

Research and Development Project Proposal

Addressing Phytophthora Blight Disease: An Emerging Threat to Pigeonpea Expansion and Production



Submitted to

**National Food Security Mission (NFSM)
Department of Agriculture & Cooperation
Ministry of Agriculture
Government of India**

Participating Institutes

**International Crops Research Institute
for the Semi-Arid Tropics (ICRISAT), Hyderabad
Banaras Hindu University (BHU), Varanasi
RAK College of Agriculture (RAKCA), Sehore
Punjab Agricultural University (PAU), Ludhiana**



**International Crops Research Institute
for the Semi-Arid Tropics**

This work
will be undertaken
as part of the



RESEARCH
PROGRAM ON
GrainLegumes

1. Project Title: Addressing Phytophthora Blight Disease: An Emerging Threat to Pigeonpea Production and Expansion

2. Participating Institutes

- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru- 502 324, Andhra Pradesh, India
- Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India
- RAK College of Agriculture (RAKCA), Sehore - 466 001, Madhya Pradesh, India
- Punjab Agricultural University (PAU), Ludhiana, India

3. Name and Designation of the Executive Authority of the Institute

ICRISAT Dr William D Dar
Director General
International Crops Research Institute for the Semi-Arid Tropics
Patancheru-502324, Andhra Pradesh, India
Phone: 91 40 3071 3222
Email: w.dar@cgiar.org

4. Project Duration: 4 years

5. Total Cost of the Project: Rs. 386.20 lakhs

6. Name and Address of Investigators

Principal Investigator:

Dr Mamta Sharma

Senior Scientist - Legumes Pathology

ICRISAT, Patancheru, 502 324, Andhra Pradesh

Tel: 040-30713493 (O), 09849925225 (M), Fax: 040-30713074

Email: mamta.sharma@cgiar.org

Co-Investigators:

ICRISAT: Dr Raju Ghosh

Visiting Scientist, Legumes Pathology,
ICRISAT, Patancheru-502324, Andhra Pradesh
Email: r.ghosh@cgiar.org

Dr CV Sameer Kumar

Pigeonpea Breeder, ICRISAT,
Patancheru-502324, Andhra Pradesh,
Email: c.sameerkumar@cgiar.org

BHU: Dr VB Chauhan

Professor, Mycology & Plant Pathology
Institute of Agricultural Sciences, Banaras Hindu University (BHU)
Varanasi, Uttar Pradesh, Email: vchauhan@bhu.ac.in

RAKCA : Dr D R Saxena

Principal Scientist & Head - Plant Pathology
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, R A K College of
Agriculture, Sehore 466 001, Madhya Pradesh, Phone: 07562227140,
Email: saxenadr@rediffmail.com

Dr AK Choudhary

Scientist, Plant Pathology
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, R A K College of
Agriculture, Sehore 466 001, Madhya Pradesh, Phone: 09977730309,
Email: akcpath21@gmail.com

PAU : Dr Livinder Kaur

Professor-Plant Pathology
Punjab Agriculture University (PAU), Ludhiana, Punjab
Email: livinder@rediffmail.com

7. Rationale and Background Information

Phytophthora blight (PB) of pigeonpea caused by *Phytophthora drechsleri* f. sp. *cajani* is emerging as a potential threat to pigeonpea production, especially when excessive rainfall within a short span of time create temporary flooding coupled with hot and

humid weather. Critical analysis of weather and PB incidence data of last one decade clearly indicate that whenever there is $\geq 300\text{mm}$ rainfall within week along with maximum ($28\text{-}35^\circ\text{C}$) and minimum ($12\text{-}24^\circ\text{C}$) temperature and relative humidity $>75\%$, the PB incidence has increased significantly and caused up to 100% grain yield losses irrespective of cropping system, soil types and cultivars. Widespread incidence of PB was recorded on local varieties, improved cultivars and newly developed hybrids of pigeonpea grown alone or in different intercropping system (Sharma et al., 2006; Pande et al., 2011). The PB epidemics were also reported from Karnataka, Maharashtra, Uttar Pradesh and other major pigeonpea growing areas in India.



Pigeonpea fields infected with *Phytophthora* blight.

