Project ID #491

Competitive Research Grant

Sub-Project Completion Report

on

Improving the performance of mechanized seeding through innovations in seed metering and delivery system

Project Duration

May 2017 to September 2018

Farm Machinery and Postharvest Process Engineering Division
Bangladesh Agricultural Research Institute (BARI)
Gazipur 1701

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka1215

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka 1215
Bangladesh

Edited and Published by:

Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
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Bangladesh

Acknowledgements

The execution of this CRG sub-project has successfully been completed by Farm Machinery and Postharvest Process Engineering (FMPE) Division of Bangladesh Agricultural Research Institute using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thank the World Bank for arranging the grand fund and supervising the CRGs by BARC. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in multiple sites. We would like to gratefully acknowledge the technical help and guidance received from Dr. Md. Israil Hossain of FMPE Divison of BARI. Preparation of the sub-project completion report required to contact a number of peoople for collection of information and processing of research data. Without the help of those people, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are due to the Director PIU-BARC, NATP 2 and his team who given their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to technology generation as well as increasing production and productivity for sustainable food and nutrition security in Bangladesh. It would also assist the policy makers of the agricultural sub-sectors for setting their future research directions.

Published in: September 2018

Printed by: [Name of press with full address]

Acronyms

Avg.	Average
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BHM	BARI Hybrid Maize
BS	BARI Seeder
cm	Centimeter
Co-PI	Co-principal Investigator
CPM	Chinese Precision Seed Meter
CRG	Competitive Research Grant
Fig.	Figure
FMPE	Farm Machinery and Postharvest Process Engineering
g	Gram
h	Hour
Hz	Hertz
km	Kilometer
kW	Kilo Watt
mm	Millimeter
PCR	Project Completion Report
PI	Principal Investigator
PTOS	Power Tiller Operated Seeder
R^2	Regression Co-efficient
rpm	Revolutions per Minute
USDA	United States Department of Agriculture
V	Voltage
VMP	Versatile Multi-crop Planter
VSD	Variable Speed Drive
W	Watt
WRC	Wheat Research Centre
WS	WRC Seeder
%	Percentage
°	Degree
2WT	Two-wheeled Tractor

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Executive Summary

Seeding is one of the most crucial agricultural operations which is mostly done manually in Bangladesh. Manual planting is a precise but tedious and labour and cost intensive operation. Mechanized planting of maize is fast and can save time and money significantly, but not precise when compared to hand planting seeds one by one. Therefore, this research project was invited to test different maize meters and to develop a precision metering system for adoption in two-wheeled tractor operated maize planters. The project tested three types of conventional maize seed meters used in Bangladesh (BARI, WRC and VMP) and an imported Precision Seed Meter (CPM) at low, medium and high rotational speeds and inclination angles. The tests were conducted using 'seeder test rig and soil bin' facility of the FMPE Division, BARI, Gazipur. Two tests were conducted – one at steady state (no vibrations due to engine or soil tillage) and the other at dynamic state (running prototype seed boxed on a PTOS to take in vibrations due to engine and roto-tilling). Performance of the seed meters was measured in terms of percentages of singles, doubles, multiples, missings, bridgings and gaps. The best seed meter was incorporated in a full scale seeder and field tested for maize, wheat, chickpea and soybean. Steady state test results showed that the CPM seed meter outperformed other seed meters for the maize varieties tested (NK40, Elite and BHM9) in terms of metering accuracy (metered 92–97% single seeds compared to 27–97% by other seed meters).Percentage of gaps (sum of percentages of missing and bridging) was up to 25–37% for BS, WRC and VMP seed meters, whereas it was ≤6%only for the CPM seed meter. The CPM seed meter was also free from seed locking/bridging. The performance parameters of the BS, WS and VMP meters fell for the Elite seeds (dent type seed having the highest length/width ratio) compared to other seeds. However, it did not change much for the CPM seed meter.

The dynamic test results showed that the performance of the CPM seed meter did not change significantly due to vibrations compared to the other seed meters. Under the vibrations, the CPM seed meter resulted in 93–97% singles, <3% doubles and ≤5% gaps which indicates its suitability for maize planting. Despite of giving the best results, the CPM seed meter accounted for some gaps (mainly for Elite seeds) which need to be investigated further by changing the metering plate, fly, seed grading, etc.

Preliminary field testing of the precision seeder for maize, wheat, chickpea and soybean resulted in satisfactory crop establishment in experimental plots. However, in order to improve its ability to handle crop residues and minimize variation of seeding depth, the other functional components of the seeder (e.g. rotor, furrow openers, and press wheels) need to be fine-tuned. The improved seeder should then be field testedin different soil and copping conditions in Bangladesh.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project:
   Improving the performance of mechanized seeding through innovations in seed metering and delivery system

2. **Implementing organization:**
   Farm Machinery and Postharvest Process Engineering Division, Bangladesh Agricultural Research Institute (BARI)

3. **Name and full address with phone, cell and E-mail of PI/Co-PI:**

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4. **Sub-project budget (Tk):**
   4.1 Total: 34,98,327.00 (Thirty four lakh ninety eight thousand three hundred and twenty seven taka only)

   4.2 Revised (if any): Not Any

5. **Duration of the sub-project**:
   5.1 Start date (based on LoA signed): 01 May 2017

   5.2 End date: 30 September 2018

6. **Justification of undertaking the sub-project:**

Despite of many challenges Bangladesh agriculture has made a remarkable progress during the last decades to meeting food security of its burgeoning population. With the augmented demand for boosting food production through horizontal (extending crop production in the fallow lands) and vertical expansions (increase yield), and in response to growing labour scarcity and mounting labour and fuel prices, the demand for appropriate farm machinery has increased manifold. Mechanization of tillage, irrigation, threshing/shelling and recently harvesting operation has played a major role to intensify cropping, utilize fallows and boost crop production in the country.

Seeding is one of the most crucial agricultural operations which is still done manually in primitive ways. There are a few thousands Chinese (mainly) and domestically produced two-wheeled tractor (2WT) operated seeders (e.g. Chinese 2BG-6A seeder, BARI seeder) being promoted to the farmers and service providers. These seeders have 48 rotary blades that rotate at the high speed of 450–500 rpm and are twice as wide as the common two-wheeled tractor rotavators. Therefore, the seeders have the capability to till the land (full tillage or strip-tillage) and sow seeds in a single pass of the 2WTs. Thus, use of these seeders can significantly save cost and time of land preparation and sowing and offer other benefits (Haque et al., 2010; Hossain et al., 2009; Justice et al., 2004; and Matin et al., 2008 a & b). However, these seeders are used mainly for land preparation and rarely for seeding outside of any project based initiative. The main bottlenecks are – lack of awareness among the farmers and the developed seeders are either too complex or un-reliable particularly for planting maize and other bold grain seeds requiring seed singulation and maintaining a prescribed seed to seed spacing. Therefore, it is important to develop seeders that can accurately meter and sow seeds and benefit farmers in terms of labour, cost and time savings.

