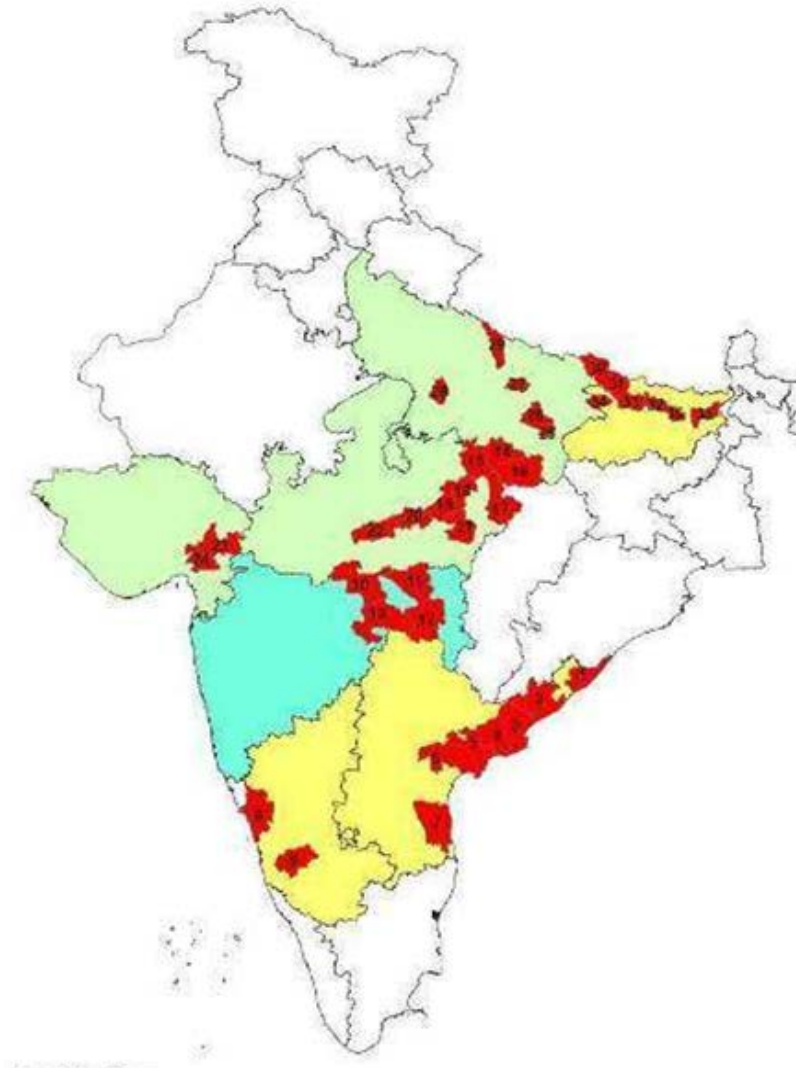
Proceedings of the Launching and Work Plan Meeting

of the NFSM-funded project

"Selection and Utilization of Water-logging Tolerant Cultivars in Pigeonpea"

JNKVV, Jabalpur, 29th June 2011



ICRISAT, JNKVV, BHU, IIPR, HAU, IARI

CONTENTS

	Page
Agenda of the Launching and work plan meeting	1
List of project members	2
Proceedings of the Launching and Work Plan Meeting	3
Session I: Welcome, remarks, introductions of participants, presentation of project objectives and previous research	3
Session II: Water logging issues related to pigeonpea cultivation	5
Session III: Work plan: logical time frame and technical program	7
Logical time frame	8
Technical Program	9
Appendix I: Project Proposal	18
Appendix II: Group picture	32

Launching and Work Plan Meeting
"Selection and Utilization of Water-logging Tolerant Cultivars in Pigeonpea"
(NFSM-funded Project)

June 29, 2011, DRS Meeting Hall, JNKVV, Jabalpur

AGENDA

SESSION I	***Chairman***	***G Kalloo***
	Rapporteur	***DK Mishra***
0900-0920	Welcome, remarks and introduction of participants	SK Rao
0920-0930	Project objectives and plans	MI Vales
0930-1000	"Water-Logging: A Neglected Production Problem"	R Sultana & L Krishnamurthy
1000-1010	Remarks by NFSM representative	S Lal
1010-1020	Remarks by Director of Research, JNKVV	SS Tomar
1020-1030	Address by Vice-Chancellor, JNKVV	G Kalloo

1030-1100 Photograph and Tea/Coffee Break

SESSION II	***Chairman***	***S Lal***
	Rapporteur	***D Khare***
1100-1115	Pigeonpea water-Logging issue in MP	JNKVV
1115-1130	Pigeonpea water-Logging issue in Haryana	HAU
1130-1145	Pigeonpea water-Logging issue in Punjab	PAU
1145-1200	Pigeonpea water-Logging issue in Delhi	IARI
1200-1215	Pigeonpea water-Logging issue in Central UP	IIPR
1215-1230	Pigeonpea water-Logging issue in Eastern UP	BHU

1230-1330 Lunch Break

SESSION III	***Chairman***	***KB Saxena***
	Facilitator	***MI Vales***
	Rapporteur	***R Sultana***
1330-1510	*Work plan matrix*: Objectives 1-5, years 1-5	

1510-1530 Tea/Coffee Break

1530-1700 *Work plan for year 1*
Formation of working groups
Plant materials
Methods and equipment
Locations: on farm, on station, laboratory
Next meeting: Location and date

1700-1730 Closing remarks

1830 Dinner

List of project members

Alphabetic list of scientists involved in the project "Selection and Utilization of Water-logging Tolerant Cultivars in Pigeonpea" and their respective contact information.

Last name	Full name	Role	Email 1	Phone no. mobile	Institution
Chaturvedi	Dr. S.K. Chaturvedi	Co-principal investigator	skchaturvedi@icar.org.in	9336214977	IIPR
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"Selection and Utilization of Water-logging Tolerant Cultivars in Pigeonpea"

JNKVV, Jabalpur, 29th June 2011

Session I: Welcome, remarks, introductions of participants, presentation of the project objectives and previous research

Chairman: Professor Gautam Kalloo

Rapporteur: Dr. A.N. Shrivastava

The session started with a welcome address by Dr. S.K. Rao. He pointed out that this is a new research area and there is a need to understand the water-logging problems in Pigeonpea in order to find solutions. He also emphasized the need for developing a strong technical program.