Widespread resurgence of PB is a serious matter of concern under the present scenario of climate change. Several sources of resistance to PB reported in earlier studies were susceptible to PB under natural epiphytotic conditions at ICRISAT center and elsewhere in the field (Pande et al., 2011). Limited information is available on the biology and variability of the PB pathogen *P. drechsleri* f. sp. *cajani* and epidemiology and management of PB disease. Identification of resistant sources to PB of pigeonpea reported by Kannaiyan et al., 1981 is of limited use in the context of resurgence of PB under the climate change scenario. Therefore, there is an urgent need to streamline and prioritize the research activities to identify PB resistant pigeonpea cultivars and their deployment in farmers' fields for sustainable pigeonpea production.

In the above context, there is an immediate need to develop effective and repeatable screening techniques for evaluation of germplasm, and breeding materials for PB resistance. A set of carefully selected germplasm, cultivars, and high yielding breeding lines need to be screened under controlled environment conditions at ICRISAT-

Patancheru and at PB hot spot locations such as BHU-Varanasi, PAU-Ludhiana and RAKCA-Sehore, MP in India. There are immense opportunities for enhancing the production and productivity of pigeonpea through a rational deployment of cultivars/varieties with resistance/tolerance to PB. Moreover, small farmers in rainfed prone areas have limited resources, and are often unwilling to spend money on control measures until damage is visible. This may sometime lead to complete crop failures under favorable environmental conditions. Since chemical control for the management of soil borne diseases is not feasible, therefore, it is important to identify cultivars with resistance to PB, which can play a major role in reducing the losses due to the disease under subsistence farming conditions. It is envisaged that this project will mark a beginning in development of an effective breeding strategy for PB resistant pigeonpea under the changing climate scenario.

8. Project Goal:

The overall goal of the project is to improve farmers' income and nutrition by enhancing the stability of production and reducing the losses in pigeonpea due to Phytophthora blight through identification and dissemination of Phytophthora blight resistant cultivars.

9. Objectives:

1. Identify pigeonpea genotypes with resistance to Phytophthora blight of pigeonpea.
2. Evaluate resistant genotypes for stability of resistance at multi-locations.
3. Evaluate Phytophthora blight resistant genotypes in farmers' fields.
4. Technology exchange and capacity building in integrated management of Phytophthora blight.

10. Strategy and Approach

1. Standardization of resistance screening techniques to Phytophthora blight

Very little is known about the biology of the PB pathogen- *Phytophthora drechsleri* f. sp. *cajani* and the epidemiology of the disease. In this context, there is a need to standardize the environmental factors such as temperature, rainfall, relative humidity and photoperiod etc. responsible for PB development in seedling and adult plants in pigeonpea. These basic studies will help in identification and standardization of the components of reliable and repeatable resistance screening techniques both in green house/controlled environment and field for identification of resistance against PB.

2. Identification of sources of resistance to Phytophthora blight

A set of pigeonpea genotypes consisting of known sources of resistance to wilt and sterility mosaic disease (SMD) and the elite wilt and SMD resistant varieties released for cultivation in different regions will be screened for resistance to PB at ICRISAT using standardized screening techniques both in controlled environment/greenhouse and field. Selected lines will be then tested across locations (Patancheru-Andhra Pradesh, Varanasi-Uttar Pradesh, Ludhiana-Punjab, Sehore-Madhya Pradesh, Bharuch-Gujarat, Bangalore-Karnataka and Badnapur-Maharashtra) to identify genotypes with stable resistance to PB. The advanced generation breeding material identified in this project will be shared with scientists in the national program to select lines with resistance to PB, and adaptation to location specific agro-ecosystems.

3. Variability in *P. drechsleri* f. sp. *cajani*

The PB pathogen *P. drechsleri* f. sp. *cajani* can adapt to a wide range of environmental conditions and have a high phenotypic and genotypic variability. There is a need for the systematic and detailed investigations to understand the existing variability in isolates of *P. drechsleri* f. sp. *cajani* in India. Therefore the pathogen will be characterized for phenotypic (cultural, morphological and pathological variability) and genotypic variability to assess the diversity in the pathogen populations from the diverse agro-climatic regions, which could be further used for development of broad based resistant varieties and hybrids of pigeonpea.

4. Assessment of the effect of PB resistant cultivars on yield losses based on area under disease progress curves (AUDPC)

The AUDPC based on incidence of the disease will be used to determine the levels of host plant resistance that would be practically attainable and economically in pigeonpea cultivation. Studies on the effect of PB-resistant cultivars on AUDPC will also be useful in assessing the contribution of resistant germplasm in regulating pathogen populations, determine the levels of pathogen resistance needed in the newly developed cultivars, and the effectiveness of disease-resistant cultivars in IDM for a sustainable pigeonpea production.

