection using the phenotypic recurrent approach. This is hoped to introduce and increase wilt resistance in pigeonpea. It is expected that response to selection should be rapid given that it is dominant. In conclusion, it can be categorically stated that the results of this study will be valuable to other breeders in developing adapted, wilt resistant varieties of pigeonpea.

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