Dr. Isabel Vales outlined the objectives and plans of the project. She stated that the main goal of the project is to develop water logging tolerant cultivars for use in poorly drained and low lying areas. In this project, besides ICRISAT six other institutions JNKVV, BHU, IIPR, IARI, HAU, and PAU are the network partners. The general objectives of the project are to (i) identify high yielding water logging, salinity and *Phytophthora* tolerant lines, (ii) incorporate water logging tolerance into locally adapted and popular varieties, and (iii) conduct on farm validation of the water logging tolerance genotypes. She also stated that important activities should include confirmation of water logging tolerance (combined with salinity and *Phytophthora* tolerance, if possible) on research stations and on-farmer's fields, seed multiplication, evaluation and association of morphological, physiological, and molecular markers with water tolerance in pigeonpea.

Dr. Rafat Sultana and Dr. L Krishnamurthy jointly delivered a presentation entitled "Water logging - a forgotten problem in pigeonpea". Dr Sultana narrated the importance of the pigeonpea crop, highlighted the yield and economic losses due to abiotic stresses. She also stated the ill effects of water logging in the forms anoxia, epinasty, and poor nutrient uptake. She also mentioned some cultural options to minimize the detrimental effects of water logging. The standardization of methodologies for screening at various critical developmental stages of the crop in the laboratory,

pot and field conditions were described based on previous work done at ICRISAT. Dr. Sultana indicated that water-logging tolerant hybrids, varieties, and lines have been identified in preliminary studies. Dr. Krishnamurthy focused on the screening of germplasm accessions from the ICRISAT's GeneBank and outlined the presence of water-logging tolerant accessions.

Dr. Shankar Lal, Ex-Director IIPR and ADG, ICAR in his remarks, enquired about the role of nitrogen application and seed coating in reducing the adverse effects of water logging. In his opinion, in most of the pulse crops (except Pigeonpea), drought tolerant genotypes also exhibit tolerance to water logging. He suggested that the screening for water logging tolerance should be done in Bihar, Jharkhand and West Bengal while PAU and HAU should work on salinity tolerance. He suggested that thorough back crossing the tolerance should be incorporated as it is governed by a monogenic dominant gene. Dr. Raj K. Gupta, Advisor BISA, CIMMYT, emphasized the screening of inbreds to develop tolerant hybrids.

Dr. S.S. Tomar, Director Research Services, shared information regarding cultivated and water logged areas of Madhya Pradesh. He also described the advantages of raised beds and ridge-furrow system for cultivation of pigeonpea in the problematic areas. Dr Tomar also referred to the work of Dr. D. Khare in screening of soybean genotypes for water logging tolerance.

The Honorable Vice-Chancellor, JNKVV, Jabalpur, Prof. Gautam Kalloo in his address mentioned that this project is the first of its kind in pulses. He stated that in the past, focus was given mostly on drought resistance in different crops and the first project on excessive moisture tolerance was launched in maize. He illustrated that lots of complexities and factors are associated with excessive moisture tolerance. He emphasized on three most important indexes viz. anoxia, epinasty and ethanol production in the breeding of tolerant genotypes. In his opinion, high temperature associated with water logging is more injurious to the crop. He suggested the need for basic, strategic, and applied research to combat the problem in an effective manner. The session ended with a thank you note given by Dr. K.B. Saxena.

Session II: Water logging issues related to pigeonpea cultivation

Chairman: Dr. Shankar Lal

Rapporteur: Dr. D. Khare

Dr. (Mrs.) S. Rao, Professor and Head Department of Plant Physiology, JNKVV, Jabalpur presented the current situation of water-logging problem in pigeonpea cultivation in the state of Madhya Pradesh. She informed the house that pigeonpea is cultivated in 320,000 ha of land, of which 56% is affected by excessive moisture. Water-logging is mainly due to high rainfall in the months of July and August, particularly in heavy black soils. The water logging stress is a serious issue in the agro-climatic zones of Kaymore plateau, Satpura hills, Central Narmada valley and Northern hills of Chattisgarh. Delayed sowing, poor plant population and infection of *Phytophthora* are the main constrains of cultivation of pigeonpea under excessive moisture. She also informed about the preliminary work on excessive moisture tolerance in pigeonpea and soybean conducted at the University.

Dr. Ramdhari, Principal Scientist, CCSHAU, Hisar highlighted the water-logging issue in pigeonpea cultivation in Haryana. In Haryana, short duration pigeonpea varieties viz., Paras and Manak are popular under Pigeonpea-wheat rotation. These varieties mainly encounter the problem of salinity along with excessive moisture due to the high water table. So far, pigeonpea has not been screened against stress due to salinity combined with water-logging. The cultivated areas of Hissar, Jhajjar and Jind are mainly affected by high water table and salinity.

Dr. Sarbjeet Singh, Principal scientist, PAU, Ludhiana discussed the problem of water-logging and salinity in the state of Punjab. The districts of Faridkot, Ferozpur, Muktasar and Sangrur located in the south western part of Punjab are affected by salinity and water-logging with high water table. The area affected by salinity and water-logging is nearly 85,000 ha in Punjab.

Dr. Ranjeet Raje, Pigeonpea Breeder, IARI, New Delhi presented the work done on water-logging in IARI. He described morphological, physiological and biochemical factors associated with water-

logging in pigeonpea. He also discussed factors to be observed and screening technique along with symptoms of water-logging on pigeonpea.

Dr. A.K. Chaudhary, Pigeonpea Breeder, IIPR, Kanpur discussed the problems associated with cultivation of pigeonpea under water-logging situation in North eastern Plain Zone of India. In this zone, extended temporary water-logging reduces germination and plant height and delays flowering, resulting in reduced pod set. Genotypic differences were observed for these traits with more sensitivity to water-logging in early varieties in comparison to late varieties.

Dr. MN Singh, Pigeonpea Breeder, BHU, Varanasi highlighted the problem of water-logging in cultivation of pigeonpea in Eastern UP.

The chairman suggested that HAU and PAU should make a common program of salinity and water-logging with short term objectives to solve the problem of farmers. Dr. K.B. Saxena suggested that the program should be finalized in consultation with Dr. Raj K. Gupta involving management as a component of the project.

Recommendations of the session

- For each maturity group at least two centers must work on screening and introgression of the trait.
- For HAU and PAU specific plan has to be prepared with consultation of Dr. Raj. K. Gupta involving salinity and alkalinity along with water logging.
- The work on management of water-logging and salinity in cultivation of pigeonpea should also be considered for direct recommendation to the farmers.
- Varieties screened out as tolerant to water-logging should be recommended for cultivation under stress prone areas immediately.
- Adoption of uniform and perfected technology for screening of water-logging tolerant genotypes.
- Demonstration of tolerant varieties on the farmers' field.
- All the equipment's must be procured by ICRISAT and delivered to the respective centers.

Session III: Work plan: logical time frame and technical program

Chairman: KB Saxena

Facilitator: MI Vales

Rapporteur: R Sultana

In the last session, Dr. Isabel Vales distributed a logical time frame to each partner institution and requested them to discuss how they could contribute towards the final goal of the project by indicating which project activities they can address and how long it would take to do it. She pointed out that this logical time frame will clearly delineate the responsibilities and also to keep track of project activities' progress in order to focus on the target.