5. Technology exchange and capacity building

The information on resistance screening techniques and selection criteria for PB resistance, sources of resistance and their potential in crop improvement for increasing crop productivity is the key to sustainable production of pigeonpea. Therefore, the project will place special emphasis on training of scientists from the NARS, to enhance the utilization of PB-resistant varieties in crop improvement.

11. Year-Wise Work Plan

Year 1

- Project planning and implementation meeting.
- Survey of major pigeonpea growing areas in India for occurrence and distribution of PB in pigeonpea.
- Study the etiology and biology of pathogen-*Phytophthora drechsleri* f. sp. *cajani*.
- Standardization of greenhouse screening techniques for evaluation of pigeonpea lines for PB resistance.
- Selection of pigeonpea varieties, germplasm and breeding lines for screening to PB resistance.

Year 2

- Annual review and planning meeting.
- Evaluate pigeonpea lines with resistance/tolerance to PB at hot spot locations such as Andhra Pradesh (ICRISAT, Patancheru), Uttar Pradesh (Varanasi), Madhya

Pradesh (Sehore), Punjab (Ludhiana), Gujarat (Bharuch), Karnataka (Bangalore) and Maharashtra (Badnapur).

- Conduct variability studies (cultural, morphological, pathological and molecular characterization) to determine the pathotype scenario of *P. drechleri* f. sp. *cajani*.

Year 3

- Annual review and planning meeting
- Confirm the resistance in pigeonpea advance lines, varieties, germplasm and breeding lines using standardized field screening techniques at all the collaborating institutes.
- Confirm the resistance with the location specific isolate in greenhouse at collaborating institutes.
- Multilocation evaluation of selected pigeonpea lines under varied agro-climatic conditions for stability of resistance.
- Seed multiplication of most promising PB resistant lines for on-farm distribution and evaluation.

Year 4

- Annual review and planning meeting.
- Screen the above identified PB resistant pigeonpea lines for one more year at all the locations to confirm the stability of resistance.
- Evaluate a set of selected PB resistant pigeonpea lines in farmers' fields under natural epiphytotic conditions.
- Seed multiplication of most promising PB resistant lines for on-farm evaluation.
- Training of NARS scientists in screening procedures of PB and selection for resistance.
- Documentation of the salient results of the project activities.
- Information Bulletin on PB screening techniques and resistant sources published.
- Submission of the final project report to the donor.

12. Expected Outputs

- Pathotype scenario of *Phytophthora drechsleri* f. sp. *cajani* in India known.
- Screening techniques (greenhouse and field) for identification of resistant sources for PB in pigeonpea developed.
- PB resistant pigeonpea lines identified as donor for direct use in the pigeonpea resistant breeding program.
- Information on PB basic research generated and shared with NARS institutes for their use in pigeonpea breeding program.

13. Adoption pathways and expected impacts

The research in this project will include both basic and applied aspects. The basic research will involve investigations on the biology of the pathogen and epidemiology of the disease including host range, dispersal and survival of the pathogen, pathogen variability including cultural, morphological and molecular characterization. The applied research will involve standardization of screening techniques for identification of resistant sources; identify resistant germplasm/breeding lines, multi-location evaluation of resistant genotypes for direct use in the breeding programs.

The project will benefit collaborating scientists in enhancing skill and R&D capacity for PB and for pigeonpea improvement. The project would provide opportunities to students and young researchers for improving their skills. The salient findings from this project will be published in form of research articles in peer reviewed Scientific Journals/Conference Proceedings and benefit the global scientific community.

The pigeonpea breeding programs of the participating institutes will further utilize the breeding materials and screening methods developed in this project and these efforts would ultimately lead to development of pigeonpea cultivars with PB resistant and suitable agronomic background. These PB resistant breeding lines would expand scope of growing pigeonpea in new niches and cropping systems and enhance productivity of pigeonpea in all growing conditions that expose pigeonpea to PB. These varieties will play an important role in mitigating the effects of climate change. The long term impacts of the outcome of this project would be enhanced income and nutrition of farmers through enhanced pigeonpea production.

