

Adoption of improved lentil varieties in Bangladesh: comparison between expert estimates, nationally representative farm household survey and DNA fingerprinting

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Background

- Food legumes get less attention in adoption and impact studies.
- But, a major source of nutrition-protein in Bangladesh, (Datta et.al. 2013).
- Major source of dietary protein for the poor, who cannot afford animal protein and other nutritive and diverse foods (Gowda and Kaul, 1982)
- Bangladesh is one of the countries in the world with very high rate (26%) of child malnutrition where 41.3% of children are underweight (UNICEF, 2009 and IFPRI Hunger Index, 2012).
- Another gap is the accuracy of variety identification- hence precision of adoption- DNA fingerprinting allows comparison between farmer-identified varieties and varietal records and can improve the accuracy of the adoption results.

Study objectives

- Estimate the extent of adoption of improved lentil varieties (in terms of both area and number of farmers) in Bangladesh using:
 - expert opinion elicitation,
 - farm household survey
 - DNA fingerprinting.
- Identify factors influencing the adoption of improved lentil varieties using novel econometric techniques.
- An assessment of congruence/divergence between farmers' preferred attributes and breeders' breeding objectives will be conducted.
- Measure the effects of lentil varietal adoption on household nutritional outcomes

Technology

- Recently released **eight lentil varieties:**

Variety name	Release date
BARI-3	1996
BARI-4	1996
BARI-5	2006
BARI-6	2006
BARI-7	2011
BINA-4	2009
BINA-5	2011
BINA-6	2011
Local	1900
	Total

- Yield advantages of up to 30%-100% over the local checks.
- Area under lentil increased from about 1.2 million ha in 2007/08 to an average of 1.6 million ha in the period 2010 -2013 showing a 33%.
- Currently, improved varieties are estimated to cover 75% of total lentil area (1.6 million ha) in Bangladesh.

Methods: Sampling

- Multistage sampling strategy is applied where the administrative units (districts and *mauzas*) is used as clusters.
- 1000 households to ensure at least 95% confidence and 3% precision levels.
- 10 districts
- Two agro-ecological zones namely active Ganges floodplain and high Ganges river floodplain

Farmer characteristics

Table 1: Distribution of samples across all 10 the districts in Western Bangladesh

District	Total number of lentil growers	Total lentil area (acre)	% of total number of lentil growers in the 10 districts	% of total lentil area in the 10 districts	Sample size was taken from the district	Number of sub-districts to sample per district	Sample size per sub-district	Number of villages to sample per district	Sample size per village
Pabna	48093	24683	7%	14%	77	2	37.3	4	19
Natore	59930	21758	9%	12%	92	2	46.5	4	23
Rajshahi	77960	13131	12%	7%	120	2	60.4	6	20
Jessore	74925	18479	12%	11%	114	2	58.1	6	19
Jhenaidah	92374	17325	14%	10%	144	2	71.6	8	18
Magura	42060	19004	7%	11%	64	2	32.6	4	16
Faridpur	70994	25646	11%	15%	108	2	55	6	18
Rajbari	52812	14339	8%	8%	80	2	40.9	4	20
Kushtia	53019	14346	8%	8%	84	2	41.1	4	21
Chuadanga	72823	6995	11%	4%	117	2	56.5	6	20
Total	644988	175706	100%	100%	1000	20		52	

Farmer characteristics

Table 2: Demographic information of the respondents

District	Age (Year)	Farming experience (Year)	Gender (%)
	Mean	Mean	Almost all male headed HHs (1% headed female)
All 10 districts	46	23	
Range	43-48	20-25	

Table 3: Educational status of sample farmers (percent)

District	Illiterate	Primary	Secondary	SSC	HSC and above
All 10 districts	21.3	28.4	20.9	17.9	11.5

Farmer characteristics

Table 4: Primary occupational status of sample respondents (percent)

District	Farming	Labor selling	Business	Job	Housewife	Student
All 10 districts	96.7	0.2	1.6	0.8	0.1	0.6

Table 5 Average demographic information of sample households (No.)