The seed metering systems used in these seeders are un-reliable due to high percentages of missing, multiples, seed locking/bridging, etc. They are also intricate to calibrate, set-up, and adjust resulting in their poor acceptability among the farmers/service providers for mechanized seeding. Mechanized seeding has been given a high priority by the government in the National Mechanization Road Map 2016 (BARC, 2016). The target set there is to realize 25% cultivated area under mechanized seeding by the year 2021 and 80% by 2041. To achieve this target, it is important to design and develop user friendly precision seed metering system suitable for adoption in 2WT seeders used in Bangladesh for both conventional and conservation agriculture based seeding systems.

7. **Sub-project goal:** To improve precision in mechanized maize planting and thus help expand mechanized maize cultivation in Bangladesh.

8. **Sub-project objectives**: The overall objective of the project is to develop a precision seed metering system for adoption in two-wheeled tractor operated maize planters used for conventional and conservation agriculture. The specific objectives are:

i) Benchmark the performance of maize seed meters and identify the critical design parameters at the 'Tillage-cum-Seeding' laboratory;

ii) Design, development and fabrication of a prototype precision maize seed metering system and evaluate its performance in the laboratory;

iii) Fabricate a full scale seeder incorporating the precision seed metering system and validate its performance through on-station field trial.

9. **Implementing location:** Joydebpur, Gazipur

10. Methodology in brief:

The study was conducted using the seeder test rig and soil bin facility of 'Tillage-cum-Seeding' Laboratory of the FMPE Division, BARI, Gazipur. Experiment 1 (steady state test) was conducted to benchmark the performance of maize seed meters available in the country for planting maize and identify their critical design parameters using prototype seed metering systems(boxes). While Experiment 2 (dynamic test) was conducted using the soil bin and a power tiller fitted with the prototype seed boxes. Details of the test rig, soil bin, prototype seed metering boxes and the experimental procedure are described in the following sections.

Seeder test rig

The seeding rig runs over two rails and is consisted of a motor (3-phase, 440 V, 750 W) driven seed meter drive shaft, a prototype seed box, a soil tilling rotor, a winch system to drive the rig, a stationary soil bin and a camera stand. The motor is connected through a variable frequency drive (changes electrical frequency input to the motor and regulate its shaft rpm) to obtain the desired rpm of the seed meter. The soil tilling rotor is driven by a 3-phase, 440 V, 7.5 kW electric motor and the winch mechanism by a 3-phase, 440 V, 5.5 kW motor. The winch moves the rig back and forth on the rails over the soil bin at a desired travel speed (were not used in this study). The soil bin was 14.0 m long, 1.7 m wide and 0.5 m deep and it allows testing of power tiller or tractor driven implement up to 1.5 m wide. The soil bin was filled with soil collected from the maize and wheat growing areas of Meherpur district. The soil contained 47.2% sand, 22.0% silt and 30.8% clay and falls in the textural class of 'Sandy Clay Loam' according to USDA soil classification system. The test rig can be fitted with high speed camera, measurement instruments and data logging systems as required (not used in this study). Thus, the rig allows testing of any tillage or seeding implement (up to 1.5 m wide) in the soil bin.

Prototype seed metering boxes

Prototype maize seed metering boxes (3–4 rows) of BARI Seeder model(BS), Wheat Research Centre Seeder model(WS), Versatile Multi-crop Planter model(VMP), and Chinese Precision Meter model (CPM)were fabricated for the tests. The boxes were fitted on the test rig though an adjustable frame that allowed change of inclination of the metering boxes (i.e., seed meters) as required for the study. The height of the seed meter from the soil was maintained similar to the actual field condition of a full scale seeder. Fig. 2 shows four different prototype seed boxes fabricated and used in the tests.

Fig. 1 Seeder test rig that holds the seed metering box and the camera for the steady state test (no forward travel or rotary speed of the rig)

BARI Seeder seed metering box (BS)

WRC Seeder seed metering box (WS)

VMP seed metering box (VMP)

Chinese precision seed metering box (CPM)

Fig. 2 Four prototype seed boxes fabricated and used for the tests

Design and modification of the Chinese Precision Seed Meter (CPM)

Design of the Chinese Precision Seed Meter (Fig. 3a, left) consists of i) a casing, ii) a 12-cell base plate, iii) a 12-cell metering plate, iv) a fly adjuster, and v) a cover as shown in Fig. 3a (middle and right). The casing holds the base plate, metering plate, fly adjuster and the cover. The seed meter is made of die casted aluminum except the cover which is made of plastic. Each seed meter is equipped with a gearbox as shown in Fig. 3b (left). However, during fabricating the prototype seeder, the individual gear boxes were replaced with a common chains-sprocket transmission system as shown in Fig. 3b (middle and right) to reduce seeder weight and cost. A five speed free-wheel type bicycle chains-sprocket transmission system was adopted in the prototype seeder. Therefore, the system is cheap and widely available in upazilla level bicycle shops. Due to the free-wheel option, the seed meters automatically stop during reversing (e.g. at turning) the seeder. This can save seed, time and effort of the operator. The Chinese Precision Seed

Meter is designed to operate vertically. However, as seen in Fig. 3b (right), the seed meters were 5° inclined from vertical to avoid seed missing due to fall off/return of the seeds from near the exit/delivery point.