14. Proposed summary budget: 386.16 lakhs

Particulars	ICRISAT	BHU	PAU	RAKCA	Total
Contractual staff	38.54	7.74	7.74	7.74	61.76
Operational	110.00	21.50	21.50	21.50	174.50
Travel	14.00	4.00	4.00	4.00	26.00
Contingency	11.50	5.00	5.00	5.00	26.50
Workshop	14.00	-	-	-	14.00
Equipment's	21.50	10.75	5.30	10.75	48.30
Sub total	209.54	48.99	43.54	48.99	351.06
Institutional overhead charges (10%)	20.97	4.91	4.35	4.91	35.14
Grand total	230.51	53.90	47.89	53.90	386.20

[Year wise detailed for each collaborating institutes is provided separately]

Year-wise budget for each collaborating institute (Rs. In lakh)

ICRISAT- Patancheru

Particulars	Year I	Year II	Year III	Year IV	Total
Special Project Scientist* (1) @ Rs.50,000/month with 5% increment /year	3.00	6.00	6.30	6.62	21.92
Research Associates** (1)@ Rs.24000+30% HRA/month)	1.87	3.75	3.75	3.75	13.12
Skilled worker (1) @ Rs. 8000/month	0.50	1.00	1.00	1.00	3.50
Operational costs (includes supplies and consumables for basic research in greenhouse/controlled environment/lab experiments, multi-location evaluation, on-station experiments, seed multiplication, irrigation and labor cost, etc.)	10.00	25.00	35.00	40.00	110.00
Travel (domestic)	2.00	3.00	4.00	5.00	14.00
Contingency (include cost for test location evaluation and miscellaneous)	1.00	3.00	3.50	4.00	11.50
Workshops/trainings (inception, annual review and planning meeting etc.)	2.50	3.00	4.00	4.50	14.00
Equipment's: [Deep freezer -20° to -40°C, Incubator (temp & RH control), Minispin centrifuge, 96 wel gradient thermal cycler for basic R&D related to project activities and maintenance]	20.00	0.50	0.50	0.50	21.50
Sub total	40.87	45.25	58.05	65.37	209.54
Institutional over heads @10%	4.09	4.53	5.81	6.54	20.97
Grand total	44.96	49.78	63.86	71.91	230.51

Note: Year-I budget calculated considering the financial year (Oct 2013- Mar 2014)

***As per national norms in CGIAR; **as per ICAR norms**

BHU- Varanasi

Particulars	Year I	Year II	Year III	Year IV	Total
Senior Research Fellow* (1) @ Rs.16000+15% HRA/month	1.11	2.21	2.21	2.21	7.74
Operational costs (includes the cost of supplies and consumables for Greenhouse/lab experiments and on-station evaluation, etc.)	1.50	5.00	7.00	8.00	21.50
Travel	0.50	1.00	1.00	1.50	4.00
Contingency	0.50	1.50	1.50	1.50	5.00
Equipment's: [Laminar air flow, Incubator and maintenance]	10.00	0.25	0.25	0.25	10.75
Sub total	13.61	9.96	11.96	13.46	48.99
Institutional over heads @10%	1.36	1.00	1.20	1.35	4.91
Grand total	14.97	10.96	13.16	14.81	53.90

***as per ICAR norms**

PAU- Ludhiana

Particulars	Year I	Year II	Year III	Year IV	Total
Senior Research Fellow* (1) @ Rs.16000+15% HRA/month	1.11	2.21	2.21	2.21	7.74
Operational costs (includes the cost of supplies and consumables for Greenhouse/lab experiments and on-station evaluation, etc.)	1.50	5.00	7.00	8.00	21.50
Travel	0.50	1.00	1.00	1.50	4.00
Contingency	0.50	1.50	1.50	1.50	5.00
Equipment's: [Laminar air flow, Incubator and maintenance]	5.00	0.10	0.10	0.10	5.30
Sub total	8.61	9.81	11.81	13.31	43.54
Institutional over heads @10%	0.86	0.98	1.18	1.33	4.35
Total	9.47	10.79	12.99	14.64	47.89