Family size	Male	Female	Working members	Male working	Female working	School going children
5.02	2.63	2.4	3.31	1.77	1.56	1.24

Farmer characteristics

Table 6 Average distribution of total and lentil growing area (ha)

District	Total farm size cultivated by the household	Area under lentils
All 10 districts	0.79	0.36

Production System

Cropping pattern-

- **Rice-Lentil- Mungbean**
- **Rice-Jute- lentil**
- **Rice-lentil-sugarcane**
- **Rice-lentil- summer vegetable**
- **Rice-lentil-fallow**

Crop Management

- Lentil mostly grow as sole crop but relay and intercropping also found
- Less production cost (tillage, intercultural operation, harvesting, threshing etc.)
- Lentil requires less tillage even it can grow without tillage
- Broad casting is common (few line sowing also found)
- Sometimes one/two irrigation is required
- Weeding also required in some cases

Production System

Crop Management

- Seed store in the plastic bottle/cane by the farmers
- Many of them also collect seed from seed dealer, neighbor and grain market
- Risk for diseases, unexpected rain, and foggy weather

Adoption Estimates by variety

Variety name	Release date	Adoption Rate	Adoption degree
BARI-3	1996	32.20%	30.51%
BARI-4	1996	22.00%	21.11%
BARI-5	2006	10.70%	9.54%
BARI-6	2006	38.10%	31.94%
BARI-7	2011	4.20%	4.27%
BINA-4	2009	0.10%	0.08%
BINA-5	2011	0.40%	0.71%
BINA-6	2011	0.50%	0.70%
Local	1900	2.50%	1.15%
	Total	110.70%	100.00%

This is more than 100% showing that some farmers are cultivating more than one variety

Bari-6, Bari-3 and Bari-4 are the top ranking varieties in terms of area with each covering 31.94%, 30.51% and 21.11% respectively

Adoption rates of lentil varieties by year of release

District	% farmers adopted varieties released in 2006 or after	% farmers adopted varieties released in 2009 or after	% farmers adopted varieties released in 2011 or after
Chuandanga	44.52	6	6
Faridpur	38.72	0.6	0.6
Jessore	61.63	1.81	1.81
Jhenaidah	34.34	6.51	6.51
Kushtia	55.56	9.84	9.84
Magura	68.62	13.3	13.3
Natore	50.17	0	0
Pabna	28.19	9.02	8.59
Rajbari	53.47	7.87	7.87
Rajshahi	.	.	.
All	51	5	5

Table: Consumption of different food item per day per person (adult)

Food item	All districts
Rice (kg.)	0.41
Wheat flour (Kg.)	0.05
Puffed rice (gm.)	8.19
Potato (Kg.)	0.08
Vegetable (Kg.)	0.08
Fish (Kg.)	0.07
Red meat (Kg.)	0.03
Chicken (Kg.)	0.04
Egg (no.)	0.28

Food item	Total
Lentil (gm.)	13.39
Other Pulses (gm)	7.74
Oil (gm.)	19.48
Milk (Liter)	0.05
Fruits (gm.)	14.38
Cookies (gm.)	10.17
Spices	5.59
Green chili (gm)	9.92
Sugar/gur (gm.)	15.97
Tea (gm.)	0.70

Anthropometric results

Table: Basic statistics of the anthropometric survey

Category	Lentil growing HH	Non-lentil growing HH nearby	Other areas	All Children
Sample child (No.)	244	158	70	472
Boys (No.)	126	80	43	249
Girls (no)	118	78	27	223
Average age (Month)	35.07	30.08	21.93	31.45
Average height (cm)	87.11	83.50	75.34	84.16
Average weight (Kg.)	11.96	11.11	9.59	11.33
MUCA (mm)	87.11	83.50	75.34	84.16

Anthropometric results

Table: Distribution of age and sex of sample

AGE (mo)	Boys		Girls		Total		Ratio Boy: girl
	no.	%	no.	%	no.	%	
6-17	64	52.5	58	47.5	122	25.8	1.1
18-29	67	54.9	55	45.1	122	25.8	1.2
30-41	42	52.5	38	47.5	80	16.9	1.1
42-53	55	53.9	47	46.1	102	21.6	1.2
54-59	21	45.7	25	54.3	46	9.7	0.8
Total	249	52.8	223	47.2	472	100.0	1.1