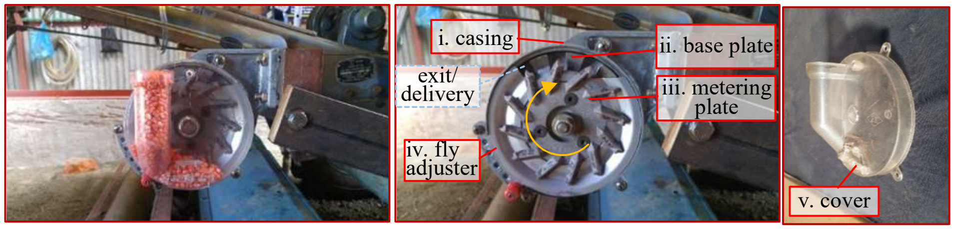


Fig. 3(a) Design of the Chinese Precision Seed Meter (*left* - seed meter filled with maize seeds, *middle and right* – components of the seed meter)

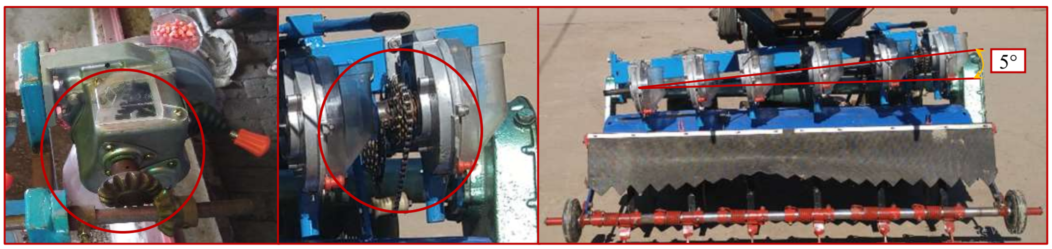


Fig. 3(b) Modification of the Chinese Precision Seed Meter

Calibration of inclination angle and rotational speed of the seed metering plates

The BS and WS seed meters were tested at three different inclination angles (marked as low, medium and high) by changing inclination of the seed metering boxes. The inclination angles 90° means the seed metering plate is perfectly vertical whereas 0° means perfectly horizontal. The angles selected for the test were decided from the field test of the PTOS (Fig. 4) operated at 0, 50, 75 and 100 mm tilling depth (Fig. 5). The VMP and CPM were operated only at vertical position (90° inclination angle) as a common practice. On the other hand, the rotary speed (rpm) of the seed meters were decided from a laboratory test (Fig. 6) by measuring speed of the metering plates at gear I and II at the engine speeds of 1300 and 1500 rpm (engine pulley used was of 135 mm diameter). Data are shown in Table 1.

Fig. 4 Field measurement of inclination angles of seed meters as varied due to tillage depths.

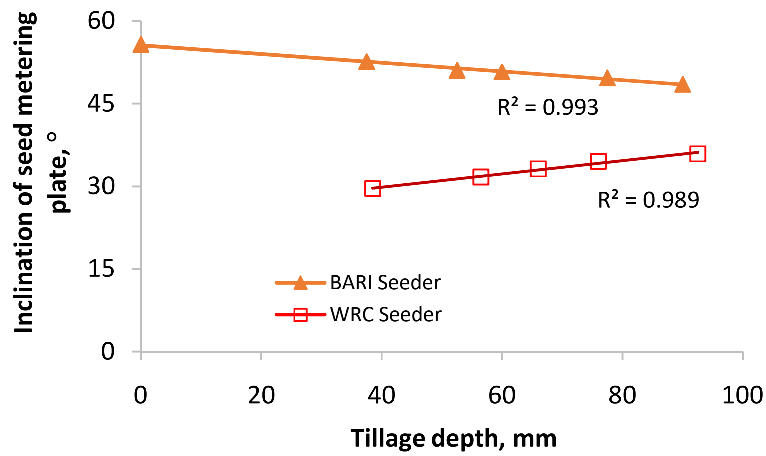


Fig. 5 Change of seed metering inclination angle of BARI and WRC seeders due to tillage depth (rotary blade operating depth) of PTOS.

Table 1 Determination and selection of rotational speed of seed metering plates for steady state test

Number of revolution of 2WT wheel	Engine speed, rpm	2WT gear position	Seed metering plate	rpm of 2WT wheel	rpm of seed meter	rpm of seed meter (assuming 5% slip)	rpm selected for steady tests
10	1300	I	*BARI (9 cells)*	9.6	9.4	8.9	8 (low), 12 (medium) and 16 (high)
		II		16.2	16.8	15.9	
	1500	I		7.9	8.2	7.8	
		II		14.2	14.0	13.3	
	1300	I	*WRC (24 cells)*	9.0	4.0	3.8	3.35 (low), 5.03 (medium) and 6.70 (high)
		II		16.2	7.0	6.7	
	1500	I		7.8	3.4	3.2	
		II		14.0	6.0	5.7	
	1300	I	VMP and CPM (12 cells)	*Since same gear ratio were used for allthe seed metering boxes, the rotary speeds (rpm) of VMP and CPM seed meters were calculated from BARI Seeder data*			6 (low), 9 (medium) and 12 (high)
		II					
	1500	I					
		II					

Calibration of variable speed drive (VSD) for drive motor's output shaft speed

Before start of any ofthe tests, the variable speed drive (VSD) was calibrated for rotary speed of the motor that drove the seed meters. Rotary speed of the output shaft and the frequency of the drive were highly correlated (R^2=1.0) as seen in Fig. 7. During tests, the rotary speeds of the drive motor that provided the desired speed at the seed meters were calculated following the equation shown in Fig. 7.

Fig. 6 Measurement of variation of seed meter's rotary speed due to power tiller's gear position and engine speed (rotary tiller off).

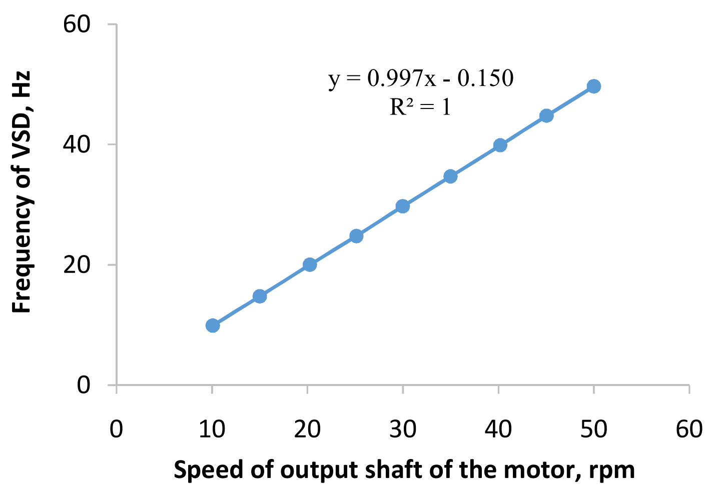


Fig. 7 Calibration of variable speed drive (VSD) for drive motor's shaft speed.

