Enhancing pigeonpea productivity and production in South Asia

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Executive summary

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is an important food legume crop of rain-fed agriculture in the semi-arid tropics. It is grown in an area of 4.86 million ha worldwide with a global production of 4.1 million tons. India is the leading pigeonpea growing country in the world, accounting for 3.73 million ha area and 3.07 million tons of production. However, its productivity is lower than the world average. Non-availability of improved varieties, poor seed systems, and biotic stresses (Fusarium wilt, Sterility mosaic disease and *Helicoverpa*) are the major constraints to enhancing productivity. Although a wide range of improved pigeonpea cultivars are now available, many farmers still continue to grow the long duration old varieties and landraces. This may be because they are either not aware of the improved varieties or do not have access to the seeds of improved varieties. The productivity of the crop can be substantially improved by the adoption of improved cultivars and associated production technologies. Moreover, the pigeonpea production area can also be enhanced in the countries of SA.

In phase I, the pigeonpea activities were conducted in Andhra Pradesh (Mahabubnagar and Rangareddy districts) and Maharashtra (Akola and Washim districts) states of India. In phase II, the activities were conducted in Andhra Pradesh, Odisha, and Bihar states. The project partners include ICRISAT-Patancheru; Acharya NG Ranga Agricultural University (ANGRAU), Hyderabad, Andhra Pradesh; National Seed Corporation (NSC); State Farms Corporation of India Limited (SFCI); Andhra Pradesh State Seed Development Corporation (APSSDC); Bihar Agricultural University (BAU), Sabour, Bihar; Odisha University of Agriculture and Technology (OUAT), Bhubaneswar; and Odisha State Seed and Organic Products Certification Agency (OSSOPCA), Bhubaneswar. Baseline and adoption survey studies were conducted in Andhra Pradesh and Maharashtra states during phase I and in the Bihar State during phase II.

TL II project has given scope for the fast-track release and breeding lines development in the target states. In Andhra Pradesh, the RGT 1 white seeded variety of pigeonpea with wilt resistance (first white seeded type for the state) was released during 2010 by the Agricultural Research Station Tandur, Rangareddy (district). This was estimated to help the farmers (120,000 households) in nearly 80,000 ha of the state where there is a peculiar preference for the white seeded types. Under the phase II of this project, the ICPH 2740 (first pigeonpea hybrid for the state) was released. The hybrid has a yield potential of 3 tons/ha under rainfed situation and fetches an additional income of $1,000 per ha for the rainfed smallholder farmer. Efforts are in progress with the State Agricultural University (ANGRAU), Department of Agriculture (Government of Andhra Pradesh), NGOs, progressive farmers and private seed companies for the large-scale seed production of pigeonea. It was expected to cover 100,000 ha by 2014. In Odisha, the hybrid ICPH 3762, which is the first variety/hybrid of pigeonpea released in the state, was released in the year 2014.

Hybrid breeding program has been initiated for ESA at ICRISAT Patancheru and maintainer lines have been identified from the African germplasm suitable for the region. This will accelerate hybrid development for the ESA region.

Breeding activities in varietal and hybrid research programs have been strengthened in NARS partners of Andhra Pradesh, Odisha, and Bihar states, and this will hasten the release of varieties and hybrids for different agroecologies of the respective states.

About 4,000 tons of various classes of seed have been generated till now for cultivation by farmers in the three target states. This has resulted in the substantial increase of the productivity and income of small and marginal pigeonpea-cultivating farmers. In Andhra Pradesh, the pigeonpea production increased from 450 kg ha^{-1} in 2007 to 600 kg ha^{-1} in 2012 due to the improving seed system and linkages with partners, which helped in the large-scale production of quality seeds.

Almost 19 tons of improved varieties and hybrid seeds were distributed in small packs during the seven years of the TL II in phases I and II. A total of 20,783 farmers (including 3,892 women) were trained on the aspects of improved crop management technology in the three states. Besides, 1,232 traders, extension personnel, and seed production officers were trained on aspects of seed production and crop management. A total of 28,500 booklets, leaflets, and pamphlets on crop management activities and packages, and practices of seed production, were distributed to the stakeholders during phase I and II. In addition, 12 students (including 5 women) were trained for their MSc and PhD degrees.

