Development and Promotion of Informal and Formal Seed System Through Farmer Participatory Seed Production of Pigeonpea (*Cajanuscajan* L.) in Uttar Pradesh, India

S. K. SINGH[1], S. K. DUBEY[1], M. ALI[1], S. N. NIGAM[2], R. K. SRIVASTAVA[2], K. B. SAXENA[2], A. S. YADAV[1] AND A. KUMAR[1]

1. Indian Institute of Pulses Research (IIPR), Kalyanpur, Kanpur 208 024, U.P., India.

2. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, 502 324, A.P., India.

Acknowledgements: To ISOPOM, Department Agriculture and Cooperation,Ministry of Agriculture, Government of India for financial support to the project and to the partner farmers of Fatehpur and Kanpur Dehat districts for their active and enthusiastic participation in the project.

Address correspondence to Sushil Kumar Singh, Principal Scientist, Agricultural Extension Section, Indian Institute of Pulses Research, Kanpur-208 024 (Uttar Pradesh), India. E-mail: sushilsinghiipr@yahoo.co.in

Pigeonpea is a major pulse crop in India. However, its productivity, which hovers around 700 kg ha^{-1}, has remained stagnant over the past several decades. Local landraces dominate the cultivation of pigeonpea in the country. A major reason for low productivity in pigeonpea is the non-availability of quality seed of improved varieties to farmers. In this paper, we share experiences of farmer-participatory pigeonpea seed production in Fatehpur and Kanpur Dehat districts in Uttar Pradesh in India. Through farmer-participatory varietal selection trials, farmers identified NA 1, long-duration pigeonpea variety and UPAS 120, short-duration variety, as their preferred choices. Long-duration variety NA 1 was preferred because of its disease resistance, higher yield, attractive seed size and color. Farmers were organized to form cooperative societies to undertake seed production, processing and marketing at the local level. Societies were also linked with the public sector seed producing agencies to participate in the formal seed production program. The C: B ratio of seed production of NA 1 variety was 1: 5.19 as compared to 1: 2.53 of the local variety. Village-level seed production not only addressed the issue of shortage of quality seeds but also brought higher incomes to farmers leading to improved livelihood.

KEYWORDS participatory approach, linkages, seed delivery, farmer association, seed marketing

INTRODUCTION

The productivity of pulses in India has remained stagnant over the past several decades. In the case of pigeonpea, which is a major pulse crop in the country (area 3.38 million ha and production 2.27 million t; http://dacnet.nic.in/eands/At_Glance_2014/4.14(B).xls), it has stayed around 700 kg ha^{-1} for the last five decades (Parthasarathi Rao et al., 2010). Non-availability of quality seed of improved varieties, poor crop management practices followed by the farmers, damage by insect pests and diseases, drought and frost are some of the factors responsible for the low productivity in pulses in India.

The state of Uttar Pradesh (U.P.) with 0.32 million ha under the crop ranks fourth in pigeonpea area in the country after Maharashtra, Karnataka and Andhra Pradesh and with 0.29 million t production, third after Maharashtra and Karnataka. The major biotic constraints to pigeonpea production in U.P. include pod fly ('Phalimakkhi', *Melanagromyzaobtusa* Malloch) and pod borer ('Phalibhedaksundi', *Helicoverpa armigera* Hübner) among the insect pests and fusarium wilt ('Ukatha', *Fusarium udum* Butler) among the diseases. However, a constraint analysis of low productivity of rainfed chickpea and pigeonpea in India by Maruthi Shankar et al. (2004) identified shortage of quality seed as one of the major constraints to increasing pigeonpea production in the country. Genetically pure seed alone can increase productivity of the crop by 10-15% (Saxena, 2006). Despite the release of several improved varieties of pigeonpea, local landraces dominate the cultivation of the crop in the country. Most of the farmers procure their pigeonpea seed from local traders or rely on their 'own-saved' or 'neighbor's- saved' seed, which in most cases is a mixture of several varieties/ landraces due to the outcrossing nature of

the crop. The private seed sector has shown little interest in engaging itself in production and marketing of seed of pulse crops due to a variety of reasons. On the other hand, public sector seed producing agencies have not been very effective in meeting the seed requirement of pulse crops. There is a need to evolve innovative approaches to address the issue of non-availability of quality seed of this crop.

The present paper documents the experiences gained in promoting pigeonpea seed production at the village level under the aegis of the Integrated Scheme on Oilseeds, Pulses, Oil Palm and Maize (ISOPOM) project jointly implemented by the Indian Institute of Pulses Research (IIPR), Kanpur and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and the Patancheru in Fatehpur and Kanpur Dehat districts in U.P.

Pigeonpea in Fatehpur and Kanpur Dehat Districts

Before irrigation became available through canals and bore wells in 1975, the cropping systems in Fatehpur and Kanpur Dehat districts were highly diversified with legumes occupying a prominent place. After 1975, the farmers shifted mainly to rice (in rainy season) and wheat (post-rainy season) cultivation. Pulses now occupy only 16-23% of the total arable area in these districts (Fatehpur - 3,99,367 ha and Kanpur Dehat - 3,14,984 ha). Pigeonpea is grown in 18-20% of the pulses area. It occupies 16,350 ha in Fatehpur and 8,760 ha in Kanpur Dehat. However, the pigeonpea productivity in both the districts (1170 kg ha^{-1} in Fatehpur and 1590 kg ha^{-1}in Kanpur Dehat) is much higher than the average productivity in U.P. (914 kg ha^{-1}) and at the national level (700 kg ha^{-1}).