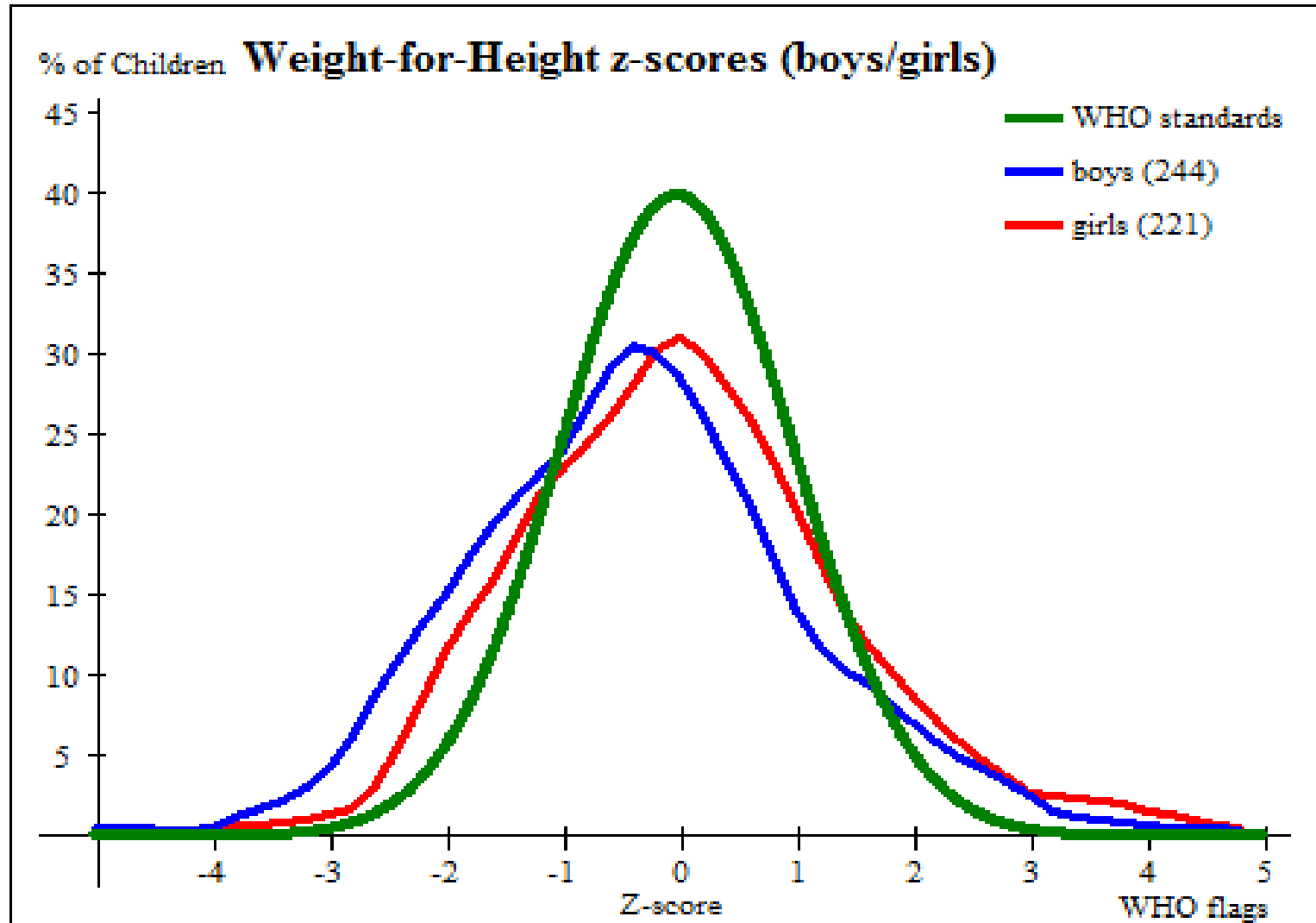
Anthropometric results

Table: Prevalence of acute malnutrition based on weight-for-height z-scores (and/or oedema) and by sex

	All n = 465	Boys n = 244	Girls n = 221
Prevalence of global malnutrition (<-2 z-score and/or oedema)	(36) 7.7 % (5.8 - 10.2 95% C.I.)	(29) 11.9 % (6.4 - 21.0 95% C.I.)	(7) 3.2 % (0.6 - 14.4 95% C.I.)
Prevalence of moderate malnutrition (<-2 z-score and ≥-3 z-score, no oedema)	(26) 5.6 % (3.4 - 9.0 95% C.I.)	(21) 8.6 % (4.5 - 15.8 95% C.I.)	(5) 2.3 % (1.2 - 4.4 95% C.I.)
Prevalence of severe malnutrition (<-3 z-score and/or oedema)	(10) 2.2 % (0.7 - 6.7 95% C.I.)	(8) 3.3 % (1.2 - 8.8 95% C.I.)	(2) 0.9 % (0.0 - 42.1 95% C.I.)