Logical time frame illustrating the involvement of partners in the different activities associated in the NFSM-funded project entitled "Selection and Utilization of Water-logging Tolerant Cultivars in Pigeonpea"

Year	Activity	1. Confirmation/screening for WL tolerance	2. Seed multiplication	3. Evaluation for WL+Salinity	4. Evaluation for Phytophthora tolerance	5. Identification of physiological linked traits	6. Identification of morphological linked traits	7. Identification of contrasting polymorphic parents	8. TxS crosses to to develop mapping population/s	9. Marker-trait association studies	10. Introgression of the traits into the elite lines	11. On-farm validation of tolerant lines	12. Crop management	13. Summarize and share results	
	ICRISAT	X	X			X	X	X	X					X	Medium maturity
	IIPR	X	X				X		X			X		X	Early maturity
	JNKVV	X	X			X	X					X		X	Medium maturity
2011	PAU			X	X	X	X						?	X	Early maturity (WL+Salinity)
	HAU		X	X									X	X	Early maturity (WL+Salinity)
	BHU	X	X		X							X		X	Long duration
	IARI	X	X			X	X		X			X		X	Early
	ICRISAT	X	X		X	X	X	X	X					X	
	IIPR	X	X				X		X			X		X	
	JNKVV	X	X		X	X	X					X		X	
2012	PAU		X	X	X	X	X					X	?	X	
	HAU		X	X								X	X	X	
	BHU	X	X		X	X	X					X		X	
	IARI	X	X			X	X		X			X		X	
	ICRISAT	X	X		X	X	X		X					X	
	IIPR	X	X		X		X		X			X		X	
	JNKVV	X	X		X	X	X					X		X	
2013	PAU		X	X	X	X	X					X	?	X	
	HAU		X	X								X	X	X	
	BHU	X	X		X	X	X				X	X		X	
	IARI	X	X			X	X		X			X		X	
	ICRISAT	X	X		X	X	X		X	X	X			X	
	IIPR	X	X		X		X		X			X		X	
	JNKVV	X	X		X	X	X				X	X		X	
2014	PAU		X	X	X	X	X				X	X	?	X	
	HAU		X	X							X	X	X	X	
	BHU											X			
	IARI	X	X			X	X		X	X		X		X	
	ICRISAT	X	X		X	X	X		X	X	X			X	
	IIPR	X	X		X		X		X			X		X	
	JNKVV	X	X		X	X	X				X	X		X	
2015	PAU		X	X	X	X	X				X	X	?	X	
	HAU		X	X							X	X	X	X	
	BHU	X	X		X	X	X				X	X		X	
	IARI	X	X			X	X		X	X		X		X	

TECHNICAL PROGRAM: 2011-2012

Activity1: Confirmation/screening of water logging tolerance in Pigeonpea

Seeds of following genotypes (early, medium and late) will be distributed by ICRISAT to **ALL** locations to confirm water-logging tolerance while seeds of highlighted genotypes will be distributed by IIPR, Kanpur. Seeds will be planted and evaluated for water-logging tolerance by the procedure written below.

Early:

ICPB 2039 and ICPH 2431,

Susceptible Check: UPAS 120

Medium:

ASHA, Maruti, JBP 110-B, LRG 30, ICPH 2740, ICPH 2671,

ICP 14085, ICPL 87051, ICPL 332, ICPL 99050, ICPL 20241, ICPL 2038, ICPL 2037, ICPL 20128, ICPL 20126, ICPL 20125, ICPL 20123 and ICPL 20120

Susceptible Check: ICP 7035

Late:

MAL 9, ICPL 20092, KPL 43, KPBR 80-2-2, IPAPB 7-2-1, IPAPB 7-2-2, IPAPB 7-2-3 (IIPR)

Susceptible Check: ICP 7035, DA 11 (IIPR),

Experiment 1a: Confirmation of WL Tolerance on station field trials (ICRISAT, IARI, IIPR, JNKVV, BHU)

General considerations and data collection

Design: RCBD, 3 replications

Plot size: 2 rows, row length 4 m.

Fertilizer: 20N:60P:20K Kg/ha

Spacing: 75 x 30 cm

Sowing should be done on flat (no ridges) vertisol fields.

Plant 1 grain per hill.

Screening Procedure: Forty days after sowing plants will be exposed to artificial waterlogging treatment for a period of 8 days; level of water should be maintained ± 5 cm above the soil surface. Fields will be drained out after the completion of treatment

Soil and meteorological observations

To observe the effect of water-logging on soil health; soil analysis before sowing (pH, Electrical conductivity, Nitrogen) and 30 days after the water-logging treatment will be carried out.

Water analysis (pH, EC): water source used for flooding will be recorded.

Meteorological data from sowing to harvesting (Temperature, humidity, precipitation, number of rainy days, rainfall distribution, solar radiation, and wind speed) will be recorded.

Physiological observations

Leaf senescence score per plot (1-5 scale; 1= 100% full plant green; 2= 75% green; 3= 50% green; 4= 25% green; 5= full yellow). Time: 8 days after drainage.

Chlorophyll content I: before water-logging treatment chlorophyll content will be measured using SPAD Chlorophyll meter from the fully expanded leaflet. Measure 3 plants per plot.

Chlorophyll content II: 8 days after completion of water-logging treatment chlorophyll content will be measured using SPAD Chlorophyll meter from the fully expanded leaflet. Measure 3 plants per plot.

Dissolved oxygen reading: Amount of dissolved oxygen will be measured daily from the beginning to the end of the treatment at a fixed time (at 11 a.m.). Record observations from 5 randomly chosen sites within the experimental field.

Root capacitance: 8 days after drainage of the field. Measure 3 plants per plot. If plants will be too thin to fix banana clip then please hold this observation till flowering.

Morphological/agronomic observations

(Measure morphological observation in 5 plants per plot)

Plant stand before water logging treatment.

Plant stand 8 days after water logging treatment (drainage).

Survival percent: (Plant stand at 8 days after water logging/plant stand before water-logging treatment) *100

Plant height at 50% flowering

Number of primary branches

Number of pods per plant

Weight of 100 seeds

Percent of shriveled seeds

Yield per plant (g)

Yield per plot (g)

Yield per ha

Percentage of plants damaged by *Phytophthora* (linked to activity 4).

Experiment 1b: Screening of germplam and new lines for WL Tolerance (All locations)

The materials included in this trial will be defined by each location based on their own interest (i.e. advanced breeding lines, locally adapted varieties, etc.) and additional lines of interest (to be defined, i.e. Genebank stocks)

i) Laboratory screening

Use germinators (if possible) at 25^{o}C or at ambient conditions.

