Project Report

(RUF Project No. 91145)

EFFICIENT USE OF SOIL NUTRIENTS: USING GENETIC DIVERSITY OF WINTER GRAIN LEGUMES FOR SUSTANABLE CROPPING SYSTEMS IN BANGLADESH

Effektiv optagelse af plantenæringsstoffer fra jord ved udnyttelse af de genetiske forskelle hos 'vintersæd' af bælgplanter, dyrket i bæredygtige afgrødesystemer i Bangladesh

(Acronym: GENESYS)

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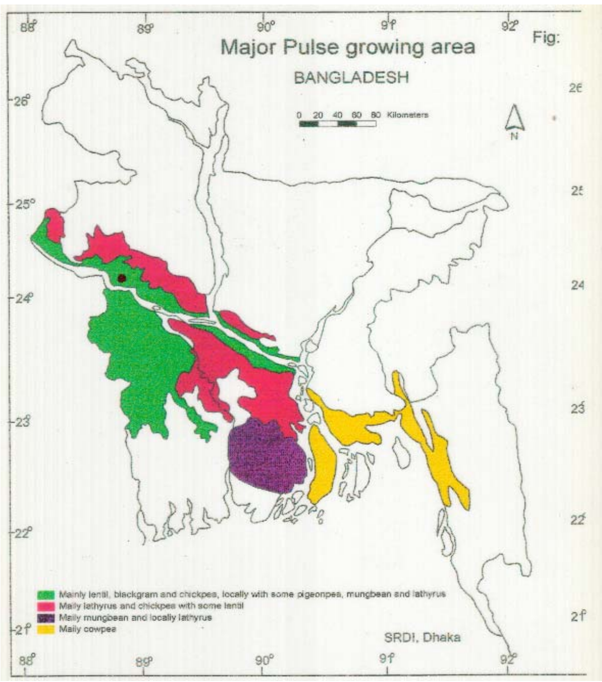


October 2004

Project partner institutions

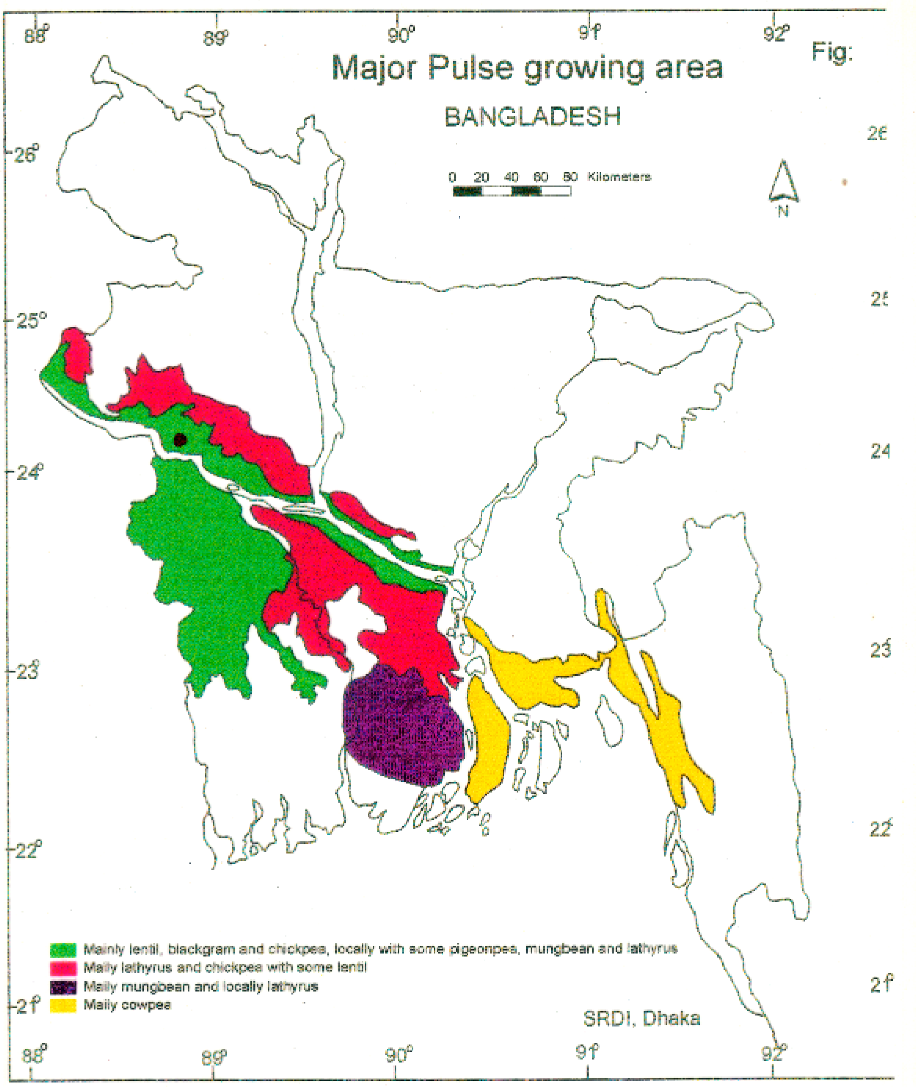
The Royal Veterinary and Agricultural University (KVL)
Plant Nutrition and Soil Fertility Laboratory, DENMARK

IN CO-OPERATION WITH

BANGLADESH AGRICULTURAL RESEARCH INSTITUTE (BARI), BANGLADESH

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS (ICARDA), SYRIA

Risø National Laboratory (Risø)
Plant Research Department, Denmark



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EFFICIENT USE OF SOIL NUTRIENTS: USING GENETIC DIVERSITY OF WINTER GRAIN LEGUMES FOR SUSTANABLE CROPPING SYSTEMS IN BANGLADESH (Acronym: GENESYS)

The goals and expected outputs of the project, as stated in the application, were

1. THE GOALS

a) To establish and foster co-operation with the partners institutions and to gain knowledge of efficient root traits of lentil and grasspea genotypes/landraces for enhancing the productivity through efficient use of soil and fertilized nutrients in underutilized, salt affected and drier areas of Bangladesh.
b) Development of strategy to support legume based sustainable cropping systems through crop diversification and IPNM.

2. THE EXPECTED OUTPUTS

(1) Identification of germplasm and breeding lines of lentil, grasspea with favorable root traits important for nutrient efficiency, salinity and drought tolerance.

(2) Knowledge based production technologies and strategies for improved varieties and integrated plant nutrition management systems developed within the existing cropping patterns and economically viable alternative cropping systems that are acceptable to farmers identified.

(3) Enhanced research capacity and technical skills of the scientists and technical staff at BARI through exchange of views and interactions with the applicant.

3. Project outputs

3.1. Summary

GENESYS was a one-year (11 August 2003 – 10 August 2004) research and development project financed by Council of Development Research (RUF) with the total requested budget of 821.566 Dkr. The project was carried out in close co-operation between The Royal Veterinary and Agricultural University (KVL), Risø National Laboratory (RISØ), Denmark, CGIAR center ICARDA in Aleppo, Syria and Bangladesh Agricultural Research Institute (BARI) Jodybpur, Gazipur. To meet the goals of the project and to perform *action research* at the levels of farmers, extension, science and policy and to bring the research results in development context, Dr. Tara Singh Gahoonia (TSG), spent time at BARI (October 2003- March 2004) and at ICARDA, Aleppo Syria (March 2004-May 2004).
The action research involved,
1) experiments with pulse crops Grasspea, Lentil and Chickpea at Pulses Research Center of BARI at Ishurdi Pabna,
2) meetings with Bangladeshi farmers during field trips, block supervisors, extension officers, politicians (MPs) of pulse growing areas as well as with the local scientists and DANIDAs advisers working on Soil Fertility and Fertilizers Program (SFFP) in Bangladesh.

3) The Danish partners of the project Dr. Tara Singh Gahoonia (TSG) from KVL and Dr. Jahoor Ahmed from RISØ were invited to participate in BARI-ICARDA Friendship days, 14-15 Feb. 2004 held in Dhaka, aimed at promotion of pulses cultivation in Bangladesh. Here we had the opportunity to address briefly the aims and long-term perspectives of the one-year project in the presence of Bangladesh Minister of Agriculture, Mr. MK Anwar, MP, Agriculture Secretary (Abdul Halim), Director-General of ICARDA (Prof. Dr. A. El-Beltagy) and Director-General of BARI (Dr. S M Islam).

At ICARDA, Aleppo, Syria, TSG participated in many trips to the research as well as farmer's fields and developed a research and development strategy. TSG was invited to participate in ICARDAs Presentation-Day (24th April 2004) and reception meeting of the members of CGIAR Science Council held at ICARDA (13 May 2004), chaired by Professor Per Pinstrup-Andersen. This contributed towards fostering of the co-operation between the participating scientists and the institutions for making long-term strategy to promote pulses cultivation particularly in Bangladesh, but also with eyes on other pulse growing developing countries of South Asia (Nepal, Bhutan, Afghanistan, Pakistan and India) and West Asia and North Africa (middle east and Sudan) regions as "spillover effects of the knowledge and technologies".

The scientific research for development was conducted to address the short- and long-term needs and perspectives of increasing pulses production. The outputs of the project are reported below from "The Research" and from "The Development" related view points. Based on the research outputs and the facts finding, the research and development strategy is presented. The research outputs were disseminated broadly to the International community through a workshop, scientific journal articles, daily newspaper articles, conference lectures and seminars.

3.2. The Research

The main scientific question addressed in the project was "whether and to what extend root system of pulses (Grasspea, Lentil and Chickpea) contribute to attain higher grain yield in nutrient poor soils of Bangladesh? It may be mentioned that chickpea was not the part of the project goals in the original application for project funds. After starting the project and after arriving at BARI in Bangladesh, I had email discussion with Paul Richardt Jensen, TSA, Danida, about the desire of local farmers and extension officers, especially in northern Barind region of Bangladesh, to grow more chickpea, if improved varieties were available. As the research on root traits of chickpea seemed possible with minor adjustment within project budget, the goals of the project were extended to include chickpea.