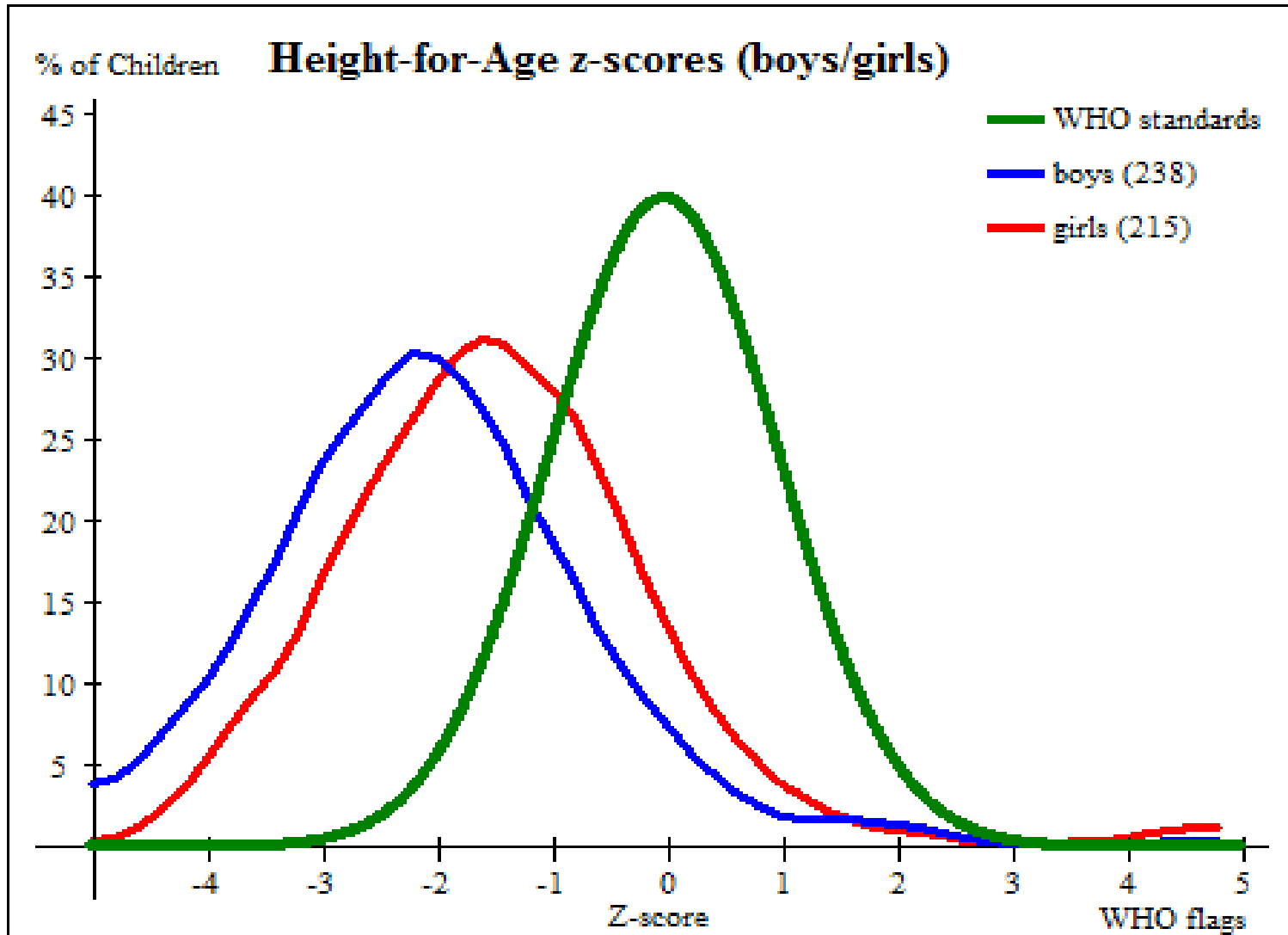
Anthropometric results

Table: Prevalence of malnutrition (Weight-for-Height z-scores)



