RECENT ADVANCES IN BREEDING FOR DISEASE RESISTANCE IN PIGEONPEA

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Abstract

Good progress has been made during the past 15 years in breeding for disease resistance in pigeonpea and effective laboratory and field screening techniques have been developed for all the major diseases. For fusarium wilt, a pot culture technique for evaluating material in the glasshouse and sick plots for evaluation in field have been standardized. For sterility mosaic, a leaf-stapling technique for evaluation in pots and field and infector-hedge and spreader-row techniques for field evaluation are available. For phytophthora blight, leaf scar and drench-inoculation techniques for use in pot culture and stem-rub, diseased-debris, and sickplot techniques for field use have been developed. Several sources of resistance to fusarium wilt, sterility mosaic and alternaria blight and a few lines field- resistant to phytophthora blight have been identified. For fusarium wilt and sterility mosaic, lines such as ICP 8863 and ICP 10976 with broad-based resistance have also been identified. A few lines such as ICP 7867, ICP 9174 and KPBR 80-2 with multiple disease resistance to two to three major diseases have also been identified. In case of fusarium wilt, sterility mosaic and alternaria blight, a few resistant and high yielding varieties such as Maruti, Bahar, and Da 11 for individual diseases have also been developed. Because limited information is available on pathogenic variability and the genetics of disease resistance, these aspects need more attention. Breeding for resistance to phytophthora blight and for multiple disease resistance should also be given priority.

Introduction

In this paper we briefly review the progress made on breeding for resistance to major pigeonpea (*Cajanus cajan* [L.] Millsp.) diseases during the past 15 years, including screening techniques, rating scales, identification of resistance sources, variability present in the pathogens, inheritance of resistance, breeding methodology, and multiple disease resistance. Constraints to resistance breeding are discussed and directions for future research suggested.

Important Diseases

The diseases of economic importance in pigeonpea in India in order of importance are sterility mosaic (causal agent not yet known), fusarium wilt (*Fusarium udum* Butler), Phytophthora blight (*Phytophthora drechsleri* Tucker f. sp. *cajani* (Pal *et al* 1970, Kannaiyan *et al.* 1981) alternaria blight (*Alternaria tenuissima* [Kunze ex. Pers.] Wiltshire and *A. alternata* [Fr.] Keissler), and dry root rot (*Rhizoctonia bataticola* [Taub.] Butler = *Macrophomina phaseolina* [Tassi.] Goid) (Kannaiyan *et al.* 1984).

More than one of these diseases can occur in same field. For example, in the states of Bihar and Uttar Pradesh, both

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sterility mosaic and wilt are serious problems. Control measures for more than one disoases are therefore needed. In present pigeonpea production systems, where the crop is generally cultivated by resource-poor farmers on marginal lands as a mixed crop or an intercrop, use of resistant varieties is the best choice for disease management.

Inoculation techniques

Fortunately, in pigeonpea, for most of the major diseases, effective laboratory, glasshouse, and field inoculation techniques have been developed. Availability of these techniques has greatly hastened progress on resistance breeding over the past 10 years.

For sterility mosaic, a leaf-stapling technique for inoculating plants grown either in pots or in field is available (Nene and Reddy, 1976). For large- scale field evaluation, infector- hedge and spreader-row techniques have been developed (Nene *et al.* 1981).

For fusarium wilt, a pot-culture technique for use in the glasshouse, and sick-plots for evaluating materials in the field have been developed (Nene *et al.* 1981).

Effective pot culture and field inoculation techniques are also available for phytophthora blight. Leaf scar (Pal *et al.* 1970) or drench-inoculation (Kannaiyan *et al.* 1981) techniques can be used for inoculating seedings in pots. Field inoculation techniques are also available for phytophthora blight. For inoculations in the field, in addition to the stem-rub method (Nene *et al.* 1981), diseased-debris and sick-plot methods have been found very effective (M.V. Reddy, T. N. Raju, Y.L. Nene- Unpublished). In the debris method, about 1 month-old plants grown on flat beds in Alfisol fields (preferably low-lying but not water-logged) are inoculated by scattering diseased pigeonpea debris. Early sowing (first fortnight of June) before or with the onset of the first monsoon rain is important for obtaining high disease incidence. If diseased plant materials are incorporated in field, at the end of the crop season the plot develops into an effective sick plot and can be used year after year without additional inoculations (Table 1).