Measurement of physical properties of maize seeds tested

Table 2 Physical properties of maize seeds tested

Maize seed	Seed size (n=100)						Length/Breadth		Sphericity[†]		Weight of 100 seeds, g
	Length, mm		Breadth, mm		Thickness, mm						
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	
NK40	5.32–11.06	9.08	5.98–9.72	7.77	3.76–8.21	5.89	0.66–1.64	1.18	6.26–8.37	7.42	26.98
Elite	8.17–13.16	10.95	5.52–9.87	7.77	3.61–6.99	4.90	0.83–2.05	1.42	6.33–8.43	7.43	27.38
BHM9	5.15–10.10	8.12	6.36–8.91	7.67	3.82–7.58	5.45	0.69–1.33	1.06	6.00–7.90	6.94	22.69

[†]Calculated as per Mohsenin (1970)

Test procedure

Seed meter test using test rig (steady state test, no vibrations due to engine or soil tillage)

As showing in Fig. 1, the prototype seed metering boxes were set on the test rig and operated at the desired speed of the seed meters using the VSD. The treatments are listed in Table 3. There was no vibrations of the seed meters or seed boxes due to engine or soil tillage that always present when the seeders are operated in the field(set on a power tiller). The purpose of this steady state test was to quantify the true effect of the seed meters on the metering performance of three popular varieties of maize seeds under different inclination angles and rotational speeds as presented in Table 3.

Table 3 Description of the seed meters and treatment runs

Seed meter types	Inclination angles	Rotational speeds of seed meters	Remarks
BARI seeder (9 cell inclined plate, plastic made)	Low (48°), medium (52°) and high (56°)	Low (8 rpm), medium (12 rpm) and high (16 rpm)	Replicated 3 times
WRC seeder (24 cell inclined plate, plastic made)	Low (28°), medium (32°) and high (36°)	Low (3.35 rpm), medium (5.03 rpm) and high (6.70 rpm)	
VMP (12 cell vertical plate, plastic made)	Vertical (90°)	Low (6 rpm), medium (9 rpm) and high (12 rpm)	
CPM (12 cell vertical plate, aluminum alloy made)	Vertical (90°)	Low (6 rpm), medium (9 rpm) and high (12 rpm)	

NBLow, medium and high speeds or inclination angles were similar to the field conditions and decided from the results of the field test data presented in Table 1.

BARI and WRC model prototype seed boxes had three chambers (allowing setting up of three seed meters for one test run). On the other hand, VMP and CPM seed boxes allowed setting up of two seed meters per each test run (so run twice to obtain three replications). During the first test run of BS or WRC, each chamber of the prototype seed box was filled up with 500 g of maize seeds that half-filled the chamber. While chambers of the VMP and CPM seed boxes were filled up with 1500 g (half-full) and 300 g seeds (full), respectively. To maintain a constant amounts of seeds in the chambers during all the subsequent test runs, additional seeds were supplied into the chambers. A digital camera was set on the rig to record the seed pick up, carry over and delivery (singles, doubles, missing, and bridging) of the seeds and subsequently count their numbers and calculate their percentages (% of singles, doubles, missings and bridgings).

Dynamic test of seed meter using PTOS (involved vibrations due to engine and roto-tilling)

As showing in Fig. 8, the prototype seed metering boxes were set on a 2WT driven PTOS and operated in the soil bin. The soil bin soil went through the process of watering, pulverization, levelling and compaction (Fig. 9) to a bulk density of 1.45 (±0.06) g cm^{-3} and soil moisture content of 22.80 (±0.30) %. For the dynamic tests, the PTOS was set up on strip-till mode and thus tilled only two furrows (i.e., two rows - four Chinses type rotary blades per row). The rotary blade operating depth was 100 mm and the engine speed was set at 1500 rpm (engine pulley diameter was 135 mm) that gave the highest possible vibrations to the seed meters (imitating field vibrations). The 2WT was operated at gear II (2.5 km h^{-1} forward speed) and the plates' inclination angle was 'high' and rotational speed 'medium' as this combination gave the best seed metering performance during the steady state test. Detail of the settings are given in Table 4. Using the video data record of each test run % of singles, doubles, missings and bridgings were calculated for the dynamic conditions.

Fig. 8 A 2WT driven PTOS is fitted with a prototype seed box for dynamic test

Fig. 9 Soil bed preparation for dynamic test of seed meters

Table 4 Seed meter settings during the dynamics test

Seed meter type	Inclination angle	Forward speed, ms^{-1}	Rotational speed, rpm
BARI Seeder	52°	0.70	12.00
WRC Seeder	32°	0.70	5.03
VMP	90°	0.70	9.00
CPM	85°	0.70	9.00

Fabrication of a full scale precision Seeder and field testing

Based on the findings of the sub-project a six row precision seeder was designed, fabricated and field tested for sowing maize, wheat, chickpea and soybean. The seeder is shown in Figs. 10 and 11.

Fig. 10 : The six row Precision Seeder designed, fabricated and tested at the FMPE Division, BARI, Gazipur

Fig. 11 On-station field testing of the Precision Seeder for planting maize, wheat, chickpea and soybean, FMPE Division, BARI, Gazipur

11. Results and discussion:

Steady state test

The data has been processed and the key results are shown in Figs. 12–15 and summarized as below:

- Generally, % of single seeds (singulation efficiency) increased with the rotary speed of the BS seed meter. However, the seed singulation efficiency did not vary due to the rotary speed of the WRC, VMP and CPM seed meters. Change of inclination angle of BS or WRC seed meter affected the singulation efficiency considerably only in case of the BHM seeds. The CPM seed meter (92–97%) outperformed the other seeds meters (27–97%) by consistently producing the highest percentage of single seeds which is highly desirable/precise.

- Percentages of undesirable double seeds reduced with the increase of the rotary speed of the BS seed meter, but did not change much for the WRC, VMP and CPM seed meters. Change of inclination angle of BS or WRC seed meter affected the % of doubles considerably only in case of the BHM seeds.The least percentages of doubles (<3%) were obtained with the CPM seed meter (for all of the varieties)which is highly desirable. On the other hand, the highest percentages (62%) of undesired doubles were obtained in case of the BS seed meter (highest for BHM9 seeds) followed by VMP seed meter (34%).

- Seed bridging (locking into the meter's cell) was not significantly affected either by the rotary speed or the inclination. However, it was affected by the variety and seed meter type. The highest% of seed bridging (24–25%) was observed for BS and VMP seed meters when Elite seeds were metered. The Elite seed is dented type (having the highest length/width ratio) and thus were easily locked into the seed meter's cells. On the other hand, there was no bridging in case of the CPM seed meter (even with Elite seeds).