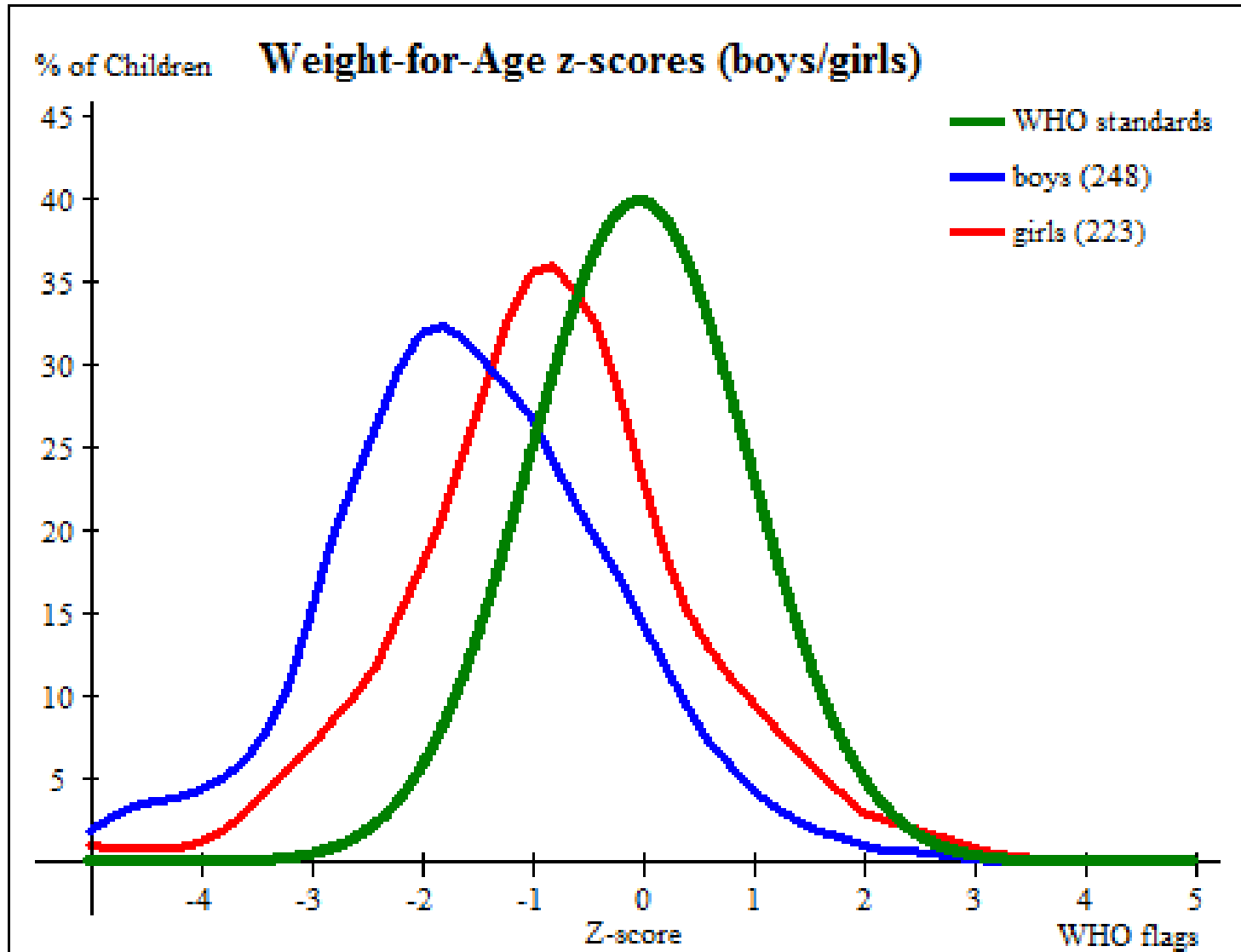
Anthropometric results

Table: Prevalence of Stunting (Height-for-Age-z-scores)