Pot and field experiments were conducted at Pulses Research Center of BARI (PRC-BARI) at Ishurdi, Pabna, where the root systems of 10 lentil, 10 chickpea and 5 grasspea varieties and potentially useful breeding lines were investigated in detail for a number of morphological and physiological traits (Figure 1). The results of the pot experiments were related to the results of field experiments at six major pulses growing locations, where the grain yield was determined and socio-economic analysis was performed.

Figure 1. *Pot experiment at Pulses Research Center of BARI at Ishurdi, Bangladesh*.

3.2.1. Lentil

To make use of the locally available resources and for keeping the technology simple, pots were made by cutting two-liter plastic bottles and then covered with black polythene to prevent exposure of light to the roots. The development of root system could be observed visually *in situ* (Figure 2), before extracting roots by washing and measuring their size by using Image analysis system. The staff at PRC-BARI was trained to make use of the Image analysis technology in root research.

Figure 2. Root *system of Bari-masur-3 (left) and Bari-masur-4 (right) in situ and roots washed out of soil.*

Significant ($p < 0.05$) variation in root size was found among the Bangladeshi commercial lentil varieties Barimasur-3 (BM-3) and Barimasur-4 (BM-4) and perspective breeding lines (Figure 3). In Bangladesh I was often confronted with the question by the local pulse scientists and extension officers, "why Barimasur-4 performs better especially in nutrient-poor soils and why it is more popular among the farmers?" As an attempt to find the answer to the question, the root morphology and physiology of BM-3 and BM-4 was investigated in detail. The research revealed that in addition to the larger root system of BM-4, its roots are also covered with more root hairs (Figure 4), which are of crucial importance for capturing nutrients and water from nutrient-poor and dry soils, perhaps also for salinity tolerance. The investigations though did not show differences in physiological properties of lentil varieties BM-3 and BM-4.

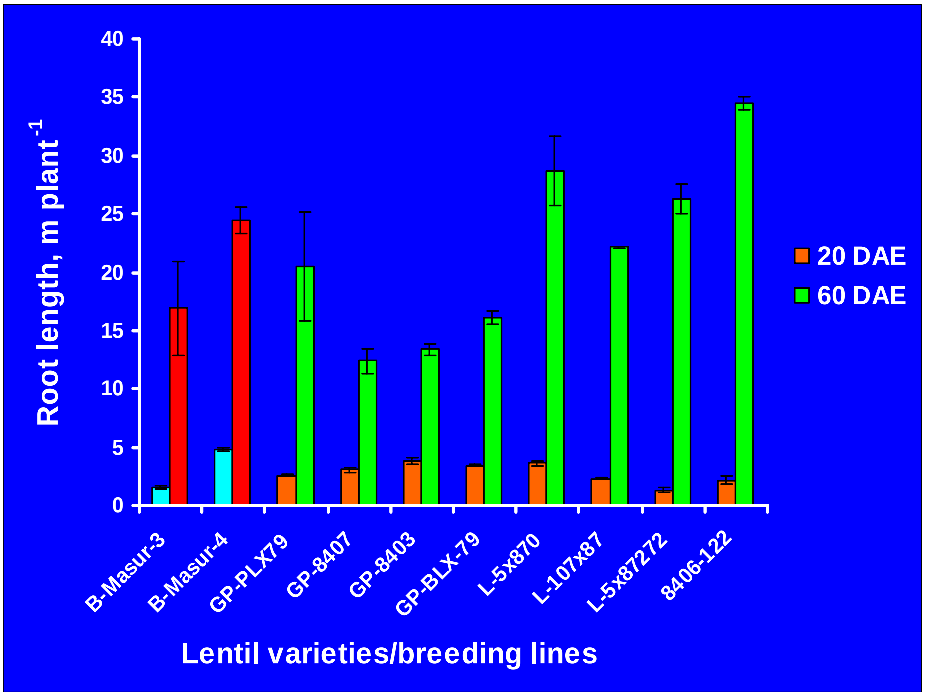


Figure 3. *Variation in root lengths of ten lentil varieties/breeding lines.*

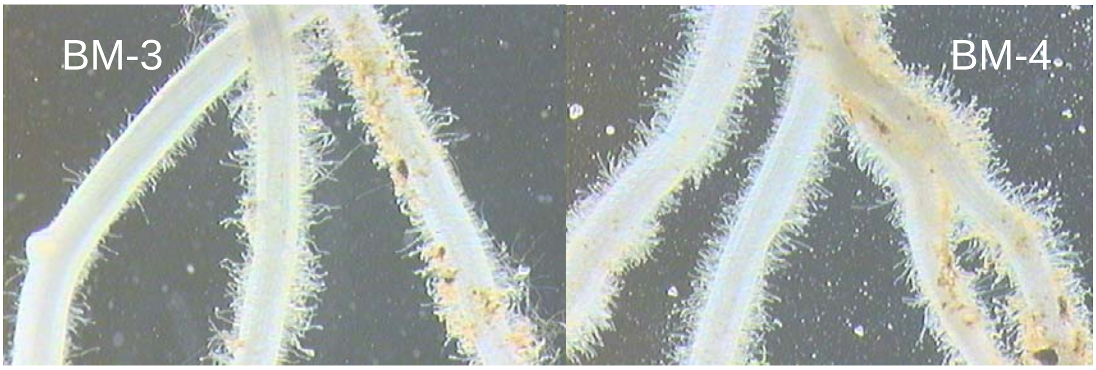


Figure 4. *Presence of root hairs on the roots of lentil varieties Bari-masur-3 (BM-3) and Bari-masur-4 (BM-4).*

The superior root morphology of BM-4 (larger root system covered with more root hairs) was related to the higher uptake of both major-nutrients (P, K, Ca, Mg and S) and micronutrients (Fe, Zn, Mn, Cu, B, Mo) by BM-4 compared to BM-3 (Table 1).

Table 1 Shoot biomass (DM) and nutrient uptake of two lentil varieties Barimasur-3 (BM-3) and Barimasur-4 (BM-4) in pot experiment (Mean ± standard error of means, n= 4).

DM and nutrients Uptake	Variety	
	BM-3	BM-4
DM (g $plant^{-1}$)	1.16 ± 0.05	1.12 ± 0.03
Macro-nutrients (g kg^{-1} DM)		
K	20.43 ± 0.75	28.12 ± 1.03
P	3.62 ± 0.05	3.95 ± 0.06
Ca	16.44 ± 0.04	20.14 ± 0.57
Mg	2.52 ± 0.06	3.06 ± 0.10
S	3.04 ± 0.11	3.05 ± 0.20
Micro-nutrients (mg kg^{-1} DM)		
Fe	376.2 ± 5	400.3 ± 7
Mn	49.1 ± 0.21	57.4 ± 1.76
Zn	25.7 ± 1.75	35.18 ± 1.46
Cu	15.6 ± 0.47	20.2 ± 1.52
B	14.7 ± 0.07	16.0 ± 0.72
Mo	1.12 ± 0.02	1.96 ± 0.04
Co	0.26 ± 0.03	0.26 ± 0.02

Under field conditions, Barimasur-4 performed better than Barimasur-3 (Figure 5).

Figure 5. *Field performance of Barimasur-3 (left) and Barimasur-4 (right).*

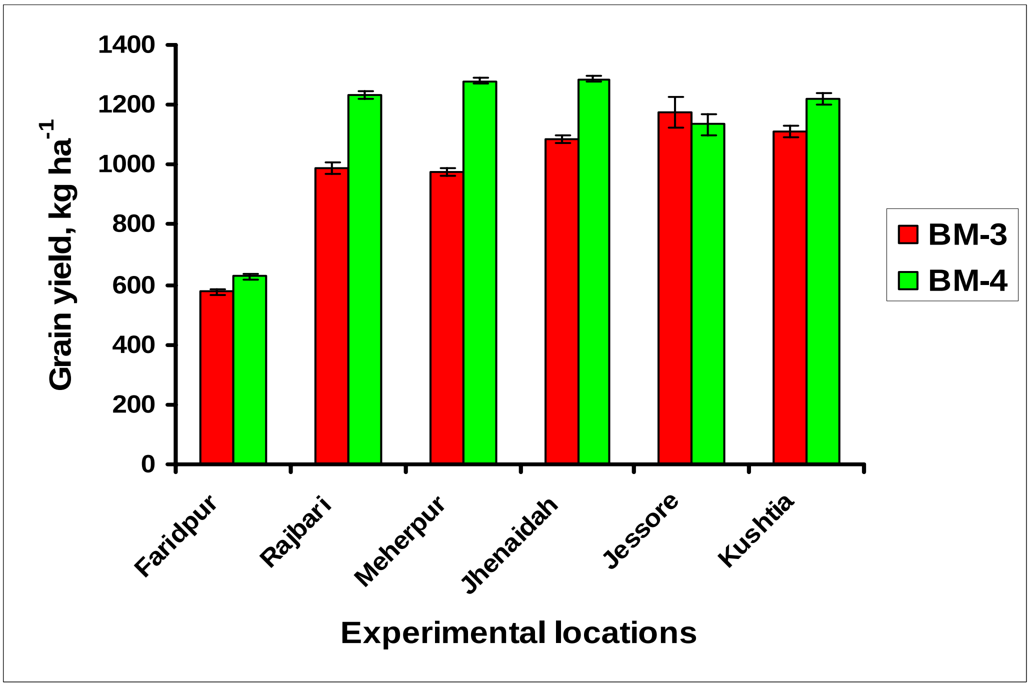


Figure 6. *Grain yield of Bari-masur-3 (BM-3) and Bari-masur-4 (BM-4) at six locations in Bangladesh.*