- Percentages of missings were the highest for the WS seed meter (32%) followed by BS seed meter (8%). The % missing was negligible for VMP seed meter (<1%) whereas it was up to 6% for CPM seed meter. It was observed in case of the CPM seed meter (vertical metering plate) that most of the times the seeds fell off the cells from near the delivery/exit. This suggests that the CPM seed meter should be set slightly inclined towards the delivery to avoid missing due to seed fall off before delivery. In case of BS and WS seed meters, the inclination did not have any effect on missing and except for the combination of BS and Elite seeds where it increased with the increase of the inclination angle (higher inclination means closer to vertical position).

- Percentage of gaps (sum of percentages of missing and bridging) was up to 25–37% for BS, WRC, and VMP seed meters, whereas it was low (≤6%) for the CPM seed meter indicating its suitability for maize seed metering at steady state. However, its ultimate suitability need to be confirmed based on the results of dynamic test that involves vibrations due to engine and roto-tilling.

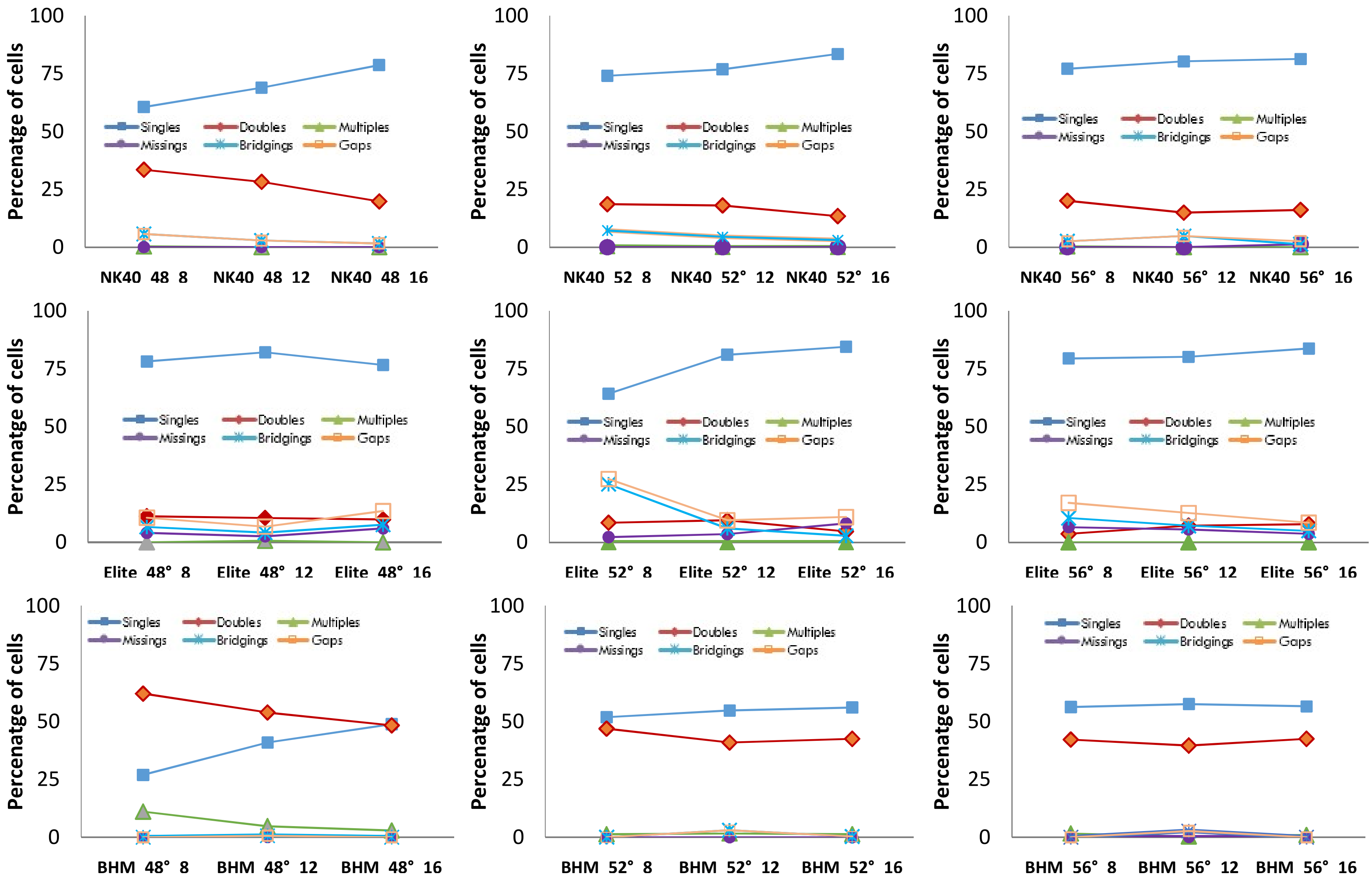


Fig. 12Effect of rotary speed and inclination on seed metering performance of BARI Seeder (Inclinations – 48°, 52° and 56°, rotary speeds in rpm – 8, 12 and 16).