*as per ICAR norms

RAKCA, Sehore

Particulars	Year I	Year II	Year III	Year IV	Total
Senior Research Fellow* (1) @ Rs.16000+15% HRA/month	1.11	2.21	2.21	2.21	7.74
Operational costs (includes the cost of supplies and consumables for Greenhouse/lab experiments and on-station evaluation, etc.)	1.50	5.00	7.00	8.00	21.50
Travel	0.50	1.00	1.00	1.50	4.00
Contingency	0.50	1.50	1.50	1.50	5.00
Equipment's: [Laminar air flow, Incubator and maintenance]	10.00	0.25	0.25	0.25	10.75
Sub total	13.61	9.96	11.96	13.46	48.99
Institutional over heads @10%	1.36	1.00	1.20	1.35	4.91
Grand total	14.97	10.96	13.16	14.81	53.90

*as per ICAR norms

15. Log frame: Year wise time schedule of output based on activities

Activities by Objectives	Objectively Verifiable Indicators (output)	Time schedule (Year and months)			
		Year 1	Year 2	Year 3	Year 4
Objectives 1. Identify pigeonpea genotypes with resistance to Phytophthora blight					
1.1. Survey major pigeonpea growing areas for occurrence and distribution of PB in pigeonpea (~6 states)	Occurrence and distribution of PB known	√	√	√	
1.2. Study the etiology and biology of PB and <i>P. drechsleri</i> f. sp. <i>cajani</i>	PB disease cycle and development known	√	√		
1.3. Identification of the epidemiological components for standardizing resistance screening techniques	Identified components for standardization resistance screening techniques	√	√		
1.4. Standardization of resistance screening techniques in greenhouse and field for PB	PB resistance screening techniques standardized	√	√		
1.5. Variability studies of <i>P. drechsleri</i> f sp. <i>Cajani</i> (~6-7 isolates)	Pathotype scenario of Pdc known		√	√	√
1.6. Screening of pigeonpea germplasm/ breeding lines to PB	Sources of resistance to PB identified		√	√	√
Objective 2: Evaluate resistant genotypes for stability of resistance at multi-locations					
2.1. Evaluate PB resistant lines with location specific isolate in green house.	Variability in PB resistant reaction known		√	√	
2.2. Multi-location evaluation of PB resistant pigeonpea germplasm and breeding lines.(~6 locations)	Stable sources of resistance to PB known		√	√	√
Objective 3: Evaluate Phytophthora blight resistant genotypes in farmers' fields.					
3.1. Seed multiplication of most promising PB resistant/tolerant lines.	Seeds available for PB resistant /tolerant lines.			√	√
3.2. On-farm demonstrations of PB resistant lines.	PB-resistant lines tested on-farm, and their usefulness demonstrated to the farmers.				√
Objective 4: Technology exchange and capacity building in integrated management of Phytophthora blight.					
4.1. Project planning, implementation and review meeting. (1-2 meeting/year)	Preparedness for implementation for targeted activities.	√	√	√	√
4.2. Training NARS scientists, technicians and students in screening procedures of PB and selection for resistance. (20-30 professionals will be trained)	Training manuals/ brochures published.		√	√	√
4.3. One information Bulletin on PB disease published.	Information shared with NARS partners and research professionals				√

16. Project Summary

Title	Addressing Phytophthora Blight Disease: An Emerging Threat to Pigeonpea Production and Expansion
Goal	The overall goal of the project is to improve farmers' income and nutrition by enhancing the stability of production and reducing the losses in pigeonpea due to Phytophthora blight through identification and dissemination of Phytophthora blight resistant cultivars.
Objectives	<ol style="list-style-type: none"> 1. Identify pigeonpea genotypes with resistance to Phytophthora blight of pigeonpea. 2. Evaluate resistant genotypes for stability of resistance at multi-locations. 3. Evaluate the Phytophthora blight resistant genotypes in farmers' fields. 4. Technology exchange and capacity building in integrated management of Phytophthora blight.
Implementing Institutions/Organizations	<ul style="list-style-type: none"> • International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru- 502 324, AP, India • Banaras Hindu Agriculture University (BHU), Varanasi, Uttar Pradesh, India • R A K College of Agriculture, Sehore - 466 001, Madhya Pradesh, India • Punjab Agricultural University (PAU), Ludhiana, India
Principal Investigator	Dr Mamta Sharma, Senior Scientist, ICRISAT, Patancheru, 502 324, AP, Tel: 040-30713493, email: mamta.sharma@cgiar.org
Duration	4 Years
Pulse crop	Pigeonpea
Budget	Rs. 386.16 lakhs