The average annual rainfall in Fatehpur is about 760 mm and the farmers grow pulses in clay loam, loam and sandy loam soils. In Kanpur Dehat, the average annual rainfall is 630 mm and the pulses are grown in loam and sandy loam soils. Almost 87 - 90% arable area in both the districts has access to full or partial irrigation. A majority of the pigeonpea crop is irrigated. Only 11 -13 % of the pigeonpea crop is grown under rainfed conditions. Most of the pigeonpea growers in these two districts normally grow local varieties (short-duration variety '*Aghani Arhar*' and long-duration variety '*Baishakhi Arhar*') of unspecified pedigrees, which are genetically inferior, usually a mixture of many varieties, susceptible to diseases and insect pests and have low productivity potential. In Fatehpur, 75% of the farmers grow long-duration pigeonpea varieties as sole crop or mixed or intercropped with sorghum and sesame. About 25% of the farmers in this district also grow short-duration varieties with irrigation under a double cropping system (short-duration pigeonpea – wheat or mustard). In Kanpur Dehat, a majority of the farmers grow long-duration pigeonpea varieties and about 70% of them cultivate it in mixed cropping with sorghum / black gram / sesame.

MATERIALS AND METHODS

The present study was conducted in Fatehpur (partially irrigated) and Kanpur Dehat (fully irrigated) districts in U.P., India. These two agro-ecologies (partially- and fully-irrigated) allowed us to undertake farmer-participatory research on long-duration pigeonpea in Kanpur Dehat district and on long- and short-duration pigeonpea in Fatehpur district. Six villages in Kanpur Dehat and seven villages in Fatehpur, which were traditional pigeonpea-growing villages in the past, were selected for project implementation.

Baseline Survey

A baseline survey was conducted in 2007/08 in partner villages of Fatehpur and Kanpur Dehat districts to appraise the pigeonpea situation from production to marketing. Data were collected using a semi-structured personal interview schedule devised for the purpose (Annex 1). This was triangulated with participatory observation, group discussion, farmers' feed-back, etc. Collected data were analyzed using descriptive and inferential statistics.

Farmer-Participatory Varietal Selection Trial

Taking into account biotic and abiotic constraints to pigeonpea production in Fatehpur and Kanpur Dehat districts and farmer- and market-preferred traits in pigeonpea, a farmer-participatory varietal selection (FPVS) trial with five improved long-duration pigeonpea varieties, Bahar, Narendra Arhar (NA 1), Amar, Azad and Malviya (Mal 13) and the local variety was constituted to identify farmer-preferred variety (ies). Those farmers, who showed interest and commitment in conducting FPVS trials and had accessible fields, were selected to conduct FPVS trials. Ten FPVS trials (non-replicated, with full set of varieties) each in the 2007 and 2008 *kharif* (rainy) season were conducted in 10 farmers' fields in Godharauli village in Fatehpur and Barhapur and KuitKheda villages in Kanpur Dehat. Each farmer was assigned one trial with 100 m^2 plot size for each variety. The varieties were evaluated for grain yield and other economic parameters besides taking into consideration the farmer's perception on their performance based on a 1- 10 scale, where 1 is the lowest and 9 the highest for preference. Farmers with small farm holdings in Fatehpur preferred to grow short-duration pigeonpea in a double cropping system. As UPAS 120 is the only short-duration improved pigeonpea variety

available in north India, it was directly included in the seed production program in Fatehpur district.

Seed Production

Because of the outcrossing nature of pigeonpea, a 'one village-one variety' concept was promoted in pigeonpea seed production. However, in the case of simultaneous multiplication of short- and long-duration varieties in the same village, time isolation was observed. Short-duration varieties are harvested in the second fortnight of November much before the flower initiation in the first fortnight of December in long-duration varieties in north India. Before the start of the cropping season, farmers' meetings were organized to decide on the seed production program. Based on the size of their farm holdings, seed production of pigeonpea was decided by the farmers themselves in each village.

The following activities were also undertaken to develop farmers' capacity in quality seed production, processing and marketing by facilitating the formation of their associations.

a. Farmers' training in crop management and seed production

In order to ensure efficient and effective quality seed production, farmers were trained in various aspects of crop production and seed production technology. These included varietal description, seed treatment and sowing methods, agronomic practices, weed management, water management, integrated nutrient and soil management, integrated insect pest and disease management including biological control methods, isolation distance and rogueing in seed production plots, postharvest technology, value addition etc.

b. Linkage with formal seed sector

The interested seed farmers were linked with the U. P. State Seed Certification Agency for seed certification and the public sector seed agencies such as National Seeds Corporation Ltd. (NSC Ltd.), State Farms Corporation of India (SFCI) and Uttar Pradesh Seed Development Corporation (UPSDC) to strengthen the formal seed sector for pulse seed production. KrishiVigyan Kendra (KVK, Farm Science Center) was also linked with farmers to provide them day to day technical backstopping and ensure quality of seed produced. All stakeholders (farmers, seed producing agencies, Department of Agriculture (DoA) and KVK staff and other district level officials) were invited to promotional and awareness activities such as diagnostic field visits, field days and participatory evaluation visits, which were organized on a regular basis to develop functional linkages.