Use seed from the previous season (if possible)

Pre-treat seed with Thiram (@ 3 g/kg of seed)

Design: CRD, 4 reps, 25 seeds per rep

Treatments:

- Control: place the seeds directly in petri plates (use 2 layers of blotting paper), maintain normal moisture.

- *168 h** (optional): maintain the seeds inside a beaker (200 mL sterilized water for 168 hours)

- *192 h**: maintain the seeds inside a beaker (200 mL sterilized water for 192 hours)

* After the submergence treatments place the seeds in petri plates (use 2 layers of blotting paper), maintain normal moisture.

Data collection

Germination percentage: 8 days after removing from the treatment.

Vigor index (on dry weight basis): Take 5 random normal seedlings from each rep and dry them in the over at 60 C for 3-4 days or until the sample turns crispy. Vigor index formula: (Mean germination percentage X mean dry weight of the 5 seedling)

ii) Pot screening (only at ICRISAT and JNKVV)

Materials:

Selected tolerant lines from the laboratory screening (i)

Controls: verified tolerant and susceptible lines.

Pots: 4 in. pots

Soil: use sterilized vertisol, FYM manure (3 soil:1 manure v/v), NPK (@20:60:20 per ha)

Design: CRD, 4 reps, 4 plants per pot, 1 in depth

Treatment:

21 days after sowing place the pots into tubs filled with water (1 in above the pots – growing tip of plants should be above the water level). Maintain water levels for 21 days. After the treatment remove the pots from the tubs and let them recover for 8 days.

Data collection:

Survival rate (calculate at 8 days after the submergence treatment is over).

Important: let the WL tolerant plants reach maturity and harvest selfed seed for further seed increase or field screening (if enough seed is produced).

Activity 2: Seed multiplication

Seed of tolerant and susceptible lines will be provided by ICRISAT/ IIPR (Year 1)

All centers will be involved in seed multiplication in subsequent years.

Use insect-proof nets

Activity 3: Evaluation of WL + Salinity (HAU, PAU)

Experiment 3a: Confirmation of WL + Salinity tolerance on station field trials

No field screening in 2011 (HAU, PAU)

Experiment 3b: Screening of germplam and new lines for WL + salinity tolerance (HAU, PAU)

i) Laboratory screening

Early:

ICPB 2039 and ICPH 2431,

Susceptible Check: UPAS 120

Medium:

ASHA, Maruti, JBP 110-B, LRG 30, ICPH 2740, ICPH 2671,

ICP 14085, ICPL 87051, ICPL 332, ICPL 99050, ICPL 20241, ICPL 2038, ICPL 2037, ICPL 20128, ICPL 20126, ICPL 20125, ICPL 20123 and ICPL 20120

Susceptible Check: ICP 7035

Late:

MAL 9, ICPL 20092, KPL 43, KPBR 80-2-2, IPAPB 7-2-1, IPAPB 7-2-2, IPAPB 7-2-3 (IIPR)

Susceptible Check: ICP 7035, DA 11 (IIPR)

Additional lines of interest (to be defined, i.e. Genebank stocks)

Use germinators (if possible) at 25^{o}C or at ambient conditions.

Use seed from the previous season (if possible)

Pre-treat seed with Thiram (@ 3 g/kg of seed)

Design: CRD, 4 reps, 25 seeds per rep

Treatments:

- Control: place the seeds directly in petri plates (use 2 layers of blotting paper), maintain normal moisture.
- *168 h**: maintain the seeds inside a beaker (50 mM NaCl –based on optimization trials- in 200 mL sterilized water for 192 hours)

* After the submergence treatments place the seeds in petri plates (use 2 layers of blotting paper), maintain normal moisture.

Data collection

Germination percentage: 8 days after removing from the treatment.

Vigor index (on dry weight basis): Take 5 random normal seedlings from each rep and dry them in the over at 60 C for 3-4 days or until the sample turns crispy. Vigor index formula: (Mean germination percentage X mean dry weight of the 5 seedling)

ii) Pot screening

Materials:

Selected tolerant lines from the laboratory screening (i)

Controls: verified tolerant and susceptible lines.

Pots: 4 in pots

Soil: use sterilized vertisol, FYM manure (10 soil:1 manure v/v), NPK (@20:60:20 per ha)

Design: CRD, 4 reps, 4 plants per pot, 1 in depth

Treatment:

21 days after sowing place the pots into tubs filled with 50 mM NaCl in water (1 in above the pots – growing tip of plants should be above the water level). Maintain water levels for 21 days. After the treatment remove the pots from the tubs and let them recover for 8 days.

Data collection:

Survival rate (calculate at 8 days after the submergence treatment is over).

Important: let the WL tolerant plants reach maturity and harvest selfed seed for further seed increase or field screening (if enough seed is produced).

Activity 4: Evaluation for *Phytophthora* tolerance

Data: Percentage of plants damaged by Phytophthora.

All the centers in experiment No. 1 (observations under field conditions)

Evaluations under controlled conditions (years 2-5)

Activity 5: Identification of Physiological Linked Traits (connect to experiment 1a)

All the centers in experiment No. 1

List of observation and procedure will be provided by ICRISAT

Activity. 6: Identification of Morphological Linked Traits (connect to experiment 1a)

All the centers in experiment No. 1

List of observation and procedure will be provided by ICRISAT

Activity 7: Identification of contrasting polymorphic parents

Genotypes: all indicated in experiment 1

Collect tissue

Isolate DNA

Screen for SSR and SNP polymorphisms

Centers: ICRISAT (2011, 2012)

Activity 8: T X S crosses to develop mapping populations

Selected water logging tolerant and susceptible genotypes will be crossed to generate F_1s to initiate the development of recombinant inbred line populations (RILs) for genetic studies.

Medium duration RIL (ICRISAT)

Short duration RIL (IIPR, IARI)

Activityt 9: Marker-trait association studies

Screening Centers for phenotyping: JNKVV, IIPR, IARI,ICRISAT

Genotyping center: ICRISAT (it will be conducted in 2014, 2015)

Activity 10: Introgression of the traits into the elite lines

Centers: All (It will be conducted during the last two years of the project)

Activity 11: On Farm demonstrations of water logging tolerant Lines

Waterlogged–prone farmer's fields will be selected for on farm demonstrations.

Early:

ICPB 2039,

Check: UPAS 120,

Centers: IIPR, IARI, HAU, PAU

Medium:

Asha, ICPH 2740

Check: ICP 7035

Centers: ICRISAT, JNKVV

Late:

IPA 203,

Check: ICP 7035

Center: BHU

Plot size 0.1 Ha, Check 0.05 Ha,

Site: 4 per location

Use spacing recommended for each maturity group. Plant one grain per hill. Apply pesticides as needed/recommended for normal crop production.