At five locations in pulse growing regions of Bangladesh, Barimasur-4 produced up to 10-20 % higher grain yield as compared to Barimasur-3 (Figure 6). The higher grain yield of Barimasur-4 was linked to its larger root system (Figure 2) which favored better capture of nutrients (Table 1)

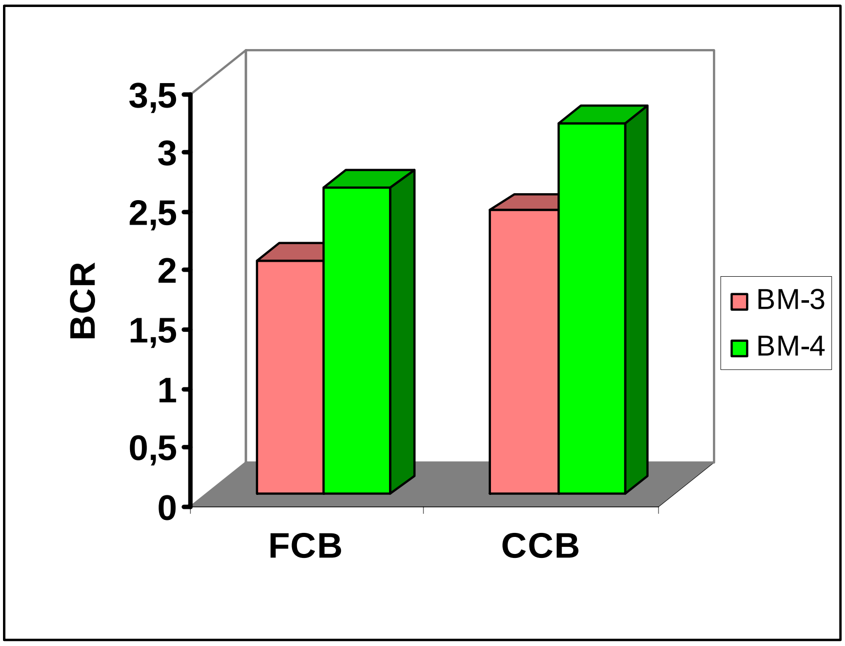


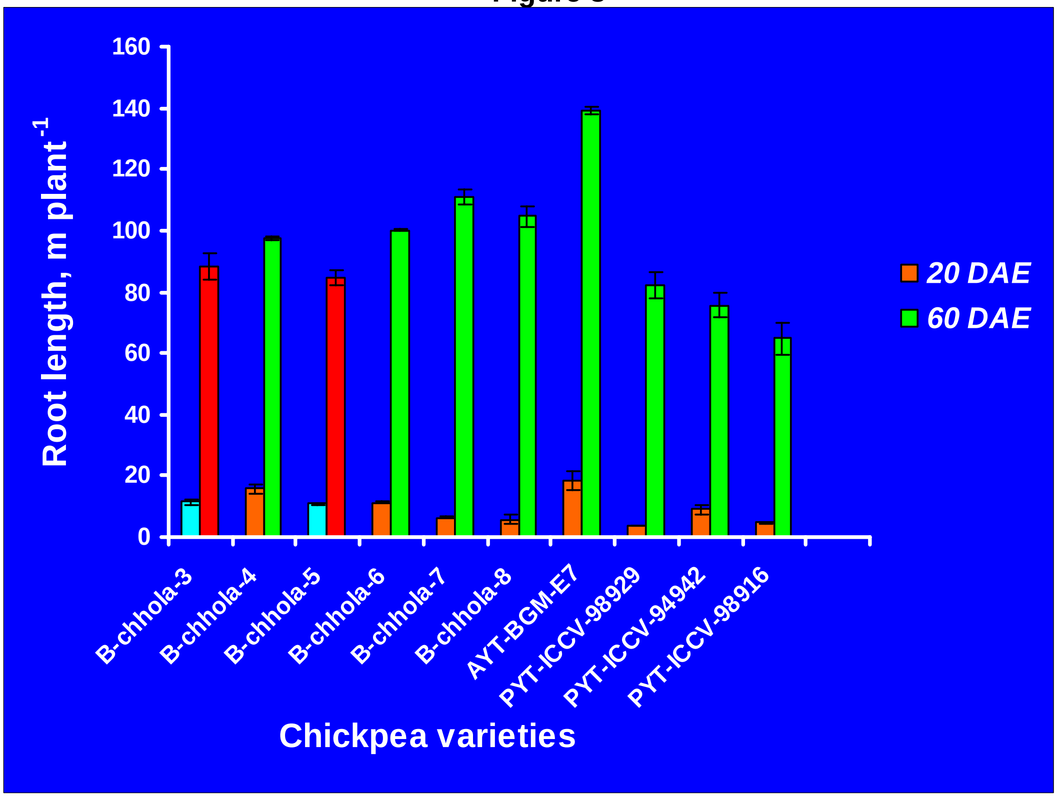
Figure 7. *Benefit Cost Ratio (BCR) as Full Cost Basis (FCB) and Cash Cost Basis (CCB) of two lentil varieties Bari-Masur-3 (BM-3) and Bari-Masur-4 (BM-4)*

Due to the higher grain yield, the benefit-cost ratio (BCR = gross return per ha / total variable cost per ha) of Barimasur-4 was higher as compared to Bari-masur-3 (Figure 7). Here it can be said that when farmers invested one Takka in cultivation of Barimasur-4, the return was about three times. With Barimasur-3, the return was about two times. Farmers could potentially earn more by cultivating Barimasur-4, irrespective of whether they used on-farm inputs (FCB) or purchased the inputs (CCB). This, at least, supports the greater popularity of Barimasur-4 among the local farmers. Its popularity may be further increased through farmers training and if high quality seeds are made easily available to more farmers. However, the dependency of expansion of lentil cultivation through the single variety may be unsafe, due to the risks of additional narrowing of the genetic base and disease and pest epidemic. More improved varieties having disease tolerance/resistance and superior root system like Barimasur-4 should, therefore, support and promote pulses cultivation in nutrient-poor soils of small and marginal farmers in Bangladesh.

3.2.2. Chickpea

Chickpea varieties differed widely in their root length (Figure 8). Their root size ranged from 70 m per plant to 140 m per plant. The two commercial varieties Bari-chhola-3 and Bari-chhola-5 are popular among the farmers. Bari-chhola-5 is the preferred variety.

Figure 8



As you can see in Figure 8, the two popular varieties, Bari-chhola-3 and Bari-chhola-5 do not differ in root length as such. However, the roots of Bari-chhola-5 are covered with more root hairs than Bari-chhola-3 (Figure 9).

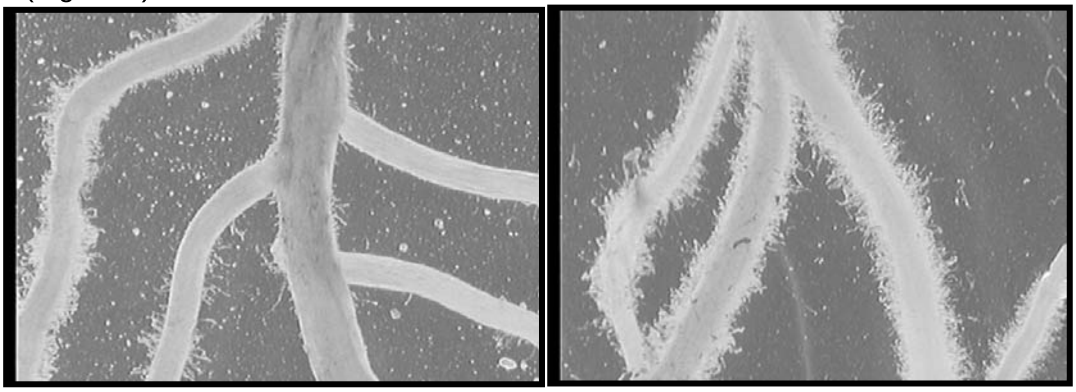


Figure 9. *Root hairs on the roots of Bari-chhola-3 (left) and Bari-chhola-5 (right)*

Both popular varieties Bari-chhola-5 and Bari-chhola-3 induced acidification of their rooting media as compared to other varieties (Figure 10). Bari-chhola-5 (68) acidified the rhizosphere more than Bari-chhola-3 (61).

Figure 10. *Root media pH change of selected chickpea varieties. More yellow color means more acidification. Barichhola-5 (68), Barichhola-3 (61).*

To bring the laboratory results closer to development, we confirmed the ability of chickpea to acidify the rhizosphere in the field (Figure 11). The roots of flowering chickpea variety Bari-chhola-5 were exposed, placed on soil bed and covered with agar-agar containing pH indicator dye Bromocresol purple. After about one hour, the root-induced acidification was indicated by yellow color near the roots. Such localized acidification in the vicinity of roots can be crucial for dissolving and uptake of most nutrients from the Bangladeshi soils which are mostly low in available nutrients.

Figure 11. *Root media pH change of chickpea variety Bari-chhola-5 in the field. It is promising that research technologies from Danish laboratories could be implemented to do `visible´ root physiological research in the chickpea fields of Bangladesh.*

Just like in the laboratory, maize did not induce pH change near the roots in the field, as indicated by no yellow color near the roots (Figure 12).

Figure 12.

The investigated varieties/breeding lines of chickpea differed in the ability to acquire and accumulate Potassium (K), Phosphorus (P), Calcium (Ca), Magnesium (Mg) and Sulphur (S) in the shoot biomass (Table 2). The chickpea varieties/breeding lines also differed to acquire and accumulate micronutrients (Table 3), like Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B) and Molybdenum (Mo). The superior ability to acquire nutrients by the chickpea genotypes was linked to the superior root morphological (larger roots covered with more root hairs) and physiological (root zone acidification) traits.

Table 2. Variation in uptake of major nutrients by ten chickpea genotypes, grown in a nutrient-poor soil in Bangladesh. (Mean ± standard error of means, n= 4).