c. Seed processing at local level

Two generator-operated mobile seed processing units (Osaw Agro Industries Pvt. Ltd., AmbalaCantt, Punjab (this does not imply endorsement of the product by the project at the exclusion of other similar products); Capacity 1 t h^{-1} based on wheat processing) were procured in June 2008 from the project resources to process farmers' seed at the village level itself. These units clean, grade, weigh and pack the seed. Young farmers were given one-day training in the operation and maintenance of the mobile seed processing machine. The modalities are being developed to hand over these machines to seed cooperative societies after the expiry of the project so that these remain available to farmers to sustain quality seed production at the village level. If for any reason these machines cannot be handed over to the seed cooperative societies,

they will be housed at IIPR, Kanpur and would be available to the seed cooperative societies on a custom hiring basis.

d. Formation of farmers' cooperative societies

Three farmers' cooperative societies ('samitis'), Krishak Beej Vikas Samiti (KBVS), KuitKheda (current membership 75) and Barahpur Kisan Seva Samiti (BKSS), Barahpur (current membership 45), both in Kanpur Dehat (formed in 2009) and Chaudgra Kisan Seva Samiti (CKSS), Chaudgra, Fatehpur (formed in 2008, current membership 112 members), were formed following the guidelines/requirements of the Registrar of the Cooperative Societies. The major purpose to encourage formation of registered societies of farmers was to promote community participation in agricultural and seed production activities in a self-sustainable manner to ensure seed sufficiency not only at the village level but also in adjoining areas. Each 'samiti' is engaged in procurement of basic seed (Breeder seed) from the public sector research institutions, production of quality seed and its processing, bagging, labeling, storage and marketing in the same or neighboring villages and districts. Anybody could become a member of these societies by paying an annual membership fee. Each member of the society has equal rights in the governance and management of the 'samiti'. They cater to the multi-dimensional agricultural requirements of the farmers from the cluster of six villages each, which have been covered under the participatory seed production program in both the districts. Each 'samiti' also has three sub-committees, i. Input Management Committee ii. Knowledge Management Committee, and iii. Marketing Management Committee, to assist the core executive team in smooth functioning of the 'samiti' and derive the advantage of scale.

RESULTS AND DISCUSSION

A. Summary results of baseline survey related to the seed situation in partner villages

a. Source of information on improved pulse varieties and their seeds: In spite of the presence of DoA, KVK, state/national seeds corporations/agencies and other institutions, the main source of information on improved pulse varieties and their seeds in two districts remained the farmers themselves (35-36% respondents) followed by agricultural programs on radio and television (18-25% respondents) in both the districts, which are easily accessible and well connected by roads. This indicated serious shortcomings in the functioning and approach of the government-supported institutions engaged in technology dissemination in these two districts. As inadequate exposure to new cultivars results in low cultivar replacement rate (Witcombe et al., 1996), the average productivity of pigeonpea in these two districts could be further raised if farmers had access to quality seed of improved varieties of their choice.

Own-saved seed (21-27% respondents), other farmers (26-30% respondents) and private traders (23-25% respondents) were the major sources of pigeonpea seeds in the districts. This clearly showed that the state/national seeds corporations/agencies and DoA were not adequately prepared to meet the pigeonpea seed requirement of the farmers. As most of the farmers grew non-descript varieties or mixtures of several varieties, the seed obtained from other farmers and local traders, who traded grains as seed, was also of inferior quality (Ravinder Reddy et al., 2010). Interestingly, this dismal situation also offers an opportunity for intervention and capacity

building in quality seed production by agricultural development agencies as farmer-to-farmer seed exchange and local seed markets are not linked to systems engaged in the improvement of seed quality. The farmers' own saved seed has the advantage of being cheap, of known quality and of being readily available (Almekinders et al., 1994).

b. Farmer- and market-preferred traits

Farmer-preferred traits in pigeonpea include high yield, short-duration, resistance to fusarium wilt, pod fly and pod borer, tolerance to drought (lower water requirement), medium seed size, attractive seed coat color and better taste and cooking quality. With all other traits being equal, quantity and quality of stalks also become important considerations because of their multiple uses. On the other hand, local traders/millers look for uniform seed size, ease in cleaning, grading and processing, low breakage during processing and high '*dal*' (split cotyledons) recovery. For farmers to get remunerative price for their produce in the market, it is essential that the newly developed varieties meet standards of market-preferred traits.

B. Performance of varieties in FPVS trials

In spite of farmers in developing countries being much interested in testing and acquiring new crop varieties to respond to the ever changing production situations (David and Sperling, 1999; Almekinders et al., 2007 and Rubyogo et al., 2007), they continue to grow local varieties, particularly in pulse crops, for various reasons. Some of these reasons include inadequate exposure to new cultivars, new varieties failing to meet farmers' aspirations, non-availability of seed of improved varieties and lack of resources for small-holder farmers to invest in seeds,

among others. The need of participatory breeding (Nigam, 2009) and farmer-participatory varietal selection (Singh et al., 2008, Nigam, 2009) in legumes has been aptly envisaged in the Indian context to promote adoption of improved varieties of pulses to raise their productivity. If adoption rates are to be improved, farmers need to try a wide range of novel cultivars in their fields through their involvement in FPVS programs (Witcombe, et al, 1996). In the present FPVS trials, only released and notified varieties were included. In the event of any one of these varieties being selected by the farmers, the large-scale provision of seed will be easier through formal and informal seed sectors (Witcombe et al, 1996). In case a farmer-preferred variety is not released by the state/national authorities and notified by the national authority, the formal seed sector will not include it in its seed production program.

a. Long-duration varieties

Two-year (2007/08 and 2008/09) average performance of five improved long-duration pigeonpea varieties and the local variety included in the FPVS trials in Fatehpur and Kanpur Dehat districts is given in Table 1. Variety NA 1 gave the highest average grain yield (1690 kg ha^{-1}) followed by Bahar (1324 kg ha^{-1}) in Fatehpur district. In Kanpur Dehat also, NA 1 (2363 kg ha^{-1}) was the top yielder followed by Bahar (2031 kg ha^{-1}) and Amar (1967 kg ha^{-1}).