Major activities

The major activities under different objectives have been listed as follows:

Objective 1:

- Development of standardized baseline and market survey instruments and methods
- Data collection for baseline and market surveys
- Compilation and analysis of secondary data for regional situation and outlook reports
- Development of standardized survey form on end-users preferences, for breeders to use in PVS implementation in crop objectives
- Early adoption studies
- Coordination and capacity building for NARS partners, including the regional partners' workshops and training

Objective 6

- Expand adoption of farmer-preferred high-yielding pigeonpea varieties
- Develop genetically enhanced pigeonpea germplasm and hybrid parents that are resistant to major diseases and high-yielding cultivars and hybrids for target environments
- Enhance NARS capacity in modern pigeonpea research and development technologies through degree and non-degree training, meetings, and workshops

Objective 8.3

- Improve the availability of foundation and certified seeds by NARS/public sector as well as the private sector
- Design and test alternative seed production models that enhance seed delivery system (tailored to various client needs)
- Enhance local capacity to produce, deliver, store, and market seeds
- Enhance local-level awareness of released varieties (demand creation)

Key achievements

Crop improvement

During phase I, RGT 1, the first white seeded variety, was released in Andhra Pradesh and was estimated to transform the livelihoods of smallholder farmers in an area of 80,000 ha, where there is peculiar preference for white seeded types. Similarly, ICPH 2740, the first pigeonpea hybrid, was released for Andhra Pradesh in 2012. The hybrid has 1 ton/ha more yield potential than local types under rainfed situations. The State Agricultural University (ANGRAU) and the State Seed Development Corporation planned for large scale seed production of this hybrid during the 2013 crop season. It was expected to cover 100,000 ha in 2014 and up to 300,000 ha by 2017. This implementation will have an impact on the livelihoods of nearly 400,000 farmers in the state.

In Andhra Pradesh, PRG 176, TDRG-4 and TDRG-28 varieties are being promoted to second year minikit testing after the successful first year testing. Three new varieties (TDRG 33, TDRG 45, and LRG 105) and three hybrids (ICPH 3762, ICPH 2751, and ICPH 3933) have entered in state and national level multi-location evaluation trials. This provides an opportunity for releasing varieties and hybrids for different ecologies.

During phase II in India, the states of Bihar and Odisha used ICPH 2671, ICPH 2740, ICPH 3762, ICP 7035, Asha, and Maruti for FPVS and identified one variety (ICP 7035) and two hybrids (ICPH 2671, ICPH 2740) to be the most preferred varieties by farmers. Large-scale seed production of these varieties and hybrids is being undertaken for their widespread distribution.

In order to breed hybrid parents for high yield and disease resistance, new 25 CMS A- lines and their counterpart B- lines were tested out of which 7 were found to be resistant to both *Fusarium* wilt (FW) and sterility mosaic disease (SMD). A total of 92 hybrid combinations were also tested in sick plot nursery in which 44 lines were found to be resistant to FW and 26 were resistant to SMD. Wilt and SMD resistant hybrid parental lines and segregating generation material were supplied to NARS partners of Andhra Pradesh, Bihar, and Odisha.

In close collaboration with other on-going projects on the use of genomic resources, the project also developed kits for parental or hybrid purity testing, MAGIC populations for bringing alleles from land races, and shuffling of genes among elite genotypes through nested association mapping. Hybrid purity assessment kits are particularly useful in assessing the quality of hybrid seed produced since it is practically impossible to use the traditional GOT (Grow Out Test) in pigeonpea owing to photosensitivity and long- duration.

Maintainers were identified for new CGMS source from *Cajanus reticulatus* (A_8), and hybrid combinations were prepared to determine the restorers. This new cytoplasm source will be helpful in diversifying the cytoplasmic base as there is a risk of homogeneity due to the use of a single source of cytoplasm in hybrid development.

Efforts have been made to incorporate obcordate leaf marker to identify CGMS and fertile plants. Stabilized A- lines of obcordate leaf shape with potential hybrid combinations have been developed. This unique leaf marker serves as a phenotypic marker in the easy identification of off types from A- line in hybrid seed production fields and hence, aids in maintaining the purity of F_1 seed.

Forty-nine genotypes were screened for water logging tolerance at IIPR-Kanpur, IARI-New Delhi, PAU-Ludhiana, HAU-Hissar, JNKVV-Jabalpur and BHU-Varanasi. It was found that ICP 5028, ICPH 2740, MAL 15, ICPH 2431, ICPA 2037 Asha, and ICPL 332 are the most tolerant genotypes. ICP 7035, ICPH 2376, ICP 8863, ICPL 87051, and ICPL 149 were found to be susceptible to waterlogging stress. Crosses were made between ICP 5028 (tolerant) × ICP 7035 (susceptible) to develop mapping populations to tag genes for

water-logging tolerance. Particularly, in the state of Bihar water-logging is a serious constraint and thus the material is under evaluation to determine the tolerant genotypes for the state.