Observations

Field emergence percentage

Phytophthora damage score

Yield

Activity 12: Crop Management (HAU & PAU)

This activity was not included in the funded proposal, however based on the interest raised during this meeting, efforts will be made to explore options.

Year 1 program will be finalized by HAU and PAU in consultation with R.K. Gupta

Activity 13: Summarize and share results (all centers)

- All centers will provide progress reports half yearly to Isabel Vales (i.vales@cgiar.org) ICRISAT) for compilation and submission to NFSM.
- A mid-term review will take place in Varanasi in November 2011. ICRISAT will send letter to the VC of BHU for approval.
- Annual meeting will be conducted in the month of April to review progress and develop plans for subsequent years.

Additional considerations:

- All centers suggested that ICRISAT should buy the equipment associated with this project. The equipment will be distributed to the corresponding collaborators.

- NFSM will release project funds to ICRISAT and ICRISAT will relocate funds to the collaborating institutes.

- A monitoring team will be constituted to assess the progress and proper implementation of the program.

Appendix 1: Project Proposal

Selection and Utilization of Water-logging Tolerant Cultivars in Pigeonpea

Project Goal

To develop water-logging tolerant pigeonpea cultivars for use in poorly drained and low lying areas.

Project Coordinators

- Dr K B Saxena, Principal Pigeonpea Breeder, ICRISAT.
- Dr N Nadarajan, Director, IIPR, Kanpur.

Participating Institutions

- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324 (A.P.)
- Indian Institute of Pulses Research (IIPR), Kanpur 208 024 (U.P.)
- Banaras Hindu University (BHU), Varanasi, (U.P.)
- Jawaharlal Nehru KrishiVishwavidyalaya, (JNKVV), Jabalpur- 482 004 (M.P.)
- Indian Agricultural Research Institute (IARI), New Delhi 110 012
- Punjab Agricultural University (PAU), Ludhiana (Punjab)
- Haryana Agriculture University (HAU), Hisar, Haryana

Project Duration – Five years

Total project Budget - Rs. 628.8 lakhs

Principal Investigators

- ICRISAT Dr. M. Isabel Vales
- IIPR Dr. A. K. Choudhary
- IARI Dr. R. S. Raje
- PAU Dr. S. J. Singh
- JNKVV Dr. D. Khare
- BHU Dr. M. N. Singh
- HAU Dr. R. Dhari

Co- Principal Investigators

- ICRISAT Drs V. Vadez, S. Pande, R. Varshney
- IIPR Dr. S. K. Chaturvedi
- IARI Dr. Sai Ram
- PAU Drs. J. Kaur, L. Kaur, O.P. Choudhary
- JNKVV Drs. S. Rao and S.K. Rao
- BHU Dr. Praveen Prakash

Expected Outputs

- Water-logging and *Phytophthora* tolerant pigeonpea cultivars available to farmers for cultivation in low-lying areas.
- Water-logging tolerant genotypes and research results shared with partners.
- Traits associated with water-logging tolerance identified and used in breeding.
- Molecular markers linked with water-logging tolerance available.

Benefits/ Outcomes

- Losses caused by water-logging in pigeonpea reduced.
- Water-logging tolerant cultivars will find new production niches in the flood prone areas.
- Farmers able to harvest good yields under temporary water-logged conditions.
- NARS partners have access to improved genetic materials for breeding locally adapted high yielding water-logging tolerant varieties.
- Information on the mechanisms and inheritance of water-logging tolerance available for use in breeding programs.

Rationale and Background Information

Pigeonpea is the second largest pulse crop of India accounting for 18.2% of the total pulse production (17.29 m t) during 2010-11. Excessive rainfall during the early growth and flowering stages of the crop leads to about 20-25% annual yield losses in pigeonpea. Over 0.5 million tons of pigeonpea seeds are imported annually to meet the domestic demand. Hence, efforts are needed to increase the production through higher yielding varieties and hybrids and/or by expanding production niches into non-traditional areas, and increased resilience to stresses such as drought and water-logging.

In India, pigeonpea is mainly grown in regions with mean annual rainfall between 600 and 1,500 mm. Water-logging (excess ground saturation) has emerged as one of the major production constraints in these regions during the past few years. This situation is likely to be aggravated further with climate change, thereby increasing the probability of erratic rainfall and temporary flooding. The National Commission on Agriculture (India) assessed that in 2005 about 0.60 million ha land was waterlogged in the country. Out of this, 0.34 million ha was estimated to be suffering from surface water stagnation, while 0.26 million ha had a significant rise in water table. Also, during 2008-2009, Ministry of Agriculture estimated that each year about 0.85 million ha area experiences water-logging. Soil water-logging and salinity are often associated in the northern States of Punjab and Haryana resulting in damage to pigeonpea plants due water-logging but also to salt accumulation in the root zone. A comparative study of pigeonpea growing regions revealed that almost all the major states that grow pigeonpea are affected by water-logging for different durations (Fig. 1, Table 1) and the worst affected states are Uttar Pradesh, Madhya Pradesh, Gujarat, Andhra Pradesh, Maharashtra, Karnataka and Bihar.

Recently, ICRISAT scientists have developed laboratory and field screening methods to simulate flooding conditions to screen pigeonpea genotypes for their tolerance to water-logging. The prominent symptoms of water-logging susceptibility in pigeonpea include chlorosis and senescence of leaves, reduced root and shoot mass and low yield. It was also observed that apparent photosynthetic rate, leaf stomata conductance, and leaf N concentration were adversely affected after three days of water-logging. The water-logged conditions in the field also damage the root system through anoxia and production of ethylene. The water-logging situation blocks air (O_2) supply to roots by clogging the air spaces and inhibiting root respiration. Water-logging also results in a severe decrease in the energy status of root cells that reduces the uptake of nutrients and water, and synthesis of root hormones. Water-logging also pre-disposes pigeonpea plants to *Phytophthora* disease. The identification of important traits associated with water-logging tolerance will help in developing new pigeonpea varieties.

Table 1. Estimates of water-logged area in major pigeonpea growing states of India during 2006-07.