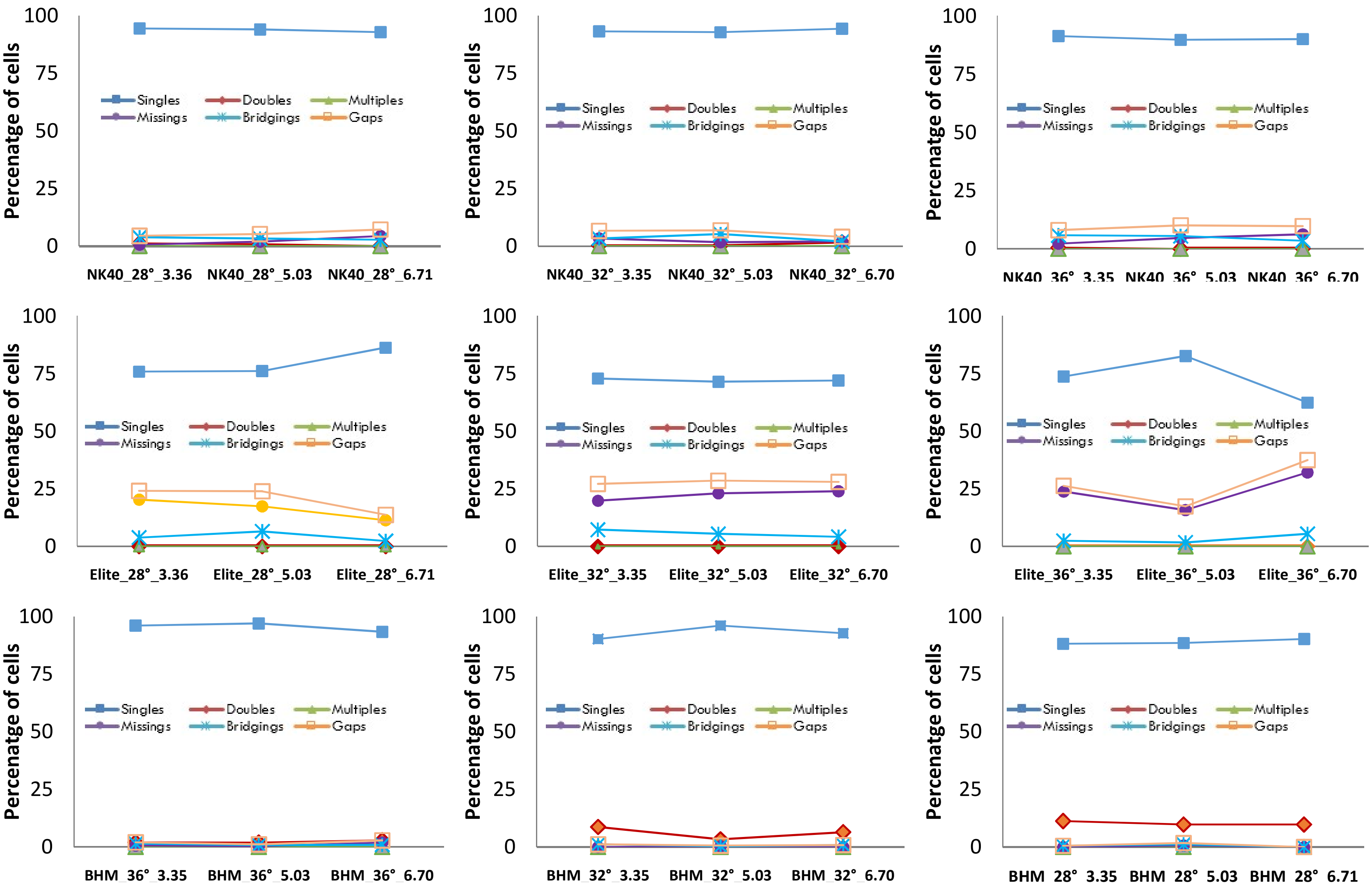


Fig. 13 Effect of rotary speed and inclination on seed metering performance of WRC Seeder (Inclinations – 28°, 32° and 36°, rotary speeds in rpm – 3.35, 5.03, and 6.70).

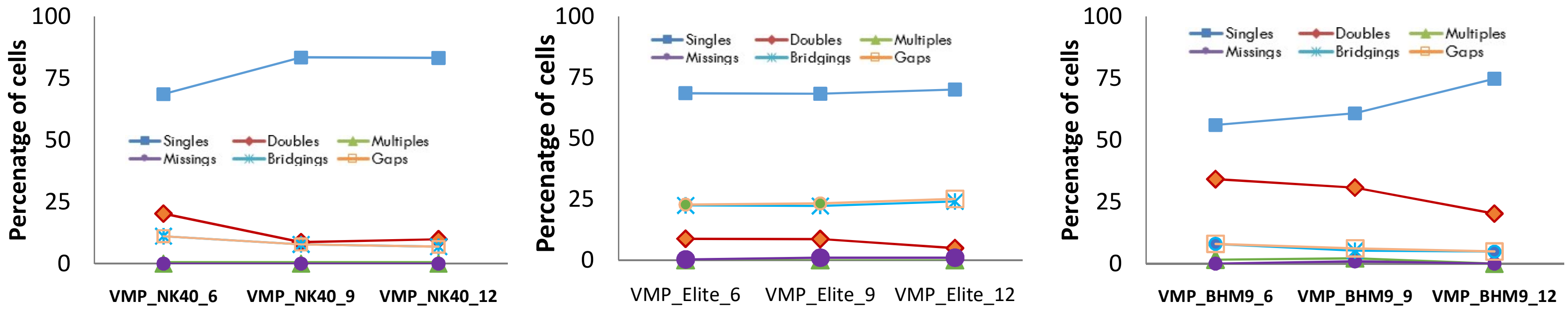


Fig. 14 Effect of rotary speed on seed metering performance of Versatile Multi-crop Planter (inclinations fixed at 90°, rotary speeds varied at 6, 9, and 12 rpm).

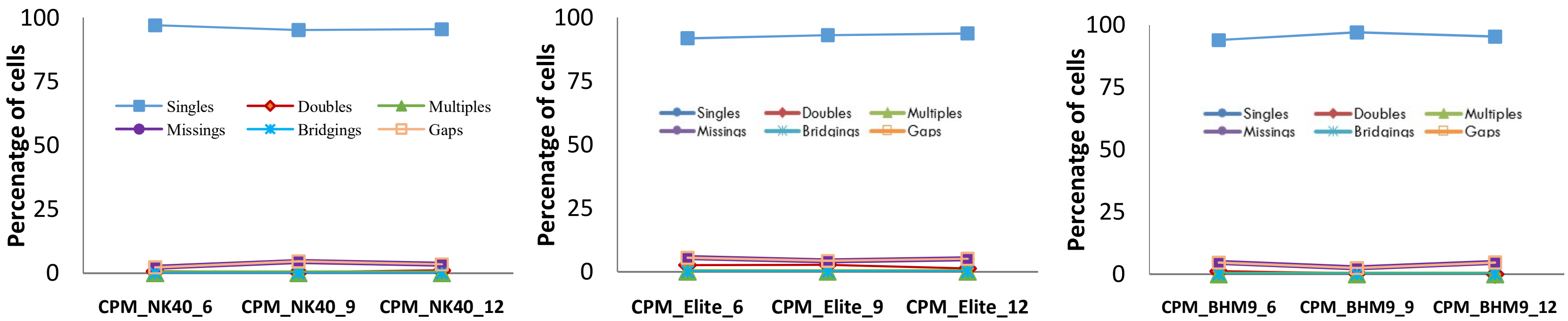


Fig. 15 Effect of rotary speed on seed metering performance of Chinese Precision Meter (inclination fixed at 90°, rotary speeds varied at 6, 9, and 12 rpm).