Genotypes	macronutrients (g kg^{-1})				
	K	P	Ca	Mg	S
B-chhola-3	20.65±0.56	2.00±0.07	16.67±0.80	1.50±0.02	1.50±0.10
B-chhola-5	24.58±0.75	2.33±0.02	18.98 ±0.43	1.67±0.08	1.37±0.10
B-chhola-4	20.24±0.36	2.04±0.08	14.13±0.38	1.35±0.06	1.63±0.12
B-chhola-6	18.60±0.66	1.97±0.10	19.76±0.58	1.34±0.05	1.29±0.10
B-chhola-7	16.18±0.24	1.73±0.06	24.17±1.14	1.57±0.09	1.40±0.06
B-chhola-8	20.23 0.49	1.55±0.02	22.66±1.15	1.54±0.04	1.62±0.09
BGM-E7	23.91±0.22	2.04±0.06	20.96±0.06	1.52±0.03	1.88±0.13
ICCV-98926	20.24±1.01	1.76±0.10	22.20±1.04	1.63±0.03	1.85±0.08
ICCV-94924	16.98±0.28	1.88±0.04	23.65±0.99	1.64±0.19	1.55±0.02
ICCV-98916	19.11±0.80	1.90±0.08	20.20±0.39	1.39±0.11	1.77±0.11

Table 3. Variation in uptake of micronutrients by ten chickpea genotypes, grown in a nutrient-poor soil in Bangladesh. (Mean ± standard error of means, n= 4).

Genotypes	micronutrients (mg kg^{-1})					
	Fe	Mn	Zn	Cu	B	Mo
B-chhola-3	443.6±5.0	47.0±1.6	25.9±0.3	6.2±0.2	15.5±0.4	0.36±0.01
B-chhola-5	490.8±16.6	57.8±2.1	29.3±0.7	7.4±0.2	11.8±0.1	0.35±0.02
B-chhola-4	443.5±5.0	50.5±1.4	26.1±0.9	6.7±0.4	12.5±0.7	0.34±0.04
B-chhola-6	413.5±20.3	49.7±1.4	25.6±1.7	6.9±0.1	11.5±0.2	0.37±0.03
B-chhola-7	452.5±7.7	58.2±1.7	26.2±0.4	6.2±0.1	11.7±0.2	0.26±0.02
B-chhola-8	487.2±4.5	59.5±0.8	27.5±1.1	5.7±0.3	8.9±0.1	0.37±0.02
BGM-E7	447.3±17.6	68.4±1.8	30.4±0.5	8.4±0.2	12.4±0.5	0.37±0.02
ICCV-98926	481.2±0.7	41.0±0.8	24.3±0.1	9.4±0.4	16.3±0.1	0.27±0.01
ICCV-94924	471.7±19.0	50.7±0.1	26.4±0.5	8.3±0.3	9.6±0.1	0.37±0.02
ICCV-98916	419.6±12.2	52.8±0.3	20.2±0.4	8.5±0.4	13.6±0.8	0.26±0.01

3.2.3. Grasspea

Grasspea (Khesari) varieties varied in their root lengths (Figure 13). The two commercial varieties khesari-1 and khesari-2 produced larger root system (Figure 14).

Figure 13.

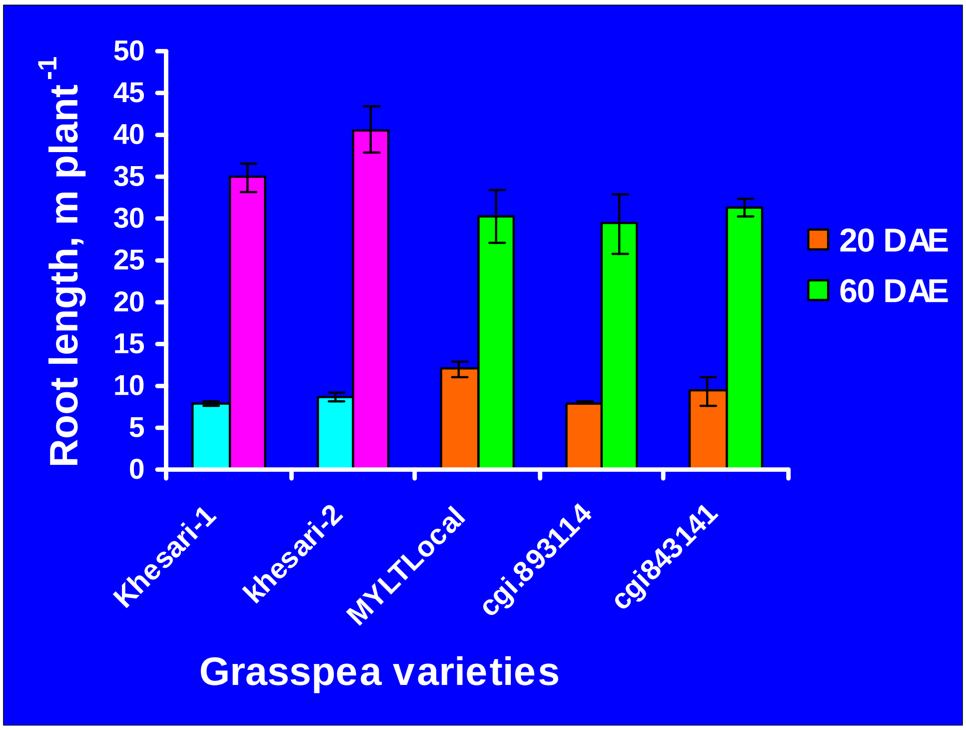


Figure 14.

The larger root system of Khesari-2 (Figure 14) was related to its better performance in the field as it can be seen in Figure 15.

Figure 15.

4. The facts finding

4.1. Farmers´ awareness and desire to grow pulses

To obtain first hand information about the situation of pulses cultivation in Bangladesh, I traveled to many pulse growing northern and southern districts of Bangladesh to meet District Agriculture Extension Officers (DAEOs), block supervisors (BS) and farmers. There was special interest to grow winter pulses among the farmers. DAEOs and BS make effort to promote pulses, because pulses require little agronomic inputs and can give more profit. At the same time, there was clear concern among the DAEOs, BS and farmers about the pest proneness and unstable and low yield of pulses.

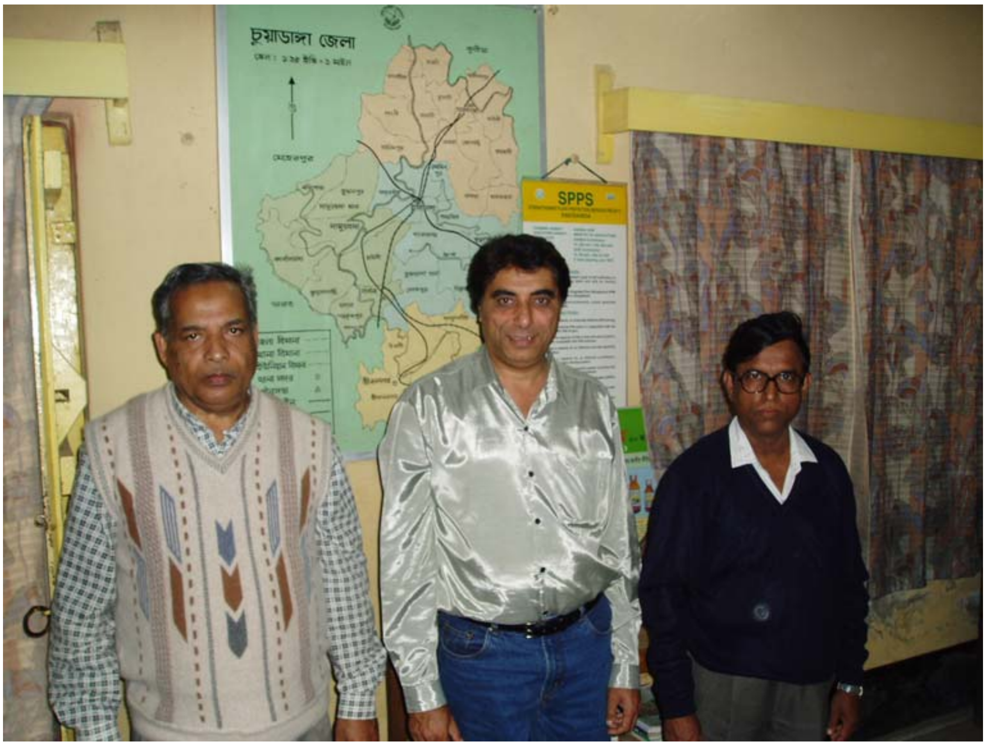
Farmers were aware of the importance of growing improved varieties of pulses, like lentil varieties Bari-masur-3 and Bari-masur-4 and chickpea varieties Bari-Chhola-3 and Bari-chhola-5. They would prefer to grow the improved varieties, but the scarcity of quality seeds often forces them to leave land fallow during winter or they grow only low yielding local landraces. I noticed that during my stay (from Oct. 2003- March 2004) at the Pulses Research Center (PRC) at Ishurdi, the scientists of PRC trained about 100 block supervisors and about 200 farmers in modern technologies of pulses cultivation, through seminars and field days.

"If you can give me high and stable yielding pulses varieties and also enough seeds, I will grow only pulses during winter", said a young farmer from Mirpur and he added " *also because after growing pulses, my rice grows better".*

4.2. The awareness of DANIDAs agriculture related activities

The majority of DAEOs were aware of the Danida Activities in Bangladesh, especially those of Soil Fertility and Fertilizer program (SFFP) in detail, but also those related to Integrated Pest Management (IPM). However, a number of Block Supervisors (BS) and farmers were confused over, whether Danida is a Danish Development Agency or is it a Dutch Development Agency from The Netherlands? I was occasionally confronted with this clarifying question.