Pigeonpea growing areas		Area		
States	**Districts**	**Total (ha)**	**Water-logged (ha)**	**Area under water-logging (%)**
Bihar	Champaran, Darbhanga,Muzaffarpur, Siwan, Purnia, Shaharsa	30000	20000	66.6
Gujarat	Broach, Baroda	250000	190000	76.0
Madhya Pradesh	Jabalpur, Sidhi, Satna, Katni, Rewa, Mandla, Hoshangabad,Narsinghpur	320000	180000	56.2
Uttar Pradesh	Varanasi, Kanpur, Faizabad, Jaunpur, Bahraich	380000	160000	42.1
Maharashtra	Amravati, Yeotmal, Chandrapur, Nagpur	1110000	220000	19.9
Andhra Pradesh	Srikakulam, Vishakhapatnam, East & West Godavari, Krishna, Guntur, Nellore	490000	74000	15.0
Karnataka	Chickmagalur, Uttara Kannada	600000	60000	10.2
Total		**3,180,000**	**904,000**	**29.0**

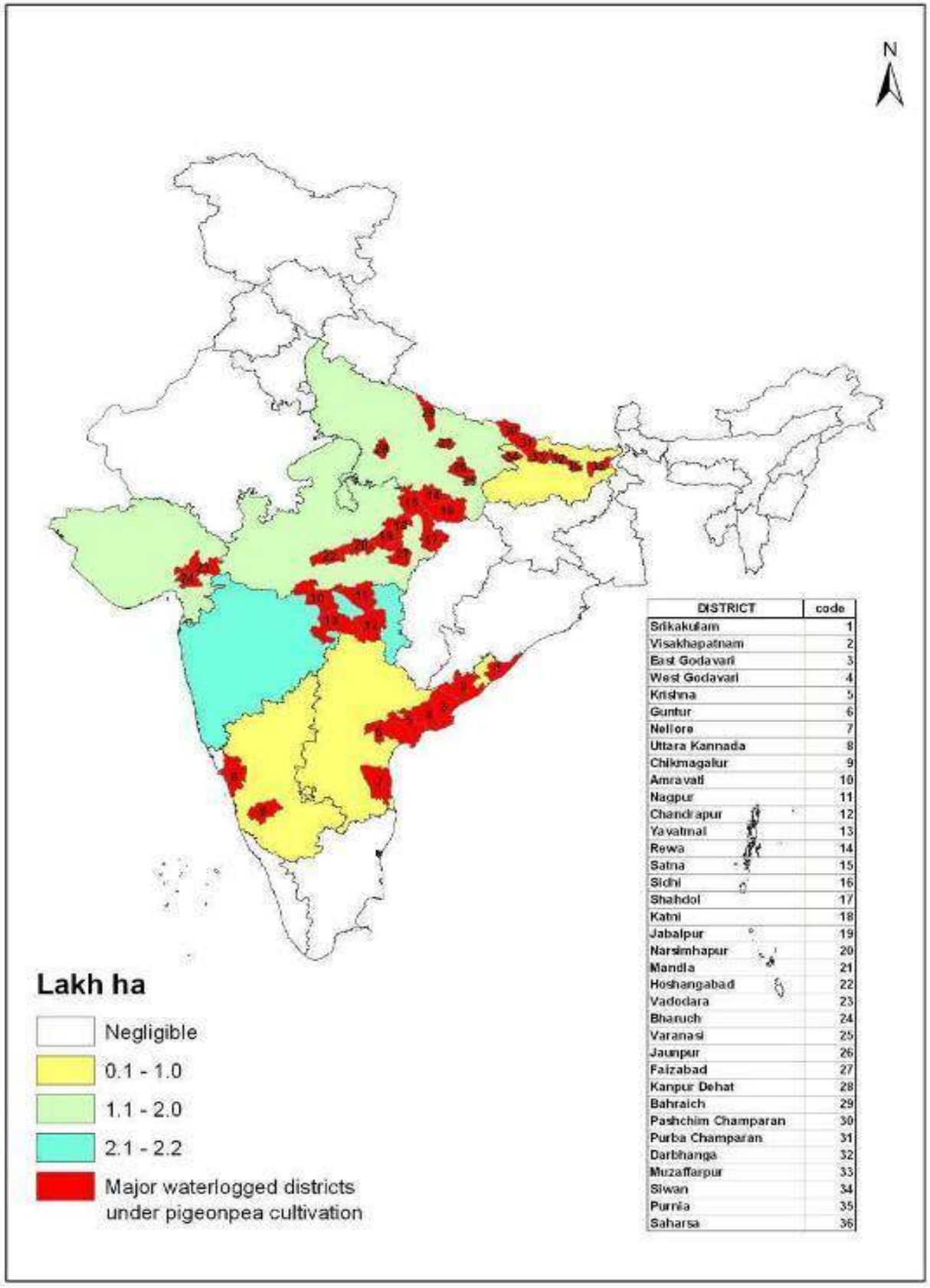

Fig.1. Waterlogged areas in the major pigeonpea growing states in India.

Highlights of the initial research on water-logging at ICRISAT

Scientists at ICRISAT have initiated research to identify genotypes tolerant to different water submergence conditions. The highlights of this research are given below:

- Screening of 500 germplasm under laboratory and field conditions in 2009 showed the presence of a significant genetic variation for water-logging tolerance, offering an opportunity to breed pigeonpea varieties for water-logging tolerance.

- Promising lines were further screened in 2010 for water-logging tolerance under field conditions and some of them survived the extended period of 45 rainy days, and flooding with a total rainfall of 950 mm (Fig 2).

- The water-logging tolerant genotypes identified after seedling screening under field conditions (Table 2) included hybrids (ICPH Nos. 2431, 2967, 2740, 4187), varieties (Asha, LRG 30, Maruti, MAL 9, Abhaya), and advanced breeding lines (ICPLs 20092, 20117, 20123, 20128, 20237, 20238, and 99050) .

- The selected genotypes will be used to study the genetic and physiological basis of water-logging tolerance, and to generate mapping populations for the development of molecular markers.

- The selected lines that survived rigorous water-logging screening of seedlings can be used directly as cultivars after appropriate on-station and on-farm testing under water-logged prone varieties.

- Water logging tolerant varieties could be available for cultivation by farmers in as short a period as 4-5 years.

Table 2: Pigeonpea genotypes showing tolerance to water-logging stress under field conditions.

	Reaction to major biotic and abiotic stresses			Yield
Pigeonpea genotypes	**Water-logging**	**Wilt**	**Sterility mosaic**	**(kg/ha)**
Varieties				
Asha	Tolerant	**R**	**R**	2230
LRG 30	Tolerant	S	**R**	1900
MAL 9	Tolerant	**R**	**R**	1800
Maruti	Tolerant	**R**	S	1440
Abhya	Tolerant	S	**R**	1702
Hybrids				
ICPH 2431	Tolerant	S	S	1519
ICPH 2671	Tolerant	**R**	**R**	2156
ICPH 2740	Tolerant	**R**	**R**	2898
ICPH 3362	Tolerant	**R**	**R**	2145
ICPH 3964	Tolerant	**R**	**R**	1573
ICPH 3992	Tolerant	**R**	**R**	1437
ICPH 4031	Tolerant	**R**	**R**	1948
ICPH 4187	Tolerant	**R**	**R**	1873
Elite inbred lines				
ICPL 20092	Tolerant	**R**	**R**	324
ICPL 20117	Tolerant	**R**	**R**	1833
ICPL 20123	Tolerant	**R**	**R**	2194
ICPL 20128	Tolerant	S	**R**	2022
ICPL 20237	Tolerant	S	**R**	1100
ICPL 20238	Tolerant	S	S	1243
ICPL 20241	Tolerant	S	S	1350
ICPL 20243	Tolerant	S	S	1333
ICPL 99050	Tolerant	**R**	S	1255
ICPL 99051	Tolerant	**R**	**R**	1172

Project Objectives

Objective 1: To identify high-yielding water-logging tolerant germplasm and breeding lines in pigeonpea.