In addition to grain yield, farmers also evaluated these varieties for their crop duration, resistance to diseases and insect pests, tolerance to drought, seed size and color, taste and potential for high market price (Table 2). Based on these traits, the farmers in both districts unequivocally selected the NA 1 for long-duration variety for large-scale seed production and popularization.

b. Short-duration variety

UPAS 120, the only available improved short-duration variety, outperformed the local variety (1200-1400 kg ha^{-1} in the former vs. 600-800 kg ha^{-1} in the latter) in Fatehpur district. Farmers found it as the best fit to replace the paddy-wheat rotation with an early pigeonpea-wheat rotation, thereby ensuring sustainability and profitability of their cereal-based production system.

Farmers' feedback and market demand favored NA 1 over UPAS 120 because of the better taste and relatively larger grain size of the former. However, farmers still rated UPAS 120 as the right choice to integrate into the prevailing cereal-dominated cropping system in the project villages due to its short duration. Yield was not always the paramount consideration in farmers' choice of a variety (Joshi and Witcombe, 1996). This clearly brought the need of a production system's perspective while developing new varieties and technologies in agriculture. Farmers' participation in trials and their evaluation process generated a lot of enthusiasm among them and many farmers have started conducting their own simple experiments before accepting any new variety/technology in different crops. For a large-scale adoption of a variety, it must be owned by the farmers. Active participation and a role in decision making while evaluating overall performance of varieties in FPVS trials gave farmers' a sense of ownership of the selected variety. Farmer-participatory varietal selection provides an effective vehicle to identify farmer-preferred variety (-ies) and hastens the process of varietal replacement (Witcombe et al, 1996). Sometimes farmer-participatory varietal selection and associated data can come in handy to get a better performing advanced breeding line released through fast track bypassing of the formal

variety release protocol (Ref: ICGV 91114 groundnut variety in Andhra Pradesh, Karnataka and Orissa; SN Nigam personnel communication).

C. Capacity building in crop management and seed production

Compared to staple cereal crops, pulses are generally pushed to marginal lands and receive poor management resulting in their low productivity (Ali, 2004). However, for economic viability and sustainability of seed production system, it is essential that farmers are trained in and follow integrated crop management (ICM) and seed production, processing and safe storage technologies. As local grain traders are also involved in informal seed trade, they also need to be trained in maintaining varietal purity and seed health and safe seed storage practices. About 2200 farmers, local traders, NGO staff and extension personnel were trained in the aforementioned aspects through 33 on-campus (IIPR, Kanpur) and off-campus training programs organized during the Jun 2007 to Sep 2009 period.

D. Seed production

With enhanced knowledge and skills in ICM and seed production technology through training, farmers were well prepared to take up quality seed production. In addition to monetary benefits, farmers also developed a culture to 'work together' through the formation of cooperative societies. While the FPVS trials were in progress, seed production of potential pigeonpea varieties, UPAS 120 in Fatehpur and NA 1 in Kanpur Dehat, was simultaneously initiated. Following the 'one village-one variety' concept initially posed problems as both participating and non-participating farmers in a village were required to grow the same variety or maintain an

isolation distance of 300 m between the two pigeonpea varieties. After a lot of persuasion, the non-partner farmers also agreed to grow the designated variety selected for seed production in place of their own variety. In many cases they were also given the seed of the designated variety.

Over a period of three years (2007/08-2009/10), a total of 79.3 t seed of NA 1 was produced from 143.5 ha involving 435 member and non-member farmers in both the districts (Table 3). In the case of short-duration variety UPAS 120, the quantity of seed produced during the same period in Fatehpur was 36.9 t from 45.6 ha involving 203 farmers. Seed production of long-duration pigeonpea variety Bahar was also taken up in the 2007/08 cropping season in 10.4 ha with a total production of 2.8 t in Kanpur Dehat. However, it was discontinued as stalks of Bahar were found unsuitable for broom and basket making.

Farmers' cooperative societies, which came up later, produced the following quantities of seed: CKSS, Chaudgra, Fatehpur - 16 t in 2008/09 and 29.1 t in 2009/10 of UPAS 120 and NA 1 varieties and KBVS, Kuit Kheda, Kanpur Dehat– 20.2 t in 2008/09 and 14.4 t in 2009/10 of NA1 variety.

E. Cost of seed production

The cost of cultivation of NA 1 variety in Kanpur Dehat worked out to Indian rupees (Rs.)14,510 ha^{-1} (Table 4). The cost of cultivation in the case of UPAS 120 was Rs. 13,310 ha^{-1}. In the case of Certified seed production plots, the following additional costs were incurred: registration fee – Rs. 28, inspection fee – Rs. 337 ha^{-1} and seed testing fee – Rs. 169 $sample^{-1}$.