In southern districts of Barisal region, DAEOs expressed the concerns, that the progressing salinity problem is counteracting the positive effects of DANIDAs SFFP. *"When sea tide comes, it brings salt, leaves it back. The receding tide takes away the nitrogen and other crop nutrients into the sea"*, was the concern of agriculture extension officer, Mr. Das, of Tala upzila in south of Bangladesh. He expressed the hope for integrating the progressing salinity problem into DANIDAs SFFP or into other programs.



The majority of District Agriculture Officers were aware of the Danida Activities (SPPS in the picture) in Bangladesh

4.3. The pulses policy and awareness

There seems to be awareness and also the political willingness at the level of Govt. of Bangladesh (GoB) to promote pulses cultivation in Bangladesh. Honourable Prime Minister Begum Khaleda Zia, during her visit to BARI on March 13, 2004, stressed the need to diversify crop production in Bangladesh. Pulses in Bangladeshi cropping systems can play a role in crop diversification as well as in diversification of the rice-dominated Bangladeshi diet. Honorable Minister of Agriculture in Bangladesh, MK Anwar, reminded us about the importance of pulses by saying *"Eat pulses every day to keep your pulse functioning properly"*. The GoB also financed a pilot project on "Lentil, Blackgram and Mungbean Development" at BARI, which has terminated in June 2004. The political willingness is also reflected by the existence of recently established Pulses Research Center (PRC) under BARI at Ishurdi in Pabna, where TSG spent most of his stay in Bangladesh. However, in the present state, PRC is ill-equipped, has little expertise and limited resources to carry out research and training, which may effectively results in improved varieties and dissemination of pulses technologies. Nevertheless, PRC has good facilities for field experiments and has good contact with poor and marginal farmers which can play an important role in disseminating the new pulse-growing technologies to promote pulses cultivation, through farmers training, demonstration during the field days and through the existence of a " technology village", which lies close to PRC.

"The *production of pulses is low and ever fluctuating, so marketing policy for pulses does not exist. If the pulses production is increased, the need for such policy may come on the agenda*", said Mr. Samshur Rahman, Member of Bangladesh Parliament from Ishurdi,

5. At ICARDA

The stay at ICARDA was mostly used for facts-finding and to evaluate "how the research experience from BARI-Bangladesh can be supplemented and then implemented in an International perspective. To develop the research and development strategy, as mentioned below, for improving pulses production in Bangladesh, I closely co-operated with lentil breeder, Dr. Ashutosh Sarker and Senior Chickpea breeder Dr. R S Malhotra of ICARDA. As a part of the knowledge dissemination plan, joint publications were written and submitted for publication to International journals. A large number of crosses between diverse genetic materials are made at ICARDA to generate breeding lines of pulses tolerant/resistant to biotic (diseases) and abiotic (drought, heat and cold) stresses. It was interesting to note that most of the trained technical staff making the crosses was women. Most of the lentil and chickpea is harvested by hand, which provides employment opportunities for rural women.

Women harvesting lentil in Syria

6. The fostering of co-operation

During my stay at BARI, a function was organised in Dhaka to mark the silver jubilee celebration of the co-operation on pulses improvement between International Centre for Agricultural Research in the Dry Areas (ICARDA) Aleppo, Syria and Bangladesh Agricultural Research Institute (BARI) Joybebpur. I was invited to attend the function, where I had first high level joint-meeting about the GENESYS project with Prof. Dr. A. El-Beltagy, Director General of ICARDA; Dr. W. Erskine, Additional Director General (research) of ICARDA, Dr. M S Islam, Director General of BARI, Dr. M M Rahman, Director Research of BARI and Dr. Tariq Hasan, Director General of Bangladesh Department of Agricultural Extensions (DAE). In the meeting, I informed the officials and scientists about the short-term and long-term goals of GENESYS project on pulses. Later I accompanied them to the farmers' field trips, organised in connection with the function.


At farmer's field with officials and scientists of BARI, ICARDA and DAE

Another meeting between the Danish, Bangladeshi and the ICARDA officials and scientists was held during my stay at ICARDA in Syria at the function of "ICARDAs Presentation Day" on 24th. April. Dr. M S Islam, DG, BARI-Bangladesh also attended ICARDAs presentation Day function. During the meeting at ICARDA, I informed the DGs and the project partners about the research outputs and experiences of my stay at BARI (Oct- 2003 – March 2004). I sought the input of ICARDA officials and scientists, regarding the use and relevance of the pulses research for development in a wider International perspectives.

A number of other small meetings were held between the Danish, ICARDA and BARI project partners to address emerging specific research and development related questions.

On June 14-15, 2004, a project workshop was organised at The Royal Veterinary and Agricultural University in Denmark at Frederiksberg, to address pulses issues and to finalise the research and development strategy to increase pulses production in Bangladesh. Besides all project partners and about 25 participants, Mr. Paul Richardt Jensen from TSA, Danida, attended the workshop (see workshop agenda in the dissemination section 10).

7. Pulses and development issues

Most of Bangladeshis earn their livings directly or indirectly from agriculture. It needs a serious thought and input, how poverty can be alleviated through increased agriculture production without further degradation of soil fertility and environment.
Bangladesh is also one of the most populous countries in the world with about 147,570 square kilometres of total land area accommodating a population of about 140 million. This makes about 1000 square meters land per person for providing infrastructure, housing and food. The actual quantum of per capita cultivable agriculture land is only 550 square meters. At the moderate rate of 1.5 % population growth, about 200 million Bangladeshi can be expected to celebrate its golden jubilee of independence in year 2021. Bangladeshi family traditions and religious consideration obstruct birth control measures. Therefore, it can be predicted that at the golden jubilee, the availability of per capita cultivable land will be only 280 square meters, much less than the area of an average family house in Denmark. It needs little imagination to recognize the tremendous load it will put on soil resources for feeding the increasing population in Bangladesh. It is often claimed that Bangladesh has reached self-sufficiency in food. There are many reasons to differ in opinion and the claim may be restricted to the production of rice.

In rice-dominated diet of Bangladeshi population, protein deficiency is a common problem, where growing children are the most affected. The price of animal protein, including fish, is high, beyond the reach of poor people. Pulses, like masur (lentil), khesari (grasspea), chhola (chickpea), mung (mungbean) and mash (black gram) offer an affordable source of protein in the rice-dominated Bangladeshi diet, particularly for the poorest of poor. Current production of pulses satisfies only half the countries need, requiring yearly import of pulses for about 32 million US$. Even then, the present daily intake of pulses in Bangladeshi diet is only 10g per person, which is well below the World Health Organisation (WHO) recommended daily intake of 40 g per person.

Based on the population growth rate of 1.5 % per year and daily pulses consumption of 15g p/person, the production of pulses needs to be increased from current about 0.38 million tons to about one million tons per year in year 2021. Additional decline in land use, due to progressing salinity and drought prone areas and deteriorating soil fertility and increasing nutrient imbalance, due to increasing rice-wheat-rice mono-cropping pattern, have threaten the sustainability of Bangladesh agriculture. River erosion devours around ten thousands hectares of land every year. Hence, the balanced production of pulses and cereals, from every unit of fertiliser and land and every drop of water may be seen as a necessity rather than an option.

Development through the promotion of pulses cultivation can be achieved because it holds the potential of improving soil health, through their ability to fix atmospheric N; human health by providing protein rich diet; it also provides quality animal fodder and feed, with a positive effect on the health of national economy due to less demand for import of protein products and nitrogen fertilizers. Despite the good intensions, awareness and many positive effects of pulses cultivation, the area under pulses is showing declining trend and production has stagnated at the cost of *boro* rice. *Boro* rice is cultivated with irrigation in winter months from December to May. The main rice crop is *aman* rice, cultivated in monsoon summer months from July to November.
Boro rice cultivation, often presented proudly as a success scenario, is rapidly replacing cultivation of pulses and other crops in many areas, is highly energy and input demanding and is entirely irrigation dependent. The poorest of poor farmers can not afford the necessary inputs and often are forced to leave their land fallow during winter. Furthermore, even good quality irrigation water contains 200-500 mg/kg of soluble salt. Irrigation water with a salt content i.e. 500 mg/L contains 0.5 tons of salt per

1000 m^3. Since crops require 6,000-10,000 m^3 of water per hectare, one hectare of land will receive 3-5 tons of salt. The removal of salt by crops being negligible; it will accumulate in the root zone, and must be leached by supplying more water than is required by the crops. Poor drainage will cause the water table to rise, mobilising salt which accumulate in the root zone. When the crop is unable to use all applied water, water-logging occurs. Due to the presence of high concentration of Arsenic in Bangladeshi groundwater, the root zone may also receive up to 6 tons per hectare of the poisonous Arsenic, counteracting the investment and efforts devoted to Arsenic mitigation. So a man-shaped vicious cycle is threatening the long-term sustainability and production of human safe food for the rapidly growing population of Bangladesh.

In Bangladesh, 30 % of the net cultivable area lies in 13 districts in the southern coastal regions, of which almost 60 % is always affected by varying levels of soil salinity (1.5-16 dS/m), resulting from tidal flooding during the monsoon months of June and October and due to upwards and lateral movement of saline ground water during the dry months of November and May. During the monsoon months, salt injury to crops is low because precipitation exceeding evaporation and locally adapted cultivars of *aman* rice can be grown. In the past, when salinity levels were low, winter pulses, particularly khesari and lentil, were the important components in the cropping patterns in this region. However, over time the salinity levels have increased and the traditional rotations have been replaced by rice monoculture with the land remaining fallow until the next monsoon rice crop.

In the northern Barind region, about 0.8 million ha are typically left fallow after *aman* rice harvest, because of low soil moisture to carry a post-rainy season crop to maturity. Nevertheless, there is noticeable interest and predictable potential in cultivating this area during winter months with chickpea and also with lentil as ‘sandwich crops’.