Disease rating scales

No specific rating scales have been developed for pigeonpea diseases. At present, in case of fusarium wilt, phytophthora blight and dry root rot lines with 0-10% mortality are arbitrarily categorized as resistant, 11-20% as moderately resistant, 21-50 per cent as moderately susceptible, 51-80 per cent as susceptible and 81-100% as highly susceptible. In the case of sterility mosaic, plants with severe mosaic symptoms and complete sterility are considered susceptible. Plants with ring spot symptoms and no sterility are considered tolerant and those with only mild mosaic symptoms and partial sterility as moderately susceptible. Plants with no apparent symptoms are considered resistant.

Based on the type of symptoms observed in a range of genotypes, we

Table 1. *A nine-point rating scale proposed for alternaria and phytophthora blight diseases of pigeonpea.*

Rating	Reaction category	Alternaria blight (% defoliation)	Phytophthora blight	
			Plant mortality (%)	Stem lesion type
1.	Highly resistant (HR)	0	0	No symptoms
2.	HR to R	1-5	1-5	Less than 5 mm long smooth lesion
3.	Resistant (R)	6-10	6-10	6-10 mm long smooth lesion
4.	Moderately resistant (MR)	21-30	11-20	More than 10 cm long, smooth lesion with girdling
5.	Tolerant (MS)		21-30	More than 10 mm long lession with cracing
6.	Moderately susceptible (MS)	31-50	31-50	Smooth galls without cracking
7.	Susceptible (S)	51-57	51-75	Large galls with cracking and girdling
8.	S to HS	76-100	76-100	Galls with cracking, girdling and breaking of branches
9.	Highly susceptible (HS)	Plants killed	Plants killed	Plants killed

propose a 9-point scale for phytophthora and alternaria blight diseases (Table 1). For phytophthora blight, the scale is based on the extent of defoliation, stem lesion size and plant mortality. In case of alternaria blight, the extent of defoliation is the main criterion.

Resistance sources

The available pigeonpea germplasm is rich in disease resistance. Several sources of resistance have been identified for sterility mosaic, fusarium wilt, and alternaria blight (Reddy, *et al.* 1990). For sterility mosaic and wilt, several lines with broad-based resistance have recently been identified. However, because of variability present in the phytophthora blight pathogen, progress on identification of stable resistance to this pathogen has been comparatively slow. Most of the lines that were earlier identified as resistant to p2 isolate of the pathogen by Kannaiyan *et al.* (1981) showed susceptibility due to appearance of p3 isolate. Though there are no lines with high levels of resistance to p3 isolate of *P. drechsleri* f. sp. *cajani*, a few lines with field resistance to both isolates have been identified. Screening for resistance to dry root rot has been very limited. Some lines such as ICPL 87, ICPL 83006, ICPL 84023, ICPL

86030 and ICPL 87119 have low incidence (25% mortality) under field conditions. A few lines with combined resistance/tolerance for 2-3 major diseases have also been identified (Nene 1988).

Inheritance studies

Inheritance of resistance to major diseases such as wilt, sterility mosaic, phytophthora blight and alternaria blight has been studied.

Fusarium wilt

The first report on inheritance of resistance to fusarium wilt was published by Pal (1934). He observed that resistance was controlled by multiple factors. Later, Shaw (1936) and Pathak (1970) suggested that the resistance is governed by two complementary genes. However, Joshi (1957) and Pawar and Mayee (1986) reported that resistance is controlled by a single dominant gene. Studies at ICRISAT suggest that in some genotypes resistance is governed by a dominant gene, while in others it is controlled by a recessive gene (K.C. Jain and M.V. Reddy - unpublished).

Sterility mosaic

Singh *et al.* (1983) observed that resistance to sterility mosaic was controlled by four independent non allelic genes - two were dominant and two were recessive. To confer resistance, the presence of at least one dominant and one recessive gene was necessary. Sharma *et al.* (1984) reported that susceptibility was dominant over resistance and tolerance and the tolerant reaction was dominant over resistance in certain lines. The reaction of F1 and segregation in F2 generations in different crosses suggested the presence of two genes and more than two alleles at each locus.