Super early lines with 85 to 95 days maturity and a yield potentiality of 1 to 1.5 tons/ha have been developed. These genotypes are under multilocation testing and have the potential for being introduced in different agroecological niches and cropping systems. In Andhra Pradesh and Odisha, a large area is under rice-based cropping systems. Currently, cultivation of rice followed by maize and sorghum cropping system is predominant but not sustainable over a longer period. The cultivation of rice followed by a short duration of pigeonpea augurs well for soil sustenance and efforts are being carried out in this direction.

Cleisto, a selfing trait, has been introduced into elite lines, and stabilized advance generations material has been developed. The material will be further advanced to test their suitability and adaptability. The selfing trait will solve the problematic issues in seed production and maintenance of isolation distance. Owing to the cross pollination nature, the maintenance of quality of the seeds produced is a major challenge with the seed organizations.

During phases I and II, elite lines in varietal front and parents of hybrid breeding were shared with NARS partners of Andhra Pradesh and Maharashtra. This helped to strengthen their breeding program, and a number of varieties and hybrids are in pipeline for release. During phase II, the NARS partners of Odisha and Bihar were supplied with the breeding material, and they have initiated research programs to develop suitable varieties and hybrids for their respective states. In Odisha, the hybrid ICPH 3762, which is the first pigeonpea variety/hybrid released in the state, was released in the year 2014.

Seed systems

Seed system and enhancing adoption of improved cultivars

Improving the availability of breeder, foundation, certified and truthfully label seeds by NARS/ public sector as well as the private sector

During phase I, a total of 1,794.45 tons of different categories (breeder, foundation, certified, and truthfully labeled seeds) was produced by the NARS in Andhra Pradesh, Maharashtra, and ICRISAT. However, the certified and truthfully labeled seed production program of 'farmer- preferred-varieties' in Maharashtra and Andhra Pradesh was undertaken at the village level.

In phase II, a total of 1,201.07 tons of various seed classes was made available during the 2013 cropping season. ICRISAT, together with various partners (BAU, Bihar and ANGRAU, AP) and farmer seed growers, produced a total of 28.09 tons of breeder seeds. The foundation seeds were produced by the seed growers (farmers) in Odisha and the public seed sector in Andhra Pradesh for a total of 158.83 tons. The farmer seed growers of Odisha, Bihar and public seed sector in Andhra Pradesh produced a total of 1,006.05 tons of certified seeds. In addition, 8.1 tons of truthfully label (TL) seeds of hybrids and varieties were produced by ANGRAU-ARS, Andhra Pradesh and farmer seed growers of Odisha and Andhra Pradesh.

Seed packets (1-5 kg) of lines of pigeonpea, distributed annually to farmers for evaluation and further seed production to ensure seed sufficiency at the individual farmer level

In phase I, ARS-Tandur distributed a total of 1,000 samples of Asha seeds (3 kg/sample) and 1,200 samples of PRG-158 seeds (2 kg/sample) in Rangareddy and Mahabubnagar districts, respectively, during farmers' field days so as to popularize high yielding varieties. In Maharashtra, PDKV-Akola distributed small seed packets (1 kg/sample) of various farmer-preferred varieties of pigeonpea to 1,866 farmers during the farmers' field days.

During phase II, a total of 15.2 tons of various farmer preferred varieties and hybrids of various pack sizes were distributed during the 2012–13 cropping season for improving pigeonpea production in the three Indian states.

Promotion and economic analysis of alternate seed system models

Constraints and opportunities

During phase I, the pigeonpea seed delivery systems, storage and marketing in both target states (Andhra Pradesh and Maharashtra) differed in terms of constraints and opportunities. In Maharashtra, the information was collected from farmers during the group discussions, meetings, training sessions, and field days. The constraints to develop an efficient seed storage, marketing and delivery system for pigeonpea were identified; these were lack of storage facilities, vulnerability of pigeonpea seeds to storage grain pests, lack of drying facilities (more relevant when harvesting coincides with unexpected rains), lack of processing, packaging, and transport facilities, varying and inconsistent response of farmers to new varieties, and inconsistent market price by seed industries. In Andhra Pradesh, the farmers faced difficulty in registering and getting their fields certified. However, the farmers of this state considered selling seeds as TL seeds to co-farmers to be an opportunity in seed delivery systems.