Given the high and increasing demand for food and balanced diet, Bangladesh can not afford to keep a vast part of its cultivable areas fallow for a season. Moreover, the production of *aman* rice is declining under continuous rice monoculture, with gradual deterioration of soil fertility. The national economy of Bangladesh is not able to bear the high cost of soil desalinisation. Hence the most economic and sustainable approach would be to improve land use by developing and introducing winter pulses varieties with high levels of salt tolerance and drought resistance. Winter period is short (90-100 days) and dry (no rain to < 100 mm) in Bangladesh. Therefore, the most persistent varieties for improving production from unit land would be high yielding, early maturing, salt tolerant and deep rooted to capture receding soil moisture, in addition of being less prone to major diseases and pest and efficient nutrient users.

The research results of GENESYS project suggest that superior morphological (root length, root hairs) and physiological (exudation of protons and enzymes) root traits facilitate efficient use of soil nutrients from the nutrient-poor soils as illustrated above in the section 3.2 "The Research" by the example of Bari-masur-3 and Bari-masur-4 and other pulses varieties. The higher return of investment in the cultivation of lentil variety BM-4, as indicated by higher BCR values (Figure 7) and its link with the ability to develop longer and deeper root system faster and better nutrients uptake suggests the economical utility of exploring the genetic diversity in root traits of pulses genotypes/landraces. The results also indicate large genetic variation among the root traits of lentil, chickpea and grasspea, which was linked to better capture of soil nutrients. The superior root traits can be incorporated in disease resistant and other superior agronomic backgrounds for breeding of high and stable yielding varieties for nutrient-poor soils.

Among winter pulses, lentil (with low to medium salinity tolerance), grasspea (hardy crop with medium salinity tolerance) and chickpea (drought resistant for being deep rooting) would be the ideal choice. These traditionally grown crops are less input demanding, occupying about 75% of the total area sown for pulses and are familiar to the rural communities. However, due to inherited low yield potential of pulses, coupled with high proneness of existing varieties to a number of biotic (diseases and pest) and abiotic stresses (salinity, drought and nutrient imbalance) and inadequate actions to promote adoption of improved production technologies by farmers and not to mention the scarcity and high price of quality seeds, pulses give unstable and low yield in farmers field; discouraging their inclusion in the cropping system. Lack of research input has also impeded the development of new high yielding pulses varieties as compared to cereals. Limiting these constraints will encourage marginal farmers in the under-utilized areas to incorporate improved varieties of lentil, grasspea and chickpea into the existing cropping pattern as winter crops; without disturbing the cultivation of *aman* rice (which constitutes 70% of all rice grown). Such diversification of cropping system can be expected to have positive effect on yields of subsequent rice or wheat crops.

Promotion of pulses cultivation offers the possibility of breaking the vicious circle of rice-rice or rice-wheat cropping systems, which are threatening the long-term sustainability of Bangladeshi development. The need to develop stable yielding pulse varieties deserves special attention of the donor organisations, because lack of funds for pulses research and development, as compared to cereals, seems to be one of the primary causes of lack of protein rich diets of poorest of poor.

8. The research and development strategy

For making use of pulses in a sustainable development, both short-term management and long-term research strategies need to be implemented.

8.1. Improved varieties

The most of the existing varieties and landraces of Bangladeshi pulses are prone to a number of diseases and terminal drought. Farmers demand improved short-duration varieties of winter pulses (due to short-winter period) and experiences let us know that if available they also adopt them. The adoption of lentil variety Barimasur-4 and Chickpea variety Bari-chhola-5 is a good example. Farmers, who adopt improved varieties and follow the modern technology packages, get a bumper harvest from pulse crops, yielding up to 2.5 tons per hectare, three times the national average. Barimasur-4 was developed from the cross between ILL 5888 (improved landrace) and ILL5782 (ICARDA breeding line) at ICARDA specifically for Bangladesh. It is an example of fruitful co-operation existing between the partner institutions. ICARDA has a good collection of pulses germplasm, Danish institutions (KVL, RISØ) has the expertise for exploring the genetic diversity among the pulses germplasm using root research methods, DNA markers and TILLING (Targeting Induced Local Lesions IN Genomes). TILLING combines chemical mutagenesis with mutation screens of pooled PCR products, resulting in the isolation of missense and nonsense mutant alleles of the targeted genes. TILLING has two significant advantages over existing plant gene knock-out tools: first, it is applicable to any plant since it does not require transgenic or cell culture manipulations. Second, it produces an allelic series of mutations including hypomorphic alleles that are useful for genetic analysis. The field research facilities of BARI can be used to implement the knowledge for development under local Bangladeshi conditions. In short-term, the pulses germplasm should be explored for genetic diversity in traits linked to disease resistance and tolerance to nutrients and drought stresses and DNA markers should be developed to support Marker Assisted Selection (MAS).

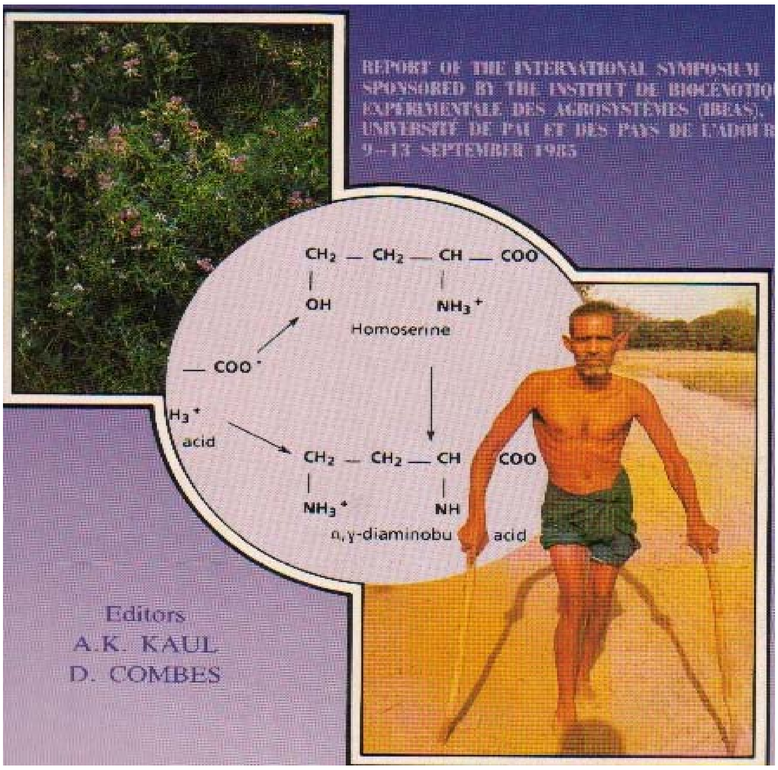
In long-term, the detected genetic diversity and the developed DNA markers and mutations should be used to breed new improved varieties. Grasspea is mainly consumed by poorest of poor where all other crops fail. Most of the land under this crop would have otherwise remained fallow after rice if there was no grasspea. The consumption of grasspea by the poor is *"the choice between starvation and accepting serious health risks".* Because of the presence of high levels of neurotoxins in seeds, the continuous consumption of *Khesari Dhal* over extended period of time (over 3 months) causes lathyrism, an irreversible paralysis of limbs in humans. Despite the knowledge of lathyrism related health risks, grasspea is the most cultivated pulse (40 % of the total land area under pulses) in Bangladesh. Hence, special attention is needed to develop low -neurotoxins toxins new varieties of grasspea (khesari) to minimise the risks of lathyrism.

Farmers, who adopt improved varieties and pulses technology packages, get bumper crops.

8.2. Better land use

The land, which is often left fallow, especially by poor and marginal farmers, during winter due to high salinity in the south (Barisal) and drought in the north (Barind) of Bangladesh, needs to be utilised more effectively. In short-term, applications of gypsum (affordable and easily available in Bangladesh) should be tried experimentally in salinity affected areas, as a body of literature suggests that salt injury to the crops is less when calcium (gypsum) is abundant in saline soils. In the northern drought-prone Barind region, chickpea, a deep rooting crop, should be promoted on a short-term basis through farmers training and motivation.

Grasspea and Lathyrism:
The choice between starvation and accepting serious health risks



If only 10 % of the fallow-left-land in Barind is sown to chickpea in winter, the daily per capita availability of pulses will increase by about 15 % in Bangladesh as a whole.

Soil moisture in the terraced rice fields of Barind disappears quickly after the rainy season and there is very little time to sow another crop during the fallow. However, if chickpea is sown during a brief window of opportunity 4-10 days after the rice harvest, a good crop can be obtained. Barind region is less prone to BGM, one of the major diseases of chickpea. If only 10 % of the fallow-left-land in Barind is sown to chickpea in winter, the daily per capita availability of pulses will increase by about 15 % in Bangladesh as a whole. This may be achieved through farmers' motivation and training and seed availability are crucial.

In long-term, the new salt-tolerant and drought-tolerant varieties of pulses should be developed by exploring the pulses germplasm from the large collection at ICARDA and also that from the landraces originating from saline areas of Bangladesh. It is worth-mentioning that scientific literature suggests that salt-tolerance and drought-tolerance have many common plant physiological features, therefore, may be targeted simultaneously in breeding work.

8.3. Production technology-relay cropping

The relay-cropping allows making most out of the short and dry winter season in Bangladesh. The seeds of winter pulses, like lentil, grasspea and chickpea, are broadcast in standing *aman* rice crop 3-4 weeks prior to harvest. As the soil is still wet, seeds germinate to produce deep root system. After rice harvest, the pulse crop is left to grow further. The Pulses Research Centre in Bangladesh has some knowledge about the technology. In short-term, this useful technology (relay cropping) needs to be promoted through intensive farmers training about the exact timing of seed broadcasting.