Phytophthora blight

Inheritance of resistance to the p2 isolate of *P. drechsleri* f. sp. *cajani* was reported by Sharma *et al.* (1982). Resistance was found under the control of a single dominant gene designated as pd_1.

Alternaria blight

Sharma *et al.* (1987) studied inheritance of resistance to *A. tenuissima* in three crosses involving resistant and susceptible cultivars. Resistance to alternaria blight was governed by a recessive gene, *abr 1*. Recently, Singh *et al.* (1988) also suggested that the resistance is controlled by a recessive gene, al 1.

Breeding methodology

The world collection of pigeonpea germplasm at ICRISAT provides a good opportunity to select diverse parents for crossing programs. In breeding for disease resistance, pigeonpea breeders have generally followed pedigree or mass-pedigree methods. In some cases a back-cross method has also been followed (Green *et al.* 1980). At ICRISAT, we successfully developed high-yielding and wilt-resistant lines from highly wilt-susceptible variety LRG 30 through gamma-ray irradiation (Dwivedi *et al.* 1989). Seeds of the wilt-susceptible cultivar, LRG-30, were irradiated with 8 doses of gamma-rays ranging from 5 to 40 kR. In the M4 generation, several wilt-resistant and high-yielding lines with better seed size than the original source were identified.

Breeders must develop an appropriate selection scheme for identifying high-yielding and disease-resistant genotypes that depends on the nature of disease resistance of parents involved in selected crosses. In resistant x susceptible crosses, the F2 generation is screened in a wilt-sick nursery and resistant plants are identified. F3 and F4 progenies are also screened in disease nursery. Progenies having less than 10per cent wilt incidence are selected for yield evaluation in a normal disease-free field using released varieties as controls. Similar approaches are followed for other diseases.

The purity of released cultivars is affected by natural outcrossing and obtaining pure pigeonpea seed is a perennial problem. Special care is needed to maintain genetic purity of disease-resistant varieties so that resistance does not break down quickly. Basic seed stock should be maintained by selfing plants with muslin or nylon cloth bags or nets. For large-scale seed multiplication, a minimum isolation distance of 200 m should be maintained between cultivars.

Disease resistant varieties

Progress in breeding disease-resistant and high-yielding varieties was rather slow until the beginning of the decade. Only 10 disease-resistant varieties were released by 1988(ICAR 1988). Now, with the availability of improved screening techniques and good resistance sources, Indian resistance breeding programs have made significant progress. Since the 1982/83 season, many entries in the pigeonpea coordinated Trials (ACT) have shown resistance to wilt and sterility mosaic. Entries with resistance to sterility mosaic are much more numerous than those with wilt resistance. For example, 26 of 115 entries in ACT during 1988/89 showed resistance to sterility mosaic. Most of the disease- resistant cultivars in the ACT were contributed by Badnapur, Hisar, Dholi, Varanasi, Kanpur, and ICRISAT Center. In the current ACT entries such as ICPL 87119, AL1, H 76-51, H 76-65, ICPL 267, DA 12, BDN 31, PDA 86-1 and PDA 85-1 are showing resistance to both wilt and SM.

Variability in pigeonpea pathogens

Multilocation testing for disease resistance in India has indicated that fusarium wilt, sterility mosaic, and phytophthora blight pathogens vary in their pathogenic ability. Limited laboratory studies at ICRISAT Center also point to the possible existence of distinct pathogenic strains in sterility mosaic and phytophthora blight pathogens. However, further studies are necessary to precisely determine variability in the pathogens.

Gaps in knowledge and constraints

Some of the major gaps in our knowledge and the constraints with regard to breeding for disease resistance in pigeonpea are:

1. Lack of complete information on genetics and mechanisms of resistance to the major diseases;

2. Lack of concrete information on the variability present in the pathogens and on their distribution;

3. Lack of stable and high levels of resistance to phytophthora blight and;

4. Lack of objective disease rating scales and information on the extent of yield loss for each score or reaction category.

Future research goals

In addition to obtaining information on the abovementioned aspects, it is essential to increase research efforts on the following aspects.

1. Breeding of multiple disease-resistant and high-yielding varieties-At present, there are few varieties with resistance to two or more of the major diseases.

2. Development of short-duration varieties with resistance to phytophthora blight - At present, field tolerance for phytophthora blight is available in the medium and long duration background. Similar tolerance must be developed for the short-duration varieties.

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