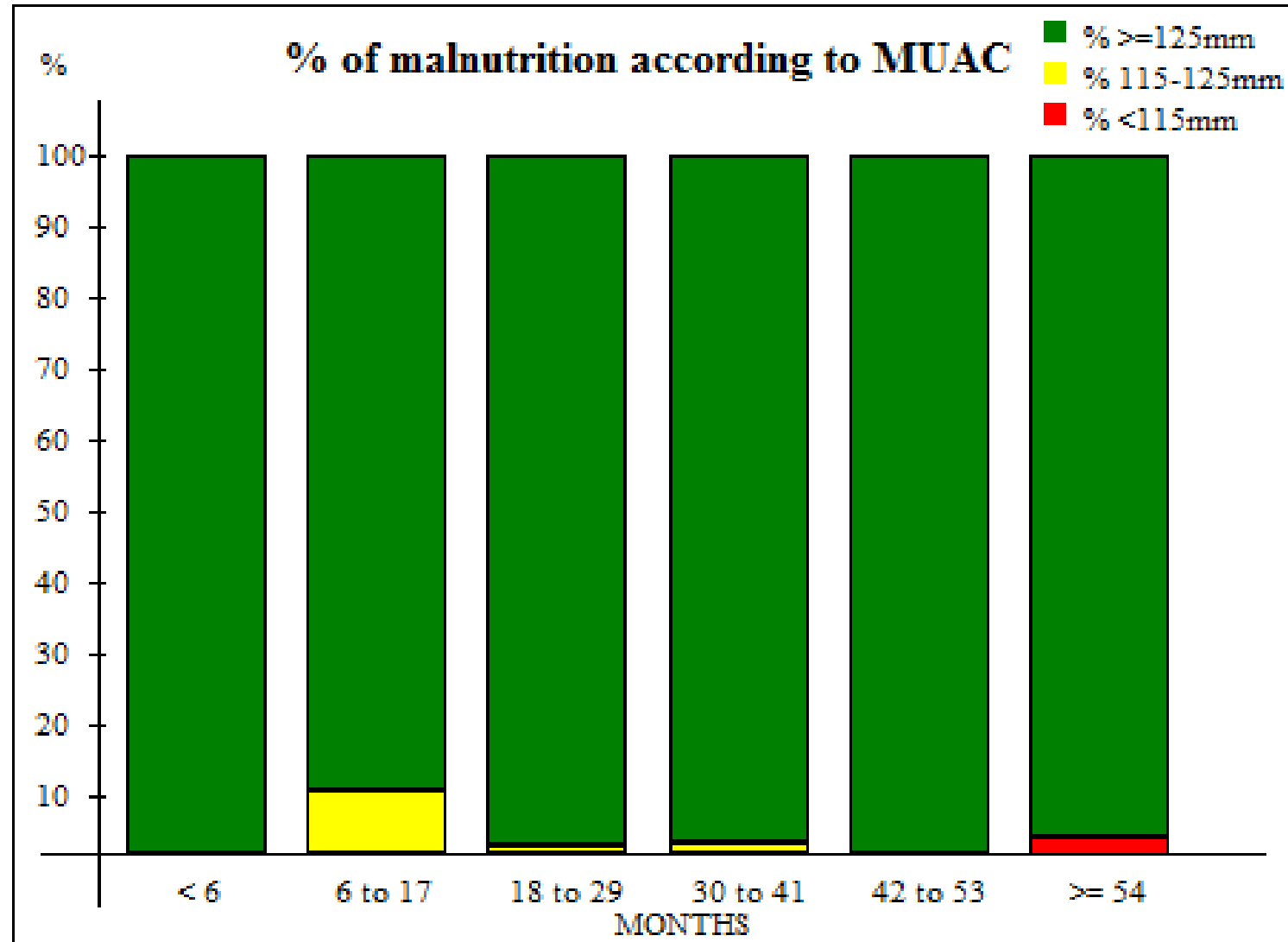
Anthropometric results

Table: Prevalence of underweight (Weight for-Age z-scores



Anthropometric results

Table: Results of MUAC based on age group



Challenges encountered

- Lack of required secondary data particularly number of lentil growers (at national, district, sub-district and village level); hence, we collected data through personal communication with DD, UAO and SAAO
- In selecting villages we depend on the information provided by UAO and SAAO
- Few farmers sold all grains/seeds; we collected seed samples showing neighbor seeds
- Farmers do not keep written record of used inputs, production and marketing data; We depend on their memory

Challenges encountered

- Enumerators had to train several times as some of them could not continue whole period of data collection;
- More time and care required for collecting food intake data;
- We were hurry as we did not want to miss the seed samples; we wanted to collect all data before sowing lentil seed in the field
- For anthropometric survey we got less children to be included;
- Private seed distributor did not provide seed sample (only one company marketed one variety of lentil seed);

DNA fingerprinting based identification of farmers lentil varieties

Sample Seed Collection Procedures

From Research Organizations

- Breeder seeds for each of the varieties released from Pulses Research Center (PRC), Bangladesh and Bangladesh Institute of Nuclear Agriculture (BINA) as reference.

Seed companies

- Two samples from each of the available released varieties were taken from randomly selected seed bags in the Bangladesh Agricultural Development Corporation (BADC) seed storage facilities using grain probes.