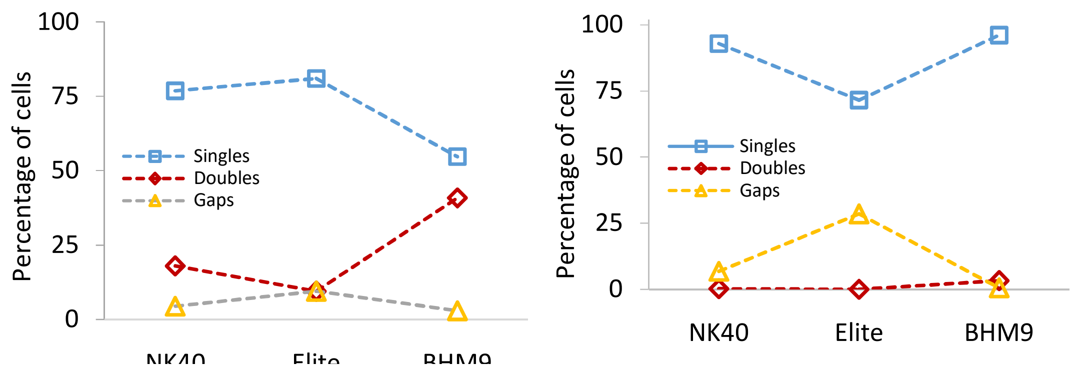
Dynamic test (involving vibrations of the seed meters due to engine and roto-tilling)

- Unlike the other seed meters, the performance of the CPM seed meter did not change significantly due to vibrations (Fig. 16). Similar to the steady state tests, the CPM seed meter produced the highest percentage of singles (93–97%), the lowest percentages of doubles (0.0–2.6%) and ≤5% gaps. Thus, the CPM seed meter outperformed the other seed metersthat produced 73–91% singles. The CPM seed meter performed well for all the maize seed varieties tested. Thus, the CPM seed meters are suitable for a wide variety of maize seeds (both flint and dent types).

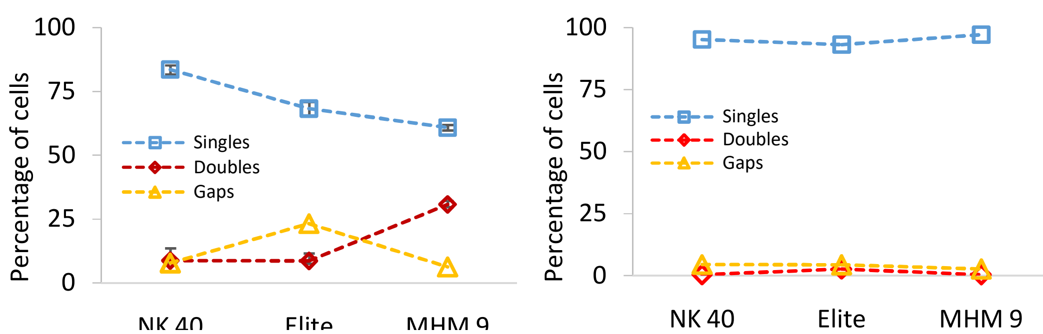
- Under vibrations, % of singles increased in case of the BS, WS and VMP compared to steady state test results. This was mainly due to reduction of % of doubles, but slightly due to reduction of the gaps. This indicates that vibrations help in cell filling mostly by single seeds and securing the seeds into the cells until delivery point.

- Results generally indicate that there is an inverse relationship between doubles and gaps. If we allow some reasonable percentages of doubles, there will be minimum percentages of gaps, and vice versa. Therefore, farmers using BS, WS or VMP seeders, should allow some doubles (and later uproot the unwanted double seedlings) to safeguard optimum plant population as the opposite (transplanting maize seedlings to fill up gaps) is not feasible.

- Preliminary test with other seeds (wheat, mungbean, chickpea) under vibrations suggests that the CPM meter (plates with smaller cell size) would also be suitable for many other crops, but needs further investigation.



BS (inclination 52°, speed 12 rpm) *WS (inclination 32°, speed 5.03 rpm)*



VMP (inclination 90°, speed 9 rpm) *CPM (inclination 85°, speed 9 rpm)*

Fig. 16 Effect of rotary speed on seed metering performance of different seed meters under vibrations due to engine and roto-tilling (dynamic test).

Fabrication and field testing

The six row Precision Seeder fabricated (Figs. 10–11) has the following specifications:

Source of Power	12–16 Hp Power tiller (two-wheeled tractors)
Rotavator	2BG-6A model rotavator (48 blades, 1.2 m wide)
No. of rows	Up to six
Tillage Options	Full tillage or strip-tillage
Seed Meter Type	Chinese precision
Tillage depth	Adjustable up to 100 mm
Forward speed	1.5–2.5 kmh^{-1} (0.4–0.7 m s^{-1})
Crops	Maize, wheat, rice, pulses (mungbean, chickpea, etc.), oil seeds (groundnut,soybean, etc.)
Field capacity	0.12–0.14 hah^{-1} (30–35 $decimalh^{-1}$)

Fig. 17belowshows the crop fields planted by the precision seeder at the FMPE Divisional research field, BARI, Gazipur.

Maize


Wheat


Chickpea


Soybean

Fig. 17 Crop fields planted by the precision seeder at the FMPE Divisional research field, BARI, Gazipur

Critical seed meter design parameters

From the steady state test results, it is obvious that the geometrical shape of seed (length/width ratio) is one of the critical design parameters that affects seed metering performance. The dented type seeds, having large length/width ratio, are difficult to meter accurately. They are prone to get locked into the seed meter's cells often causing repeated miss hills during planting (until noticed by the operator and cleared manually). Therefore, dented type seeds should be avoided for mechanized planting using seeders commonly available in Bangladesh. Cell shape is another critical design parameter. The CPM seed metering system is always free from any seed locking (even for dented type seed) as its cell design is different from other seed meters. Unlike other seed meters, the seeds do not completely enter into the cell of the CPM seed meter; rather jointly held by the cell and the fly adjuster plate (Fig. 3a) so that they are easily released at the exit/delivery when the fly adjuster plate ends. Using the fly adjuster, the length of travel of the seed, picked up by the cell can be adjusted to remove any multiple seeds (the longer the travel, the better the seed singulation).