Objective 2: To identify high-yielding water-logging tolerant germplasm and breeding lines in pigeonpea under water-logged saline soil conditions.

Objective 3: To incorporate water logging tolerance in high-yielding locally adapted pigeonpea cultivars.

Objective 4: On-farm validation of water logging tolerance of selected pigeonpea genotypes.

Objective 5: To generate and share information on various aspects of water logging tolerance in pigeonpea.

Project Activities

Activity 1: Confirmation of water-logging tolerance of the selected Pigeonpea genotypes.

Activity 2: Evaluation of saline tolerance of pigeonpea water-logging tolerant genotypes.

Activity 3: Identification of morpho–physiological and genetic marker traits linked to water logging tolerance and introgression of water-logging tolerance into adapted cultivars.

Activity 4: Large scale on-farm validation of selected water logging tolerant genotypes in the selected flood prone areas.

Activity 5: The results of different experiments will be summarized, shared with partners and other scientists and published jointly by project partners.

Work Plan

Coordination and management

- A project launching and planning meeting will take place in the month of June, 2011, to clearly define the plan of work for each partner at each location including the strategies, monitoring and evaluation aspects.

- One meeting will be organized per year to coordinate project progress and re-align work, as necessary.

- A project reports will be prepared by the end of each cropping season.

Year 1 (2011 – 2012 season)

- The selected tolerant and susceptible lines identified during 2010 will be tested under field conditions with uniform water-logging treatments at all project locations in 2011.
- Tolerant lines adapted to two or more locations will be identified.
- Water logging tolerant lines selected for large-scale on-farm testing.
- Seeds of the selected lines will be multiplied under controlled pollination.
- Molecular markers polymorphism for contrasting (susceptible/tolerant) water logging parents.
- Contrasting water-logging (susceptible/tolerant) genotypes that are polymorphic at the molecular marker level will be crossed to initiate the development of a mapping population.

Year 2 (2012 – 2013 season)

- Seeds of selected lines will be multiplied in isolation.
- All the promising lines will be screened for *Phytophthora* disease resistance under controlled conditions at the selected locations.
- Two of the project locations, Punjab Agricultural University (PAU), Ludhiana (Punjab) and Haryana Agriculture University (HAU), Hisar, Haryana will evaluate water-logging tolerant pigeonpea genotypes under saline soil conditions of selected water-logging tolerant pigeonpea genotypes.
- Morpho-physiological traits closely linked with water logging tolerance will be identified.
- F_1s will be grown, observations recorded, backcrosses made, and selfing will be done for generation advancement.
- Field evaluation of water-logging tolerant lines will be carried out under natural conditions.

Year 3 (2013 – 2014 season)

- On-farm evaluation at multi-locations will be given highest priority during Year 3.
- Multiplication of seed in isolations will be undertaken.
- The lines will again be evaluated for *Phytophthora* disease resistance.
- Advancing crosses and bulk segregation analysis using molecular markers.
- Backcross, F_1, and F_2 generations will be evaluated to determine the genetics of water-logging tolerance. At the same time selfing will continue to advance the mapping population towards recombinant inbred lines (RIL).
- The selected genotypes will be characterized for various morphological traits.

Year 4 (2014 – 2015 season)

- On-farm evaluation of the selected lines will continue.
- Multiplication of seed in isolations will continue.
- The lines will again be evaluated for *Phytophthora* disease resistance.
- The selected genotypes will be characterized for various morphological traits and a water logging tolerance index will be developed.
- The mapping population will be selfed to advance towards recombinant inbred lines (RILs).
- Genetic information on the water-logging tolerance will be published in International Journals.

Year 5 (2015 – 2016 season)

- On-farm evaluation of the selected lines will continue and the results summarized with respect to the variety recommendations.
- Multiplication of seed in isolations will continue.
- The selected genotypes will be characterized for various morphological traits.
- The mapping populations will be screened for water-logging tolerance and also genotyped with markers and marker-trait association studies will be conducted.
- The salient results of the project activities will be published in International Journals.
- Final Project Report including year 5 results will be submitted to the donor.

Details of Budget (Rs Lakhs)

(a) JNKVV, Jabalpur

Items	2011-12	2012-13	2013-14	2014-15	2015-16	Total
Root capacitance Meter	1.0	-	-	-	-	1.0
Oxygen meter	1.5	-	-	-	-	1.5
Chlorophyll meter	0.5	-	-	-	-	0.5
SRF (1)*	2.4	2.4	2.8	2.8	2.8	13.2
Skilled workers (2)# or JRF	2.0	2.2	2.3	2.3	2.3	11.1
Travel	1.0	1.0	1.0	1.0	1.0	5.0
Operational costs	2.0	3.0	4.0	4.0	4.0	17.0
Contingency	2.0	2.0	3.0	3.0	3.0	13.0
Sub-total	**12.40**	**10.60**	**13.10**	**13.10**	**13.10**	**62.30**
10% Overheads	**1.24**	**1.06**	**1.31**	**1.31**	**1.31**	**6.23**
Total (a)	**13.64**	**11.66**	**14.41**	**14.41**	**14.41**	**68.53**

*SRF salary: As per norms of the DAC and ICAR during different years of the project

(b) BHU, Varanasi

Items	2011-12	2012-13	2013-14	2014-15	2015-16	Total
Root capacitance Meter	1.0	-	-	-	-	1.0
Oxygen meter	1.5	-	-	-	-	1.5
Chlorophyll meter	0.5	-	-	-	-	0.5
SRF (1)*	2.4	2.4	2.8	2.8	2.8	13.2
Skilled workers (2)# or JRF	2.0	2.2	2.3	2.3	2.3	11.1
Travel	1.0	1.0	1.0	1.0	1.0	5.0
Operational costs	2.0	3.0	4.0	4.0	4.0	17.0
Contingency	2.0	2.0	3.0	3.0	3.0	13.0
Sub-total	**12.40**	**10.60**	**13.10**	**13.10**	**13.10**	**62.30**
10% Overheads	**1.24**	**1.06**	**1.31**	**1.31**	**1.31**	**6.23**
Total (b)	**13.64**	**11.66**	**14.41**	**14.41**	**14.41**	**68.53**