F. Seed disposal

Of the total quantity of seed of NA 1 produced in different years, about 17 - 58% in Fatehpur and 14 - 50% in Kanpur Dehat were retained by the farmers for sowing the crop in the next season. On an overall basis, about 34% of the seed produced by farmers was retained by them (Table 5). Similarly, for UPAS 120, farmers in Fatehpur retained 12 - 28% (average 21%) of the seed produced in different years for seed use in the next season. A large proportion of farmers preferred to save their own seed rather than buying new seed each year. This highlighted the need for safe seed storage practices at the household level.

Both institutional and non-institutional marketing channels were utilized to dispose of the production. The NSC Ltd. was the main institutional player in purchasing the seed. The non-institutional channels included local traders and neighboring and other farmers.

In 2008/09, members of CKSS, Fatehpur sold 1.5 t seed of UPAS 120 to NSC Ltd. as quality seed @ Rs. 38 kg^{-1}. But the members of KBVS, Kanpur Dehat preferred to sell their NA 1 seed to local traders (3.66 t) than to NSC Ltd. in spite of the former giving only Rs. 35 and the latter Rs. 41 kg^{-1} (Table 6). This was mainly because the local traders were easily accessible and they made prompt payment in full, which helped farmers to meet their immediate cash requirement for social and other obligations. In the case of NSC Ltd. the payment is often delayed as the management takes its own time to decide on the purchase price and they release only part payment (80%) at the time of procurement. The remaining payment is released after grading and checking for quality control. This may sometimes take many months. These bureaucratic delays discourage many farmers from participating in formal seed production. The price of seed also

varied with the variety. Even NSC Ltd. offered Rs. 38 kg^{-1} for UPAS 120 and Rs. 41 kg^{-1} for NA 1. A substantial proportion of the production (average 32.7% for NA 1 and 21% for UPAS 120) was sold as grain at a lower price, which is surprising. Looking at the limited availability of quality seed in legumes, it is essential that the seed production is not diverted for sale as grain and DoA should make necessary arrangements to procure such quantities.

G. Economic analysis of seed production

Growing pigeonpea for seed purpose is more profitable than growing it for food use. The C:B ratio for seed crop was 1:5.19 as compared to 1:2.53 of the crop grown for food use (Table 7).

H. Sufficiency of quality seed at the local level

The quality seed of improved, farmer-preferred varieties contributes to improved agricultural productivity as it responds to farmers' needs and situations (Pelmer, 2005). Sperling and Cooper (2003) conceptualized farmer-level seed security as the situation in which a farmer has access to the sufficient quantities of seeds of their preferred varieties with desired physical qualities. They further reiterated that since a majority of small-scale farmers operate in lo- input systems, their seed security is guaranteed when they produce enough food and put some in reserve to be used as seed for the next season. Small-scale farmers, however, encounter manifold challenges of biotic and abiotic stresses putting, thereby, the village-level seed sufficiency at risk (Rubyogo et al, 2005). Further, small farmers are often compelled to sell their total produce in the market due to immediate cash requirement to clear debt and attend to other social obligations. The own-saved seed is akin to blocking that much capital for the next 6-8 months which becomes

uneconomical to farmers as they have to clear loans taken at high interest rates. To ensure seed sufficiency at the village level, not only the cultivation and multiplication of farmer-preferred varieties following ICM is important, the formation of producers' association and developing their capacity to initiate seed based micro-enterprises is equally important (Penrrose-Buckley, 2007). Jones et al. (2001) empirically reported that farmer-to-farmer informal dissemination of preferred seed was quicker through such associations and farmers' groups particularly in pigeonpea in semi-arid regions of Kenya.

Based on the findings and experiences of the study, a functional 'seed system model' depicting roles of various stakeholders and related institutional linkages and anticipated outcomes is shown in Fig 1.

The suggested seed system model has the following advantages:

i. Improved access to and availability of quality seed of farmer-preferred varieties for all groups of farmers

ii. Minimum overhead

iii. Seed is stored in the village

iv. Seed is available at a reasonable price and at the right time

v. Institutional support for Breeder/Foundation seed supply and technical backstopping

vi. Institutional support for capital requirements

vii. Potential for linkages with formal seed sector

LESSONS LEARNT AND CONCLUSIONS

For faster and sustainable agricultural development, a farmer-participatory approach is essential. The ISOPOM project, which followed this approach, helped farmers to identify their preferred pigeonpea varieties and in producing and ensuring availability of their quality seed at the village level, and enhanced their productivity, increased farm income, changed cropping patterns and increased area under the pulse crops. The pigeonpea cultivation, which was hitherto ignored by the farmers due to high risk, was re-popularized in both the districts. There is 25-35% increase in area in the 2009 rainy season as compared to the previous years. Further, 70-80% area under pigeonpea is now covered by improved pigeonpea variety NA 1. However, episodes of high rainfall and prolonged droughts associated with climate change did adversely affect the seed production program. Farmers were advised to adopt the full package of ICM to derive the maximum advantage of genotype x management interaction (Dhar et al., 2002) and monitor the crop regularly for insect pest attacks so that appropriate control measures could be initiated in time. Any delay in managing insect pest attack can cancel the gains expected from improved genotype and ICM.