Sample Seed collection procedures cont'd

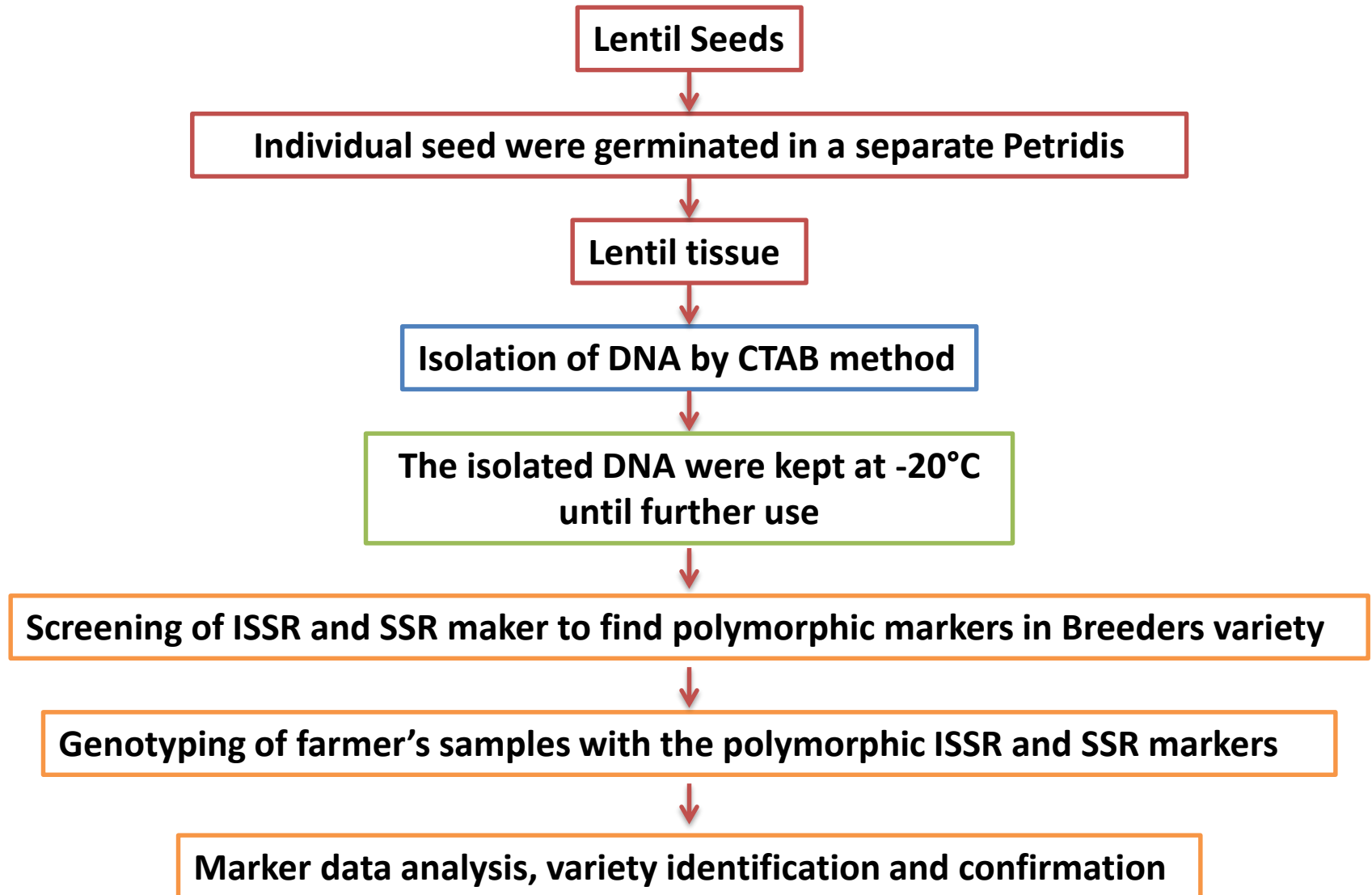
Local Seed dealers

- Two samples from each of the varieties sold by a random sample of 2 dealers per sub district were taken using grain probes