By the time of Phase II implementation, the seed system was well established in Andhra Pradesh state in collaboration with SAU and the Department of Agriculture. There was no channelized pigeonpea seed system in Odisha and Bihar; however, efforts are in progress to establish proper seed channel in these states.

Formal and informal seed sector linkages

In phase I, PDKV-Akola established linkages with Maharashtra State Seeds Corporation Limited (MSSCL) and Krishi Vigyan Kendras (KVKs) at Karda and Durgapura to facilitate efficient seed production and marketing. While in Andhra Pradesh, ANGRAU-Hyderabad established similar linkages with Andhra Pradesh State Seeds Development Cooperation (APSSDC) and Adarsh Rythu for efficient production and seed diffusion. The involvement of APSSDC and Andhra Pradesh State Seed Certifying Agency (APSSCA) in roguing, inspection and selection, and certification of farmers' seed production fields ensured purity and quality of pigeonpea seeds. In addition, the seed village concept was introduced to grow one variety in target villages to guarantee isolation so as to avoid seed contamination. In Maharashtra, the MSSCL has linked farmer groups of selected villages, involved in seed production, for efficient marketing and diffusion of certified seeds in Akola and Washim. The MSSCL function is to monitor seed production plots, which will lead to the assurance of the procurement of seed produced by the farmers.

Transaction costs in seed marketing

In Maharashtra, it is difficult for individual farmers to market the seeds, but in Akola and Washim districts, the farmers have organized themselves into groups to carry out marketing of their seeds to other farmers. In both the districts, the government has also provided seed subsidies under various schemes and packages. In Andhra Pradesh, the seeds produced at the local level has authentic source of seeds, are much cheaper, are well perceived by local farmers since the varieties are adapted to the locality, and are high-yielding as compared to the seed procured from outside the districts or state.

Promotion and formal recognition of informal seed sector

In Maharashtra, Bihar and Odisha, there is a need to strengthen informal seed sector through the approach of 'seed village concept' where 'one variety-one village' strategy should be popularized

because formal seed sector cannot lead to the supply of a huge quantity of quality seeds. The seed village concept will solve the problem of the lack of quality seeds required by the villagers. However, in Andhra Pradesh, the seeds produced in Mahabubnagar and Rangareddy districts were offered for certification by APSSCA, whereby the informal seed production was formalized.

Adoption and impacts

The top two pigeonpea growing districts, Rangareddy and Mahabubnagar, were chosen in Andhra Pradesh for the introduction of new varieties and crop technologies. Similarly, Akola district in Maharashtra was chosen for the implementation of the project. In each of the selected state, three villages were selected for intervention (called them as 'adopted' villages) and another three similar villages were picked up as control villages for the sake of comparison. Thirty pigeonpea growers were randomly chosen from each of the village while 15 pigeonpea growers were randomly chosen from each of the control village. Thus, 180 sample farmers were selected for conducting the baseline survey from the intervention villages from the two states while 90 farmers from the control villages were chosen for the same purpose. Data relating to marketing aspects were also collected from the traders, processors, retailers and consumers, apart from the sample farmers. The reference period for data collection was 2006-07 season as the data was collected in 2007-08. The relevant secondary data was also collected from the Directorates of Economics and Statistics of Andhra Pradesh and Maharashtra states and analyzed for better understanding of the performance of pigeonpea in these states over a period of time.

Farmers' Participatory Varietal Selection (FPVS) trials were conducted during the rainy season of 2008-09 in the adopted villages. Some new varieties were tested vis-à-vis the ruling varieties in the region to assess their comparative performance. Farmers were asked to rank the varieties based on the traits preferred by them. The varieties selected by the farmers were taken up for seed multiplication. The farmers were supplied with small quantities of seeds to increase their quantity and bulk the supply so that they can gradually switch over to the preferred varieties. In 2009-10, early adoption surveys were commissioned to assess the dent of the new varieties and whether this adoption has caused any improvement in the yields and incomes of the farmers.

During the baseline survey, the total cropped area under pigeonpea during rainy season was 331.7 ha in the three adopted villages of Andhra Pradesh. Around 61.5% of pigeonpea area was occupied by the Asha variety followed by Abhaya (11%), a local variety called Nallakandi (11.1%), Maruti (7.5%), Lakshmi (5%), Durga (2%), LRG-30 (1%), LRG-41 (0.5%), and white pigeon pea (0.4%). Asha was observed as the single dominant variety in the adopted village groups during 2007-08. Overall, nearly 90% of the cropped area during the baseline survey in adopted villages was under improved cultivars whereas the remaining 10% was occupied by a local variety Nallakandi.