For a long time to come, the informal seed sector will continue to play a dominant role in legumes in India as their seed requirement is large and no single agency is capable of fully meeting it. To ensure good quality of seed produced by the informal seed sector, capacity enhancement of all those involved in seed production, processing and distribution is essential. Training in ICM and seed production technology enhanced famers' knowledge and skills, which

prepared them well for taking up quality seed production and consequently acquiring more profit from pulses seed production. Local seed traders were also sensitized in maintaining the varietal integrity and quality of seed at their level. In addition to monetary benefits, farmers also developed a culture to “work together through the formation of cooperative societies", which enhanced their bargaining power in the market and gave them voice to raise issues that concern them in various fora. Ultimately both economic and social benefits and cooperative working helped farmers to improve their livelihoods. Registration for quality seed production is cheaper as a group than as individuals. Farmers also felt that seed production of each variety should be taken up in compact blocks to facilitate uniform and timely application of cultural and plant protection measures. With compact blocks, it is also easier to keep stray cattle and wild animals away from seed production fields. This will also facilitate visits of seed certification agency officials, who should visit seed production plots more frequently.

For long term sustainability of seed ventures linking with formal seed sector is beneficial. In India, marketing of Truthfully Labeled seed (TL seed) is legally permissible. This gives an opportunity to seed cooperatives to diversify their seed production activities. The cooperative societies are, now, engaged in production and marketing of quality seed of pigeonpea and chickpea in their own and neighboring districts. They have been advised to brand their seed produce for better marketing. Impressed with the initial success of these cooperative societies, a majority of small and marginal farmers in partner villages are approaching them for joining in participatory seed production programs.

FUTURE PLAN

To sustain and further strengthen the pigeonpea seed production initiative through farmers' cooperative societies in Fatehpur and Kanpur Dehat districts in U.P., the following steps were planned by the project partners.

1. For ensuring availability of quality seed at village level and stabilize seed delivery system (both formal and informal seed sector), IIPR, Kanpur, one of the partners in the ISOPOM project, will provide Breeder seed of pigeonpea varieties at a cost basis to farmers' cooperatives as per their demand. It will also assist these cooperatives in obtaining Breeder/Foundation seed from other sources.

2. IIPR, Kanpur will provide regular skill oriented training (on and off-campus) to members of the farmers' cooperative societies and monitor their seed plots during the cropping season.

3. Office bearers of the farmers' cooperatives will establish and promote close linkages with district level functionaries engaged in seed and input supply sectors.

4. Linkages between formal seed sector and farmers' cooperative societies would be further strengthened.

5. Under their corporate social responsibility, NSC Ltd. and other public sector seed agencies should support farmers' cooperative societies engaged in seed production and provide for seed processing and storage infrastructure development at village level.

6. On request, ICRISAT will provide small quantities of seed of new pigeonpea varieties and hybrids and their parental lines to the members of farmers' cooperative societies for their evaluation and seed multiplication.

References

Ali, M. 2004. Role of pulses in crop diversification in India. In *Role of legumes in crop diversification and poverty reduction in Asia*, 42-56 (Eds. CLL Gowda and S Pande). Proceedings of the Joint CLAN Steering Meeting, 10-12 Nov 2003, Patancheru, India: International Crops Research Institute for the Semi-Arid Tropics.

Almekinders, C. J. M., Louwaars, N.P. and de Bruijn, G.H. 1994. Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica* 78: 207-216.

Almekinders, C. J. M., Thiele, G. and Daniel, D. L. 2007. Can cultivars from participatory plant breeding improve seed provision to small scale farmers? *Euphytica*153: 363-3372.

David, S. and Sperling, L. 1999. Improving the technology delivery mechanisms: Lessons from bean seed system research in east and central Africa. *Agriculture and Human values* 16: 381-388.

Dhar, V., Singh, N. B., Singh, F. and Majumdar, N. D. 2002. Pigeonpea: Package of practices. Indian Institute of Pulses Research, Kanpur.

Jones, R. B., Audi, P. A. and Tripp R. 2001. The role of informal seed systems in disseminating modern varieties: example of pigeonpea in semi-arid areas of Kenya. *Experimental Agriculture* 37: 539-548.

Joshi, A. and Witcombe, J. R. 1996. Farmer participatory crop improvement. II. Participatory varietal selection, a case study in India. *Experimental Agriculture* 32: 461-477.

Maruthi Shankar, G.R., Yadav, I.P.S., Dharmraj, P.S., Gupta, G.P., Antkar, V.N., Ghajbiye, K.S., Thyagaraju, C.R., Girija, A., Vittal, K.P.R. and Chary, G.R. 2004. Constraint analysis of low productivity of rainfed chickpea and pigeonpea in India. *Indian Journal of Pulses Research* 17 (2): 162-166.

Nigam, S. N. 2009. Designing farmer-participatory varietal selection in legumes. *In Legumes for Ecological Sustainability*, 519-528 (Ed. M. Ali, S. Gupta, P. S. Basu and Naimuddin). Proceedings of the national symposium on legumes for ecological sustainability: emerging challenges and opportunities, 3-5 Nov 2007, IIPR, Kanpur. Indian Society of Pulses Research and Development.

Parthasarathi Rao, P., Birthal, P.S., Bhagavatula, S. and Bantilan, M.C.S. 2010. Chickpea and pigeonpea economies in Asia: Facts, trends and outlook. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Pelmer, D. P. 2005. Agriculture in the developing world: Connecting innovations in plant breeding research to down stream applications. *PNAS* 102 (44) 15739-15746.

Penrrose-Buckley, C. 2007. Producer organization: A guide to developing collective rural enterprises. Oxfam GB, Oxford, UK.