Relay cropping of pulses helps making most out of dry and short winter season

8.4. Knowledge and Technology dissemination

To generate new knowledge and improved pulses technologies, a large number of field experiments are conducted yearly by pulse scientists at Pulses Research Centre at Ishurdi and other regional centres of BARI. However, the outputs are mostly published in internal reports and rarely published in widely accessible scientific literature. There is a short-term and long-term (capacity building) need to train and to motivate pulse scientists to expose their work to a wider scientific community and then improve their expertise and outputs by learning from International inputs and critics. As a short-term step of motivation, the research outputs of the GENESYS project were disseminated jointly with Bangladeshi and ICARDA scientists so that it can be reach wide groups of public and scientific community soon possible.

8.5. Human resources development and capacity enhancement

The human resources development through training of M.Sc. and Ph.D students will be more effective if it includes the modernization and upgrading of the laboratory facilities, perhaps also IT facilities, of Pulses Research Center of BARI at Ishurdi.

9. The outline of the suggested approaches to realize the strategy

Improved varieties

- The germplasm enhancement for biotic (pest and diseases) and abiotic stresses (nutrients, salinity and drought)
- Mapping of agronomic traits and disease resistance with molecular markers
- Development of less toxic grasspea lines with DNA markers (Ph.D student)
- TILLING (Targeting Induced Local Lesions IN Genomes) to isolate novel genotypes
- Seed production

Better Land Use

- Improved root traits for abiotic stress
- Salinity management with potential use of Gypsum and improved varieties
- Phosphorus, micronutrients and pulses (Ph.D student)
- Field trials

Production technology

- Relay cropping of pulses
- Seed priming (water soaking of seeds before sowing)
- Integrated pest management and disease resistance varieties
- Integrated plant nutrition systems
- Fine-tuning of sowing and crop management technology

Technology dissemination

- Farmers motivation and training
- Demonstration on farmers fields
- Technology village as a model of pulses technologies
- Preparation of dissemination materials at farmers level

- Farmers field days and workshops

Human resources development and capacity enhancement

- Joint supervision of Ph.D students
- Short–term scientists exchange
- Upgrading of laboratory facilities at BARI for pulses research

Involvement of farming and rural community

- Farmer to farmer dissemination
- Involvement of farmer in seed production (a positive experience from ICARDA, Syria)
- Training of rural women for pulses storage
- Involvement of rural women in testing cooking quality
- Farmer participatory variety selection (PVS)

Integrated Plant Nutrient Management (IPNM)

- Balanced use of fertilizers
- Nutrient efficient varieties
- Green manure and nitrogen fixation
- Inoculations to enhance nitorgen fixation
- Composting-renewable supply of plant nutrients and recycling of house waste
- Gaining from the impact of DANIDAs SFFP programme

Enhancing research capacity and technical skills in Bangladesh

- Laboratory and (IT) facilities at PRC Ishurdi
- Ph.D student, Micronutrients and pulses
- Ph.D student, Genotyping and mutation
- Extensive exploitation of ICARDAs pulses germplasm for Bangladeshi conditions

10. The Dissemination of project outputs

The project outputs were disseminated though a workshop and as joint-publications through various media.

Project Workshop was held on 14 June - 15 June 2004

Workshop Avenue: The Royal Veterinary and Agricultural University (KVL), Frederiksberg, Auditorium 3-14

Workshop theme: Increasing Winter Grain Legumes production in Bangladesh:

Past experience, present expertise and future opportunities
Workshop agenda
Monday, 14.06.2004

9.00 - 9.10 Dr. Tara Singh Gahoonia (Associate Professor, KVL): Project Introduction and welcome.
9.10 – 9.20 Dr. Niels Erik Nielsen (Professor in Soil Fertility, KVL): Welcome on behalf of Department of Agriculture sciences and its commitment and contribution to promote agriculture in developing countries.
9.20 – 9.40 Mr. Paul Richardt Jensen (Consultant, TSA, Danida): Bangladesh: A bilateral partner land of Danish Development Aid.
9.40 – 10.10 Dr. M M Rahman (Director Research, BARI, Bangladesh): Winter Grain Legumes of Bangladesh: Their importance, production constraints and promotion possibilities.
10.40 – 11.10 Dr. Ashutosh Sarker (Pulse Breeder, ICARDA-Syria): Breeding of improved varieties of winter grain legumes: An International perspective with eyes on Bangladesh.
11.10 – 11.30 Dr. Ahmed Jahoor (Senior Research Scientist, RISØ): Molecular markers and Marker Assisted Selection (MAS): Prospective of applications for breeding of winter grain legumes in Bangladesh.
11.30 – 12.00 Mr. Omar Ali (Scientific Officer, Pulses Research Centre-BARI- Ishurdi, Bangladesh): Technology transfer and socio-economics of winter legume varieties adoption at poor and marginal farmers' level: Procedures, problems and perspectives.
12.00 - 12.30 Dr. Tara Singh Gahoonia: Root systems of Bangladeshi Winter Grain Legumes: Efficient capture of fertilizer and soil resources for better agro-economics.

13.30 pm – 4.30 pm Visit of Bangladesh and ICARDA delegates to Risø National Laboratory

Tuesday 15.06.2004 (9.00 am – 4.00 pm)
Meeting of project partners-Strategy to promote pulses in Bangladesh (BARI-ICARDA-RISØ-KVL)

2) Articles in refereed International scientific journals

Gahoonia T S, Omar Ali, A Sarker, M Matiur Rahman, W Erskine (2004). Root traits, nutrient uptake, multi-location grain yield and benefit-cost ratio of two lentil (*Lens culinaris*, Medikus.) varieties. Plant and Soil (accepted, www.kluweronline.com/issn/0032-079X/articles in advance).

Gahoonia TS, Rawshan Ali, R S Malhotra, A Jahoor, M Matiur Rahman (2004). Root morphological and physiological traits and uptake of twelve nutrient elements by chickpea (*Cicer arietinum L.*) genotypes. (submission to Plant, Cell and Environment).

Gahoonia T S, Omar Ali, A Sarker, Niels E Nielsen, M Matiur Rahman (2004). Genetic variation in root traits and nutrients acquisition of lentil (*Lens culinaris, Medikus*) genotypes. (submission to Euphytica).

Gahoonia TS, Omar Ali, A Sarker, A Jahoor, M Matiur Rahman (2004). Exploration of reasons for adaptation of Grasspea. Focus on genetic variation in root system and nutrient acquisition. (Expected submission to Genetic Resources and Crop Evolution).

3) Conference lectures

Gahoonia TS (2003). Getting a handle on soil phosphorus: eyes on plants own essence and sense. Oral presentation: 2nd *International Symposium on Phosphorus in the Soil-Plant Continuum.* September 21-26, 2003, Perth, Australia.

Gahoonia TS, Rahman MM, Sarker A, Ali O, Nielsen NE and Jahoor A (2004). Winter Grain Legumes: 'Cinderella' of Cropping Systems in Bangladesh. Oral presentation, *8th European Agronomy Conference*- Agronomy in Developing Countries, 11-15 Juli 2004, Copenhagen, Denmark

Gahoonia TS, O Ali, R Ali, A Sarker and MM Rahman (2004). Root morphological and physiological traits as related to multi-location grain yield and Benefit-Cost Ratio (BCR) of tropical legumes and cereal varieties. Plenary lecture at International Conference Rhizosphere 2004 - Perspectives and Challenges - A Tribute to Lorenz Hiltner, Munich, Germany – held in September 12-17 2004.

Gahoonia T S (2004) Root biology and rhizosphere processes of tropical legume and cereal varieties: Understanding science to benefit farmers. Contribution abstract, 15th International Plant Nutrition Colloquium, Beijing

Pandey R and **Gahoonia TS** (2004). Phosphorus acquisition of wheat genotypes. Using genetic diversity to save limited world resources of phosphorus. Poster, *8th European Agronomy Conference- Agronomy in Developing Countries*.11-15 Juli 2004, Copenhagen, Denmark

4) Seminars

Gahoonia T S (2004) Phosphorus bottleneck of cereals and tropical legumes production: *Agar-culture to Agri-culture*. Lecture at Indian Agriculture Research Institute (IARI), New Delhi, February 2004.

Gahoonia T S (2004) Pulse checking of pulses cultivation in Bangladesh. *Diagnostic and cure at the "roots" of the problem.* Lecture at Bangladesh Agriculture Research Institute, Joyebpur Gazipur. March 2004.

Gahoonia T S (2004). Root biology and nutrient efficiency of ICARDAs mandate crops. *Genetic diversity in the spot light*. Lecture at ICARDA, Aleppo, Syria. May 2004.

5) Newspaper and popular public articles

Gahoonia T S (2004) Weakening pulse of pulses cultivation in Bangladesh. National Daily Newspaper Bangladesh Observer Magazine. Dhaka, May 21. 2004.

Gahoonia T S (2004) Udvikling i Bangladesh: Landbruget skal ud af ond cirkel. Jord og Viden (in press)

Udvikling i Bangladesh: Landbruget skal ud af ond cirkel

Tara S Gahoonia

Størstedelen af befolkning i Bangladesh tjener til livets ophold direkte eller indirekte ved landbrug. Det kræver alvorlige overvejelser og en god indsats for at lindre fattigdomen ved forhøjet landbrugsproduktion uden yderligere forringelse af jordens frugtbarhed og miljøet.

Bangladesh er endvidere et af verdens tættest befolkede lande med et areal på ca. 147.570 km^2 og en befolkning på omkring 140 millioner. Det er ca. 1000 m^2 jord per indbygger til infrastruktur, bolig og mad. Det reelle tal for jord der kan opdyrkes er kun 550 m^2 per indbygger. Med en befolkningstilvækst på 1,5% vil ca. 200 millioner bangladeshere fejre deres 50 års uafhængighedsdag i 2021. Fødselskontrol modarbejdes her af familietraditioner og religiøse hensyn. Det kan derfor forudsiges at der til jubilæet kun vil være 280 m^2 jord til rådighed per indbygger, meget mindre end arealet på en alm. dansk parcelhus. Det kræver ikke megen fantasi at forestille sig hvilket enormt pres der kræves af jorden for at kunne brødføde den voksende befolkning i Bangladesh. Det hævdes ofte at Bangladesh er blevet selvforsynende med fødevarer. Det er der delte meninger om, og måske gælder det kun for risproduktionen.