*SRF salary: As per norms of the DAC and ICAR during different years of the project

(c) IARI, New Delhi

Items	2011-12	2012-13	2013-14	2014-15	2015-16	Total
Root capacitance Meter	1.0	-	-	-	-	1.0
Oxygen meter	1.5	-	-	-	-	1.5
Chlorophyll meter	0.5	-	-	-	-	0.5
SRF (1)*	2.4	2.4	2.8	2.8	2.8	13.2
Skilled workers (2)# or JRF	2.0	2.2	2.3	2.3	2.3	11.1
Travel	1.0	1.0	1.0	1.0	1.0	5.0
Operational costs	2.0	3.0	4.0	4.0	4.0	17.0
Contingency	2.0	2.0	3.0	3.0	3.0	13.0
Sub-total	**12.40**	**10.60**	**13.10**	**13.10**	**13.10**	**62.30**
10% Overheads	**1.24**	**1.06**	**1.31**	**1.31**	**1.31**	**6.23**
Total (c)	**13.64**	**11.66**	**14.41**	**14.41**	**14.41**	**68.53**

*SRF salary: As per norms of the DAC and ICAR during different years of the project

#Skilled worker@ Rs 8,000/month

(d) ICRISAT, Patancheru

Items	2011-12	2012-13	2013-14	2014-15	2015-16	Total
Root capacitance meter	1.0	-	-	-	-	1.0
Oxygen meter	1.5	-	-	-	-	1.5
Chlorophyll meter	0.5	-	-	-	-	0.5
RA (2)*	7.8	7.8	8.11	8.11	8.11	39.93
Skilled workers (3)	3.0	3.4	3.6	3.6	3.6	17.2
Travel	2.5	3	3.5	3.5	3.5	16.0
Operational costs	7.9	8.8	9.0	10.1	10.2	46.0
Contingency	3.0	3.0	4.0	5.0	5.0	20.0
Consultants (Scientist from research areas)	1.0	1.0	1.0	1.0	1.0	5.0
Review and planning meetings	1.0	1.5	2.0	2.0	2.5	9.0
Sub-total	**29.20**	**28.50**	**31.21**	**33.31**	**33.91**	**156.13**
15% Overheads	**4.38**	**4.28**	**4.68**	**5.00**	**5.09**	**23.43**
Total (d)	**33.58**	**32.78**	**35.89**	**38.31**	**39.00**	**179.56**

*RA @ Rs 25,000+30% HRA/month for year 1 & 2 and @ Rs 26,000+30% HRA for years 3 to 5.

(e) IIPR, Kanpur

Items	2011-12	2012-13	2013-14	2014-15	2015-16	Total
Root capacitance meter	1.0	-	-	-	-	1.0
Oxygen meter	1.5	-	-	-	-	1.5
Chlorophyll meter	0.5	-	-	-	-	0.5
SRF (2)*	4.8	4.8	5.6	5.6	5.6	26.4
Skilled workers (3)#	3.0	3.4	3.6	3.6	3.6	17.2
Travel	1.5	1.5	1.5	1.5	2.0	8.0
Operational costs	3.0	4.0	5.0	5.0	5.0	22.0
Contingency	2.0	3.0	3.0	4.0	4.0	16.0
Miscellaneous	1.0	-	-	-	1.0	2.0
Review and planning meetings	-	0.3	0.50	0.50	1.0	2.3
Sub-total	**18.30**	**17.0**	**19.2**	**20.20**	**22.20**	**96.90**
10% Overheads	**1.83**	**1.7**	**1.92**	**2.02**	**2.22**	**9.69**
Total (e)	**20.13**	**18.7**	**21.12**	**22.22**	**24.42**	**106.59**

*SRF salary: As per norms of the DAC and ICAR during different years of the project

#Skilled worker @ Rs 8,000/month

(f) PAU, Ludhiana

Items	2011-12	2012-13	2013-14	2014-15	2015-16	Total
Root capacitance meter	1.0	-	-	-	-	1.0
Oxygen meter	1.5	-	-	-	-	1.5
Chlorophyll meter	0.5	-	-	-	-	0.5
SRF (1)*	2.4	2.4	2.8	2.8	2.8	13.2
Skilled workers (2)# or JRF	2.0	2.2	2.3	2.3	2.3	11.1
Travel	1.0	1.0	1.0	1.0	1.0	5.0
Operational costs	2.0	3.0	4.0	4.0	4.0	17.0
Contingency	2.0	2.0	3.0	3.0	3.0	13.0
Sub-total	**12.40**	**10.60**	**13.10**	**13.10**	**13.10**	**62.30**
10% Overheads	**1.24**	**1.06**	**1.31**	**1.31**	**1.31**	**6.23**
Total (f)	**13.64**	**11.66**	**14.41**	**14.41**	**14.41**	**68.53**

*SRF salary: As per norms of the DAC and ICAR during different years of the project

#Skilled worker @ Rs 8,000/month

(g) HAU, Hissar

Items	2011-12	2012-13	2013-14	2014-15	2015-16	Total
Root capacitance meter	1.0	-	-	-	-	1.0
Oxygen meter	1.5	-	-	-	-	1.5
Chlorophyll meter	0.5	-	-	-	-	0.5
SRF (1)*	2.4	2.4	2.8	2.8	2.8	13.2
Skilled workers (2)# or JRF	2.0	2.2	2.3	2.3	2.3	11.1
Travel	1.0	1.0	1.0	1.0	1.0	5.0
Operational costs	2.0	3.0	4.0	4.0	4.0	17.0
Contingency	2.0	2.0	3.0	3.0	3.0	13.0
Sub-total	**12.40**	**10.60**	**13.10**	**13.10**	**13.10**	**62.30**
10% Overheads	**1.24**	**1.06**	**1.31**	**1.31**	**1.31**	**6.23**
Total (g)	**13.64**	**11.66**	**14.41**	**14.41**	**14.41**	**68.53**

*SRF salary: As per norms of the DAC and ICAR during different years of the project

#Skilled worker @ Rs 8,000/month.

Note in relation to purchase of equipment for this project: During the first planning meeting we will discuss the best strategy to purchase equipment. If the project members agree, ICRISAT will request quotes for the combined equipment to benefit from bulked ordering. Accordingly, the equipment will be distributed to the partners as indicated in the proposal.

Appendix II: Group picture of the participants of the Launching and Work Plan Meeting of the NFSM-funded project "Selection and Utilization of Water-logging Tolerant Cultivars in Pigeonpea", JNKVV, Jabalpur, 29th June 2011