Ravinder Reddy Ch., Nigam, S.N., ParthasarathyRao, P., Ahmed, S., Ratnakar, R., Ashok, A., Ashok Kumar, A., Reddy, B.V.S. and Gowda, C.L.L. 2010. Village seed banks: An integrated seed system for improved seed production and supply – A case study. Information Bulletin No.

87. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Rubyogo, J. C., Remington, T. and Jones, R. 2005. Seed systems for reaching a broad range of users quickly and efficiently. Proceeding of the Harvest Plus Reaching End Users Meeting, 5-7 May 2004, Rome, Italy (IPGRI-Macaresse).

Rubyogo, J. C., Sperling, L. and Assefa, T. 2007. A new approach for facilitating farmers' access to bean seed. *LEISA Magazine* 23 (2) 27-29.

Saxena, K.B. 2006. Seed production systems in pigeonpea. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Singh S. K., Kumar, S., Singh, A. K., and Sah, U. 2008. Sustainable improvement in pulses productivity in Hamirpur district of Uttar Pradesh: An approach of farmer participatory varietal evaluation. *Indian Research Journal of Extension Education* 8 (2&3): 32-37.

Sperling, L. and Cooper, H. D. 2003. Understanding seed systems in seed security. In *Improving the effectiveness and sustainability of seed relief*. Proceedings of a stakeholders' workshop in Rome 26-28 May 2003: Food and Agricultural Organization.

Witcombe, J. R., Joshi, A., Joshi, K. D. and Sthapit, B. R. 1996. Farmer participatory crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity. *Experimental Agriculture* 32: 445-460.

ACCEPTED MANUSCRIPT

Table 1.Average performance of long-duration pigeonpea varieties included in FPVS trials in Fatehpur and Kanpur Dehat districts, 2007/08 – 2008/09.

Variety	Grain yield (kg ha^{-1})					
	Fatehpur			Kanpur Dehat		
	2007/08[1]	2008/09[1]	Average	2007/08[1]	2008/09[1]	Average
NA 1	1683	1697	1690	2356	2371	2363
Bahar	1321	1328	1324	2029	2032	2031
Amar	1245	1259	1252	1956	1979	1967
Azad	961	971	966	1821	1823	1822
Mal 13	715	728	721	1701	1730	1715
Local	915	928	921	1323	1327	1325
LSD (5% p level)	198.5	194.5	184.6	141.5	145.1	136.2

CV (%)	19.3	18.7	18.2	8.4	8.6	8.2

1= Average of 10 non-replicated trials with 100 m^2 plot sizefor each variety.

Table 2.Farmers' assessment of pigeonpea varieties for various traits and their overall rank (2007/08-2008/09).

Variety	Average score for the trait[a]								Total score	Overall rank
	Grain yield	Short-duration	Market price[b]	Taste	Disease resistance[c]	Drought tolerance[d]	Frost tolerance	Tolerance of insect pests[e]		
NA 1	8.8	6.5	7.9	8.4	8.2	7.6	8.2	5.9	61.5	I
Amar	7.1	7.3	7.8	6.4	7.0	7.6	6.2	7.4	56.8	III
Bahar	7.6	7.5	8.2	7.8	7.9	6.2	7.5	7.3	60.0	II
Mal 13	6.5	8.0	7.9	7.1	7.0	4.5	6.5	7.1	54.6	V
Azad	6.9	7.5	7.5	6.2	7.0	7.2	6.1	7.2	55.6	IV
Local	6.2	6.8	7.0	8.0	5.6	3.4	7.1	7.6	51.7	VI

a=Scored on a 1 - 10 scale, where 1 = the lowest, and 10 = the highest for preference; b= scored based on seed size and color preferred by growers, traders and millers; c= assessed at initiation of secondary branches and flowering and at pod formation stage; d= assessed at flower initiation stage, and e= assessed at flowering and pod formation stage.

Table 3.Year-wise seed production of long-duration pigeonpea variety NA 1 in Fatehpur and Kanpur Dehat districts, U.P.

Cropping season	District	No. of farmers	Area (ha)	Total production (t)
2007/08	Fatehpur	68	23.7	4.2
	KanpurDehat	41	17.0	22.8
2008/09	Fatehpur	30	9.0	10.6
	KanpurDehat	67	31.2	20.2
2009/10	Fatehpur	83	19.2	7.1
	KanpurDehat	146	43.4	14.4
	Total	435	143.5	79.3

Table 4.Cost of production of NA 1 pigeonpea variety in Kanpur Dehat, 2009/10.

S. No.	Operation/Activity	Expenditure in Indian rupees ($Rs.ha^{-1}$)
1	Land preparation	2320
2	Seed and sowing*	1560
3	Fertilizers	580
4	Interculture	1880
5	Irrigation	3360
6	Insecticide	2410
7	Harvesting, threshing, winnowing, packaging etc.	2400
	Total	14,510

* Pigeonpea seed rate 8-10 kg ha^{-1}.

Table 5.Details of year-wise seed disposal of long-duration pigeonpea variety NA 1 in Fatehpur and Kanpur Dehat districts.