I bangladeshernes risdominerede kost er proteinmangel et almindeligt problem, og hvor børnene i voksealderen rammes hårdest. Prisen er høj på animalsk protein, fisk medregnet, og derfor uopnåelig for den fattige del af befolkningen. Bælgfrugter (*dhal* på bangali og *pulses* på engelsk), som linser (masur), græsærter (khesari), kikærter (chhola), mungbønner (mung) er et billigt opnåeligt proteinkilde i den risdominerede kost, især hos den fattigste del af befolkningen. Den nuværende produktion af bælgfrugter dækker kun halvdelen af landets behov, hvorfor der importeres bælgfrugter for ca. 32 millioner US$. Selv da er det daglige forbrug kun ca. 10 g bælgfrugter pr. person, hvilket er meget under WHOs anbefalede daglige indtagelse på 40 g pr. person.

Med befolkningsvæksten på 1,5% per år og en daglig indtagelse af 15 g bælgfrugt per person, skal produktionen af bælgfrugter forhøjes fra de nuværende 0,38 millioner tons til ca.1 million tons årligt i 2021. Hertil kommer at et faldende landbrugsareal på grund af stigende saltindhold i jorden og arealer med tendens til tørke og ringere jordfrugtbarheden og stigende næringsstofmangel, og på grund af et forøget ris-hvede-ris-monokultur dyrkningsmønster, truer landbrugets bæredygtighed i Bangladesh. Floderosion sluger ca. 10.000 hektar land hvert år. Derfor er den alsidige produktion af bælgfrugter og korn, der kan trækkes ud af hver enkelt gødningsdel, land og vanddråbe en nødvendighed snarere end en mulighed.
Ved at fremme bælgfrugtdyrkning er det muligt at støtte en udvikling der kan lykkes, da det giver mulighed for en berigelse til jordens frugtbarhed på grund af bælgfrugters evne til at fiksere atmosfærisk-N. Desuden kan bælgfrugter fremme den menneskelige sundhed ved en proteinberiget kost samt kan bruges som kvalitetsfoder til dyr. Det kan forventes at have en positiv påvirkning af

nationaløkonomien grundet mindsket import af proteinprodukter og kvælstofgødning. Statsminister Begum Khaleda Zia, understregede under sit besøg på Bangladesh Agricultural Research Institute (BARI) den 13. marts 2004 at det var nødvendigt at udvide afgrødeksortimentet i Bangladesh for at opretholde produktiviteten.
Landbrugsminister MK Anwar sagde meget rigtigt *"Eat pulses every day to keep your pulse functioning properly"* (Spis bælgfrugter hverdag for at holde din puls ordentlig igang) ved en festlighed i anledning af 25 års jubilæet for samarbejdet om bælgfrugter mellem Internationalt Centre for Agricultural Research in the Dry Areas (ICARDA) Aleppo, Syria og BARI, Jodybpur. På trods af de gode intensioner, forståelse og mange positive forbedringer i bælgfrugtdyrkningen, indskrænkes dyrkningsarealet og produktionen er stagneret til fordel for boro-ris. Boro-ris dyrkes med overrisling i vintermånederne fra december til maj. Den vigtigste risafgrøde er aman-ris, der dyrkes i monsum sommermånederne juli til december.

Den nedafgående produktion af bælgfrugter vækker bekymring og bælgfrugter betragtes som stedbarn i afgrødesystemet. Udvikling af nye bælgfrugtsorter der passer til klimaet i Bangladesh ønskes. Boro-ris dyrkning, der ofte bliver stolt præsenteret som en succes, og som i stigende grad erstatter dyrkningen af bælgfrugter og andre afgrøder i mange dele af landet, kræver stor energi og arbejdskraft og er afhængig af vanding. Det har de allerfattigste bønder ikke råd til og er ofte tvunget til at lægge deres jord brak om vinteren.
Selv godt vand vil indeholde 200-500 mg/kg af opløseligt salt. Vand med et saltindhold f.eks. på 500 mg/l indeholder 0,5 tons salt per 1000 m^3. Da mest de afgrøder kræver mellem 6.000 til 10.000 m^3 vand per hektar giver det 3-5 tons salt pr hektar. Fjernelse af salt ved hjælp af afgrøder er ubetydelig; det vil akkumulere i rodzonen, og skal udvaskes med mere vand end afgrøden behøver. Dårlig dræning vil forårsage at grundvandspejlet stiger, som mobiliserer salt der så samles i rodzonen. Når afgrøden ikke kan opsuge det tilførte vand, sker der en vandmætning. På grund af et højt indhold af arsenik i Bangladeshs grundvand, kan rodzonen også bliver forurenet med op til 6 tons giftig arsenik, hvilket modvirker de investeringer og kræfter der arbejder for fjernelsen af arsenik. Så en menneskeskabt ond cirkel truer den langsigtede bæredygtighed og produktion af sund menneskeføde til den hurtigt voksende befolkning i Bangladesh.
I Bangladesh ligger 30% af det dyrkede areal i 13 distrikter i den sydlige kystregion, hvoraf næsten 60 % altid er påvirket af forskellige niveauer af saltning af jorden (1,5 – 16 dS/m) som stammer fra tidevandsoversvømmelser i monsunmånederne fra juni til oktober og af opstigning og sidebevægelser af salt vand i tørkemånederne fra november til maj. I monsunmånederne er saltskaderne på afgrøderne små, da nedbøren er større end fordampningen og de lokale sorter af aman-ris kan dyrkes. Før i tiden, da saltniveauet var lavt, var vinterbælgafgrøder især khesari og linser vigtige bestanddele i dyrkningsmønsteret i denne region. Men nu er saltniveauet steget og den traditionelle vekslen mellem afgrøderne er erstattet med monokulturen ris og med jorden lagt brak indtil den næste monsumrisafgrøde. I den nordlige Barind region, ligger der typisk omkring 0,8 millioner ha brak efter en aman-rishøst, fordi den lave jordfugtighed ikke kan bringe en efterafgrøde til modenhed. Ikke desto mindre er der en mærkbar interesse og et forudsigeligt potentiale ved dyrkning af kikærter og linser på dette areal gennem vintermånederne som 'sandwich afgrøder'.

Med det store og stadigt stigende krav om mad og alsidig kost, kan Bangladesh ikke tillade at lægge enorme dyrkningsarealer brak. Ydermere er produktionen af aman-ris faldende ved den stadige monokultur med gradvis forringelse af jordens frugtbarhed til følge. Bangladeshs nationaløkonomi kan ikke klare de store omkostninger til afsaltning af jord. Derfor vil den mest økonomiske og bæredygtige tilgang være at forhøje dyrkningen ved at udvikle og introducere vinter bælgfrugtsorter med en høj salttolerance og tørkeresistens. Vinterperioden er kort (90-100 dage) og tør (ingen regn til 100 mm regn) i Bangladesh. Det skal derfor være modstanddygtige sorter der skal forbedre produktionen, der har stort høstudbytte, tidlig modning, er salttolerante og med langt, dybt rodnet der kan fange den resterende jordfugtighed og dertil være modstanddygtige over for de fleste sygdomme og skadevolder samt en effektiv udnytter af næringsstoffer.

Det ideelle valg blandt vinterbælgfrugterne vil være linser (med lavt til mellem salttolerance), khesari (afgrøde med mellem salttolerance) og kikærter (tørkeresistent pga. lange, dybe rødder). Disse traditionelt dyrkede afgrøder er mindre omkostningskrævende, optager omkring 75% af det totale tilsåede areal med bælgfrugter og er kendt i landsbysamfundene. Men på grund af bælgfrugters lave høstudbytte og med de kendte sorters store tilbøjelighed til sygdomme og skadevolder, samt saltning, tørke og næringsstofmangel og bøndernes utilstrækkelige tiltag med at fremme brug af forbedrede produktionsteknologier og ikke at forglemme, manglen på såsæd af høj kvalitet, giver bælgfrugter et ustabil og lavt udbytte. Alt det modvirker deres indlemning i afgrøderotationen. Mangel på forskning har også hindret udviklingen af nye bælgfrugtsorter med et højt høstudbytte sammenlignet med kornafgrøder. Begrænses disse hindringer, kan det medføre at opmuntre bønderne i marginalområderne til at anvende forbedrede sorter af linser, khesari og kikærter som vinterafgrøder på de braklagte marker uden det forstyrrer dyrkningen af aman-ris (som udgør 70% af al dyrket ris). En sådan afveksling i dyrkningssystemet kan forventes at have en positiv virkning på høsten af den efterfølgende ris eller kornafgrøde.

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Pulsen på bælgfrugtdyrkningen i Bangladesh slår endnu, men er ustabil. En forbedring af pulsen er en realistiske forventning og inden for rækkevidde i det velorganiserede forskningsmiljø ved BARI. Afdelingen for Agricultural Extension fungerer godt. Oprettelsen af Pulse Research Centre ved Ishurdi udtrykker positive intensioner af Bangladesh myndigheder til at genoplive dyrkningen af bælgfrugter for at sikre en proteinrig kost til dets befolkning. Ved at fremme bælgfrugtdyrkningen er der en mulighed for at bryde den onde cirkel af ris-ris eller ris-hvede dyrkningssystem, som truer bæredygtigheden i Bangladeshs udvikling. Behovet for at udvikle sorter af bælgfrugter med et stabilt høstudbytte fortjener særlig opmærksomhed fra donororganisationerne side, fordi manglende økonomisk støtte til forskning og udvikling af nye sorter af bælgfrugter, sammenlignet med kornarter, er en af de vigtigste årsager til mangel på proteinrig kost hos de fattigste fattige.

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