In the case of control villages, the cropped area under pigeonpea crop was estimated to be 125.3 ha. Nearly 77% of the cropped area was covered by the Asha variety followed by local cultivars (7.11%), Lakshmi (6.14%), Abhaya (5.82%), Durga (2.26%), and white seeded variety (1.8%). The spread of improved varieties (Asha and Maruti) released in early 1990s' was dominant during baseline surveys in both the adopted and control villages. Relatively, the diffusion of Asha was much higher in the control villages than in the adopted villages. Other improved cultivars released in early 2000s' occupied less pigeonpea area both in adopted and control villages.

Similarly, Maruti was the first improved variety of pigeonpea introduced in Maharashtra state in the year 1999-2000 and it occupied a peak area within a short period of time. Based on the baseline survey conducted in 2007-08, the Maruti variety occupied 177 ha of pigeonpea area with a major share of 89% of the total in adopted villages, followed by Asha (8%) and Vipula (1.9%). Nearly 95% of the pigeonpea cropped area under control villages was dominated by Maruti variety followed by Asha (3.5%) and Vipula

(1.7%). The awareness and spread of these improved varieties was impressive in both the adopted and control villages during the baseline survey year. It was possible largely because of the prior contacts of the sample farmers with the research stations and scientists and subsequent efforts of Agricultural Universities and Department of Agriculture & Extension.

The early adoption surveys conducted during 2009-10 in both states indicate significant penetration of TL II introduced cultivars in the targeted locations. The extent of area under Asha came down from 61.5 to 43% in Andhra Pradesh. LRG-41 (20%) and PRG-158 (8%) gained significant area coverage by 2009-10. Around 26% of productivity enhancement was noticed in the new cultivars. In Maharashtra, the coverage of Maruti declined significantly from 89% to 47% in adopted villages while 95% to 55% in control villages. New cultivars like BSMR 736 (17%) and BSMR 853 (10%) diffused profusely. Asha also penetrated well from 3.5% to 15% between 2007-08 and 2009-10. Nearly 15% yield gains were perceived by farmers in the project sites.

During the phase II of the TL Project, two new locations (Bihar and Odisha) in India were identified for targeting and introduction of new technologies. But the baseline surveys were takenup only in Bhagalpur and Banka districts of Bihar with reference to 2010-11. Subsequently, FPVS trials were carried out during 2012-13. The mother trials conducted in different locations have concluded that Asha, ICP 7035, and ICPH 2740 were the most preferred varieties over the traditional variety 'Bahar'. There were no systematic efforts in the state of Bihar for crop improvement of pigeonpea by SAU. TL II has provided a way for the small holder farmers to have access to high yielding varieties suitable for their niches.

Capacity building

Farmers

In phase I, a total of 4,307 farmers (Andhra Pradesh – 2,474 and Maharashtra – 1,833) were trained in seed production, crop management, seed health, IPM, and post-harvest practices to enable them to produce quality seed. Aside from the training, Farmers' Day gatherings were also organized in Maharashtra with 351 farmers (including 21 women). This event showcased to farmers the isolation requirement in pigeonpea, identification of off-type plants in seed production blocks, off-type removal at appropriate time, irrigation scheduling, fertilizer application (including use of bio-fertilizers), harvesting, and seed storage.

In phase II, a total of 5,135 farmers (including 1,340 women) of Andhra Pradesh, Odisha, and Bihar were capacitated on various topics such as seed production and management including integrated and disease management, post-harvest and storage, and marketing.

Local seed traders and processor

During the three-year project period (phase I), a total of 533 traders/dal mill operators in Andhra Pradesh and Maharashtra were trained in seed storage, processing, and marketing. Around 10 dal mill operators (owners) and 76 local traders of Andhra Pradesh participated in the training course offered by ANGRAU at ARS, Tandur. In Maharashtra, training for local seed traders and dal mill owners at village level were implemented with 447 participants.

In phase II, 43 seed entrepreneurs of Andhra Pradesh and Odisha were capacitated on post-harvest storage and marketing.

Extension/NGO/Private Seed Company

During the phase I, 699 extension officers, NGO staff and private seed sector personnel were trained in seed production, scientific storage, stored grain pest management, and marketing network. In Andhra Pradesh, a training-cum-field day program was attended by 220 participants in Kosgi village of Mahabubnagar district and 346 participants in ARS, Tandur while in Maharashtra, 133 participants attended the training at KVK Karda, Washim.