12. Research highlights/findings:

i. At steady state (laboratory condition) the singulation efficiency increased with the rotary speed of the BS seed meter, but did not vary for WRC, VMP and CPM seed meters. The highest percentage of single seeds were obtained with the CPM seed meter (92–97%) which is highly desirable/precise.

ii. BS seed meter produced the highest percentage of doubles (up to 62%).

iii. In steady state test, the percentage of gaps was up to 25–37% for BS, WRC, and VMP seed meters, whereas it was ≤6% for the CPM seed meter. There was no bridging of seeds with the CPM seed meter. The high performance of the CPM seed meter maintained even at the high rotational speed of the seed meter indicating that it would be suitable for both low speed (2WT operated) and high speed (4WT operated) seeders.

iv. In dynamic test (replicating the field operation of the seeder in a soil bin lab), the performance of the CPM seed meter did not change significantly compared to the steady state test. The CPM seed meter produced 93–97% singles, <3% doubles and ≤5% gaps which indicates its high suitability for maize planting. Preliminary laboratory test of the seed meter showed it would be suitable for some other corps, but require thorough field testing.

v. Using six CPM seed meters, a six row prototype Precision Seeder was fabricated and field tested for maize, wheat, chickpea and soybean. The preliminary test results show that the seeder can be used to sow these crops satisfactorily.

vi. This research project aimed to improve the seed metering and delivery system. However, it was felt during the field test that the other functional components of the seeder (e.g. rotor, furrow openers, and press wheels) need to be improved for its better residue handling ability and even seed placement into the soil for uniform seed germination and seedling growth.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	**PP Target**		**Achievement**		**Remarks**
	Phy (#)	**Fin (Tk)**	**Phy (#)**	**Fin (Tk)**	
(a) Office equipment	3	190000.00	3	190000.00	
(b) Lab and &field equipment	7	510000.00	7	510000.00	
(c) Other capital items	1	10000.00	1	10000.00	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Lab repair			80000.00	33801.00	

3. Training/study tour/ seminar/workshop/conference organized:

Description	**Number of participant**			**Duration (Days/weeks/ months)**	**Remarks**
	Male	Female	Total		
(a) Training	20	0	20	1 day	
(b) Workshop	-	-	-	-	-

C. Financial and Physical Progress

Fig in Tk

Items of expenditure/activities	**Total approved budget**	**Fund received**	**Actual expenditure**	**Balance / unspent**	**Physical progress (%)**	**Reasons for deviation**
A. Contractual staff salary	928227	799324	568285	231039	61.2	Early PI change, Late manpower recruitment
B. Field research/lab expenses and supplies	1088000	1222941	1222941	0	112.4	
C. Operating expenses	220000	209999	209999	0	95.5	
D. Vehicle hire and fuel, oil & maintenance	150000	144446	144446	0	96.3	
E. Training/workshop/seminar etc.	174600	68870	68870	0	39.4	
F. Publications and printing	160000	0	0	0	0.0	
G. Miscellaneous	35000	27977	27977	0	79.9	
H. Capital expenses	742500	703700	750500	-46800	101.0	

D. Achievement of Sub-project by Objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
Benchmark the performance of maize seed meters and identify the critical design parameters using a high speed camera at the 'Tillage-cum-Seeding' lab	- Designed and installed test bench - Fabricated 4 types of seed meters - Measures geometrical parameters of 3 varieties of maize seeds - Lab tested 4 types of prototype seed meters at varying speeds and inclinations (static test)	- Seed meter test bench - Four prototype seed boxes - Measured seed metering efficiency data of different seed meters under static condition	- Faster and low cost testing of seed meters - Better understanding of performance of seed meters available in Bangladesh
Design, development and fabrication of a prototype precision maize seed metering system and evaluate its performance in the laboratory	- Evaluated 4 types seed meter in terms of seed metering performance in dynamic condition with vibrations - Identified best bait design	- Measured seed metering efficiency data of different seed meters under dynamic condition - Improved seed meter (precision seed meter)	- Improvement of seed metering performance
Fabricate a full scale seeder incorporating the precision seed metering system and validateits performance through on-station field trial	- A 6 row precision seeder has been fabricated - Experiment has been set up to compare the precision seeder's performance with BARI seeder and conventional hand planting	- A six row multi-crop precision seeder	- Reduction of crop production cost - Mitigation of labour crisis - Reduction of drudgery - Increase of crop yield

E. Materials Development/Publication Made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	-	-	-
Journal publication	-	-	-
Information development			
Other publications, if any			

F. Technology/Knowledge Generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Have developed an improved seeder for planting maize and other seeds

ii. Generation of new knowledge that help in developing more technology in future

New knowledge on seed metertypes and their interaction with maize seed varieties and operating parameters has been developed that will help guide development of more efficient maize seeders in future

iii. Technology transferred that help increased agricultural productivity and farmers' income

Farmers and manufacturers have been trained on operation, fabrication and repair of the developed seeder that will help increase maize production and reduce drudgery and cost of maize planting and thus help increase productivity and farmers' income

iv. Policy Support

Encourage local manufacturing of the precision seeder (technological support, training support, provision of subsidy, soft loans, etc.)

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring[description & output of consultation meeting, monitoring workshops/seminars etc.):

Description	Output
New Innovation through the project should be reported	Reported in the PCR
Title, objectives, activities, output and outcomes should be corrected and consisted in the PCR	Corrected in the PCR

ii) Field Monitoring (time& No. of visit, Team visit and output):

A fieldmonitoring team consisted of Dr. Md. Mia Syed Hasan, Dr. Md. Abdul Jalil Bhuyan and M&E Specialist of PIU, BARC visited the project activities on 14 March 2018 and expressed their satisfactions on the progress of the sub-project. They suggested to develop a full scale seeder for the farmers (in addition to the laboratory models) so that farmers get benefited. Accordingly, a full-scale precision seeder was fabricated as presented in Fig.10and11.

H. Lesson Learned/Challenges (if any)

i) For successful and timely completion of any project/sub-project, timely recruitment of manpower and allocation of fund/resources need to be ensured

ii) To achieve any successes/visible output in any agricultural project/sub-project, which is cropping season based, minimum time duration of the project should be three years

I. Challenges

Start of the sub-project activities was a challenge due to change of PI. Recruitment of the new PI and sub-project manpower took away about six months' time.

Signature of the Co-Principal Investigator
Date ………………………….
Seal

Counter signature of the Head of the organization/authorized representative
Date …………………………..
Seal

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