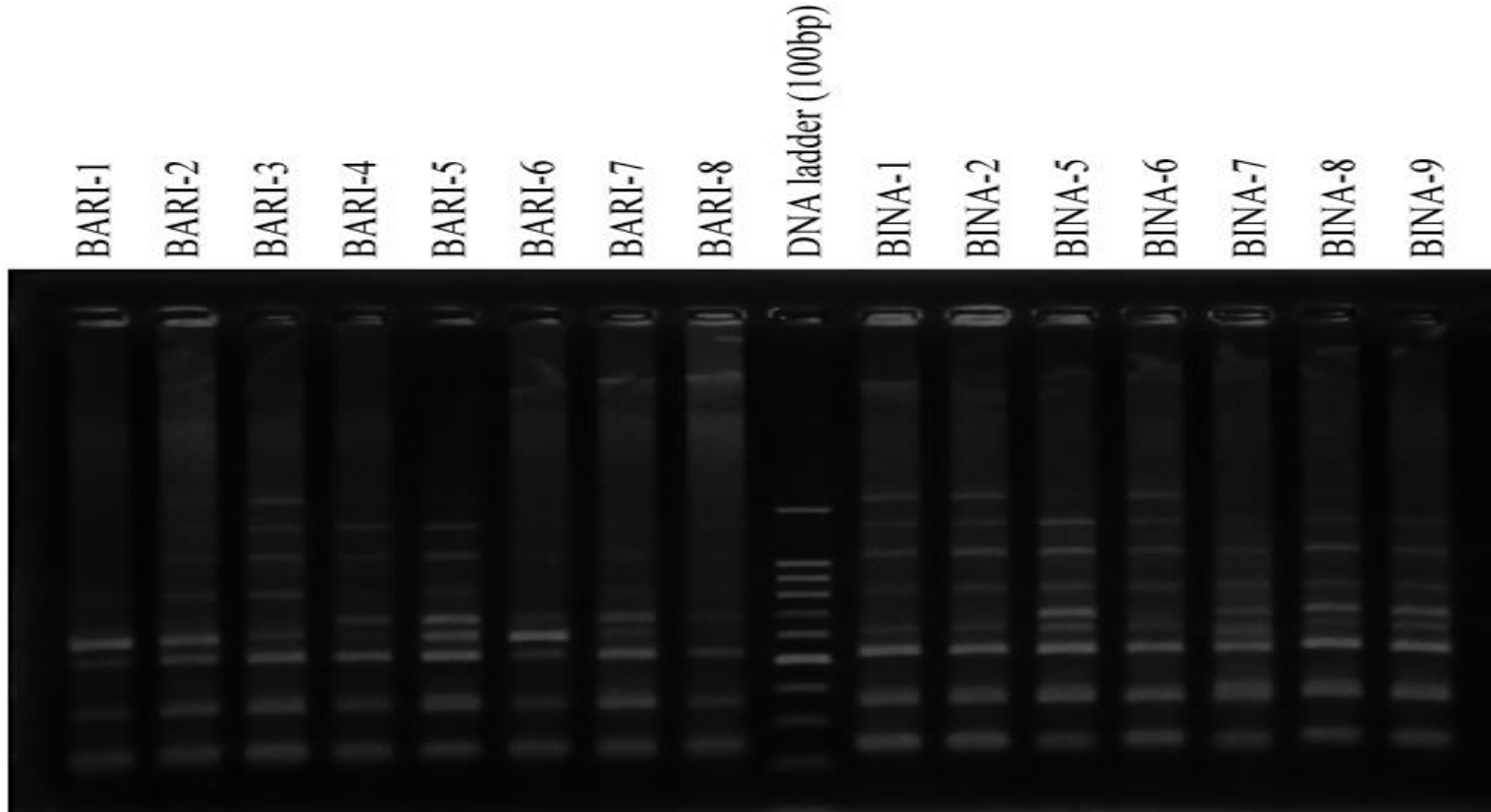
Seed from farmer's house

- A handful of (100-200 grains) of lentils from the particular bag or any other container where they stored the seed/grain from the particular plot were taken and the seed/grain sample were placed into the plastic bag and sealed it using the zip locker
- For each sample, unique and easy to understand code that can be easily matched with survey questionnaire identification code was assigned.

Flow chart for DNA fingerprinting procedure



DNA fingerprinting data generated by *HB011* ISSR marker across different breeder's samples



Partial comparison of DNA results of field data and breeders varieties

Sample ID	Identified variety by farmer	Matched with breeder's variety by DNA fingerprinting
Q0029	BARI-4	BARI-3
Q0360	BARI-6	Unmatched
Q0438	BARI-4	BARI-4
Q0456	BARI-3	BARI-4
Q0460	BARI-4	BARI-4
Q0789	BARI-3	BARI-3
Q0820	BARI-3	BARI-3
Q0848	Local	BARI-4
Q0007	BARI-7	BARI-7

Estimates of mismatch

- Analysis is not complete

But

So far mismatch between farmer identification and DNA identification is estimated not to exceed 5-6% of the total samples.

Challenges of the varietal identification by DNA fingerprinting

- **Challenges of own experience**
 - Higher within-variety variations
 - Lower between-variety variations
 - Low polymorphisms between variety
- **How these challenges are addressed**
 - Large set of ISSR and SSR markers were screened to find polymorphic markers among the varieties
 - Both dominant and co-dominant marker (i.e., ISSR and SSR) were used in DNA fingerprinting
 - Clustering and comparing of DNA fingerprinting data to match farmers variety with breeder variety

Next steps

- Genotyping of remaining samples
- Data analysis and comparing data of breeder varieties with farmer identified varieties