In phase II, 939 (including 395 women) extension personnel in Andhra Pradesh and Odisha participated in various trainings and seminars on seed production and management including integrated disease management, post-harvest and storage, and marketing.

Farmers field day/farmer's fair

During the three-year period of the project (phase I), a total of 6,421 farmers attended the farmers' field days/fairs in Andhra Pradesh and Maharashtra. In Maharashtra, 1,791 farmers (including 3 women farmers) attended field days/fairs organized by KVK Akola and Washim. In Andhra Pradesh, ANGRAU organized farmers' field days with an attendance of 4,630 farmers (including 1,150 women farmers). In both states, the project staff involved in the program demonstrated how to conduct roguing of off-type plants, maintenance of isolation distance, control measures of pests and diseases, etc. Aside from these field days, 75 farmers were given the chance to visit demonstration fields at ICRISAT Headquarters. ICRISAT staff guided the farmers in different projects such as watershed and pigeonpea hybrid seed production technology.

During phase II, 2,292 including 417 women farmers attended the farmers' field day and trade fairs conducted in Andhra Pradesh, Odisha and Bihar.

Awareness activities through print and electronic media

Pigeonpea seed production manual in local language

In phase I, PDKV-Akola, in association with ICRISAT, prepared pigeonpea manuals on seed production (500 copies) and crop management (500 copies) in Marathi. Similarly, ANGRAU-Tandur published and distributed 3,500 copies of manuals on pigeonpea seed production and IPM technologies in Telugu. During phase II, 28,500 leaflets/ booklets were distributed on improved crop management practices in Andhra Pradesh, Odisha, and Bihar.

Radio, television and print media

During phase I in Maharashtra, 20 articles regarding the conduct of field days, training programs, visits of the ICRISAT scientists and exposure visit of farmers to ICRISAT, Hyderabad and targeted villages were published in local newspapers. These were also covered by three local radio stations and one local TV station for wider circulation of the project activities and gains among the farmers. In Andhra Pradesh, five local TV stations telecasted information on pigeonpea varieties and crop management technologies. During phase II, a total of 151 events (local newspaper: 118; TV programs: 20; and radio talks: 13) on local awareness were published and attended/conducted in various topics.

Degree students

Six students (2 women and 4 men) were trained for their MSc and PhD during phase I, and 6 students (3 women and 3 men) were under training for their MSc and PhD during phase II.

Infrastructure and equipment

Seed production facilities were upgraded at partner NARS research stations in Andhra Pradesh and Maharashtra. Installation of submersible pump, lay down of PVC pipelines (2800 ft), and fencing of field were upgraded in PDKV, Akola research station to strengthen and improve irrigation facilities and protect the crop from animals for better seed production. In Andhra Pradesh, the facilities for seed production were upgraded at the ANGRAU Research Station in Tandur.

List of equipment purchased by Andhra Pradesh during phase I

No.	Item	Qty.	Purpose	Cost (₹)
1	HDPENylonnet	205 kg	For isolation in Nucleus seed plots	67,035.00
2	Meteorological equipment	1	For recording daily weather parameters	41,490.00
3	Winnower	1	For winnowing of harvested produce	49,044.00
4	Water tanker	1	For providing life-saving irrigation tools	227,552.00
5	Cooling incubator cum shaker	1	For maintenance of *Fusarium udum* cultures	350,000.00
6	Horizontal and vertical electrophoresis systems.	1	For molecular variability work of the wilt pathogen	125,000.00
			Total	860,121.00

Seed storage facility (godown) with a capacity of 300 tons was constructed at ARS, Tandur, Andhra Pradesh. However, in Maharashtra, the farmers were not keen on having a seed storage facility due to the non-availability of land to construct the facility.

Lessons learned

- Farmers' awareness of the improved varieties and availability of the seed of improved varieties are the key factors in spreading high-yielding cultivars.
- FPVS trials were effective in enhancing awareness of farmers regarding improved varieties and in spreading new varieties.
- The farmers need some orientation and close follow-ups for their active participation in FPVS trials.
- Farmers participation in varietal selection reduces the time required for varietal testing and possible high adoption of tested varieties before or after formal release.
- Involvement of seed certifying agencies in Andhra Pradesh makes it easy to release good quality seeds of various seed classes.
- The farmers were keen to undertake seed production of improved varieties, provided arrangement was made for the procurement of seed through national/state seed corporations or other agencies.