Cropping season	District	Procurement by NSC Ltd. (t)[1]	Quantity sold in nearby market (t)		Quantity kept for next year's use as seed (t)
			As seed	As grain	
2007/08	Fatehpur	-	2.15	1.05	1.00
	Kanpur Dehat[2]	-	2.20	5.90	5.70
2008/09	Fatehpur	-	1.00	3.50	6.10
	KanpurDehat	3.66	4.60	9.00	2.90
2009/10	Fatehpur	1.85	2.04	1.90	1.26
	KanpurDehat	2.15	3.40	1.65	7.20
	Total	7.66	15.38	23.00	24.16

1. Procured from members and non-members of the 'samitis', 2. IIPR, Kanpur procured 9.0 t quality seed.

Table 6.Details of seed disposal of short- and long-duration pigeonpea by the farmers' cooperative societies ('samitis') in the project districts, 2008/09.

S. No.	Disposal channel	Unit/Rate	Chaudgra Kisan Sewa Samiti, Chaudgra, Fatehpur	Krishak Beej Vikas Samiti, Kuit Kheda, Kanpur Dehat
1	Quantity sold to NSC Ltd.	kg/ Rs. kg^{-1}	1500 (28%), 38	3660 (17%), 41
2	Value of quantity sold to NSC Ltd. (A)	Rs.	57,000	1,50,060
3	Quantity sold to local traders as seed	kg/ Rs. kg^{-1}	800 (15%), 32	2500 (12%), 40
4	Value of quantity sold to local traders as seed (B)	Rs.	25,600	1,00,000
5	Quantity sold in nearby	kg/ Rs. kg^{-}	750 (14%),	9000 (45%),

	market as grain	^{1}	28	35
6	Value of quantity sold in market as grain (C)	Rs.	21,000	3,15,000
7	Quantity sold to neighboring village farmers as seed	kg/ Rs. kg^{-1}	900 (17%), 30	5000 (25%), 38
8	Value of quantity sold to neighboring village farmers as seed (D)	Rs.	27,000	1, 90, 000
9	Gross income (A+B+C+D)	Rs.	1,30,600	7,55,060

Figures in parentheses indicate the proportion of total quantity of seed sold.

Table 7.Economics of seed production of pigeonpea variety NA 1 in Kanpur Dehat, 2008/09.

S. No.	Indicator	Variety	
		Local	NA 1
1	Average seed yield (t ha^{-1})	1.02	2.23
2	Cost of cultivation (Rs. ha^{1})	10,110	14,764
3	Prevailing market price (Rs.t^{-1})	35,000	41,000
4	Gross income(Rs. ha^{-1})	35,700	91,430
5	Net income (Rs. ha^{-1})	25,590	76,666
6	B:C ratio	2.53	5.19

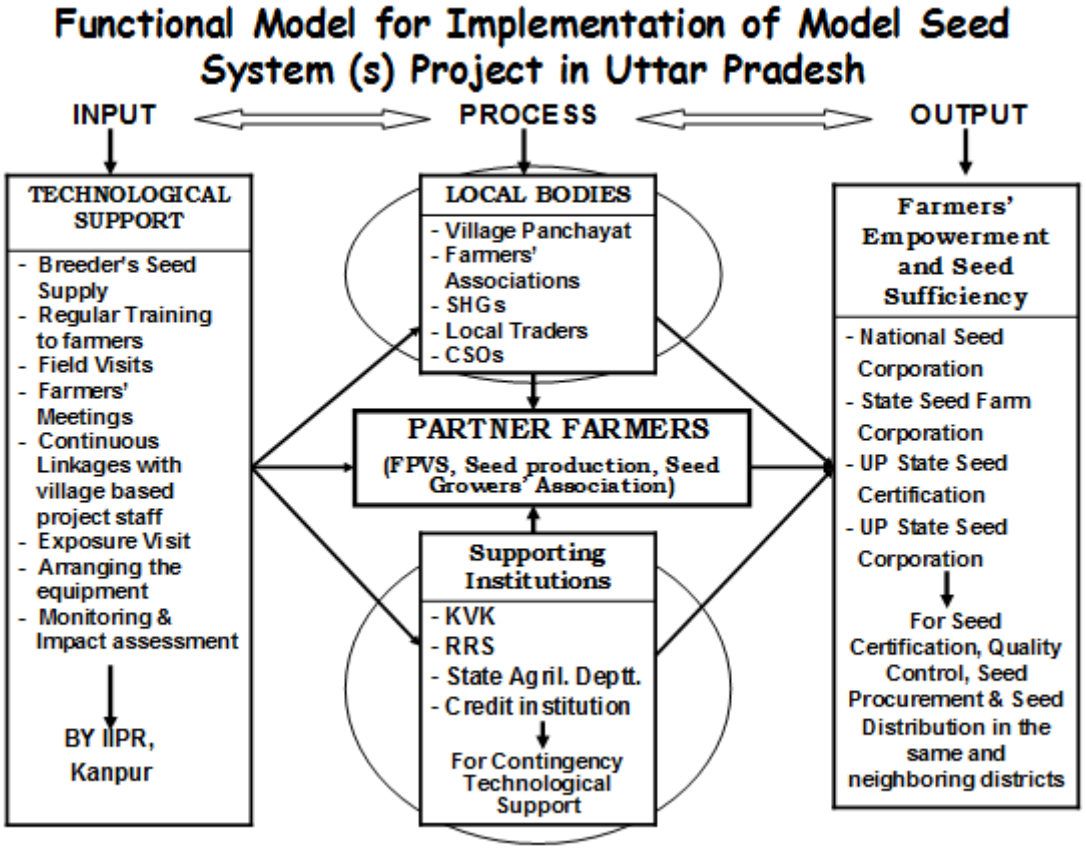

Fig. 1