Cereal Systems Initiative for South Asia
Phase III

Bangladesh and Nepal

Semi-Annual Report
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Dr. Biniam Iyob, USAID Washington

Eric Witte, USAID Washington

Submitted by:

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Principal Investigator/Project Director: Dr. Andrew McDonald
Title: Project Leader, CSISA; Principal Scientist, CIMMYT
Mobile Phone: +977-9808757832
Email: a.mcondald@cgiar.org
Web site: http://csisa.org
Mailing address: CIMMYT International, South Asia Regional Office, P.O. Box 5186, Botany Division, NARC, Khumaltar, Lalitpur, Nepal

Contributors: Mina Devkota, Narayan Khanal, Rabin KC, Gokul Paudel, Anant Regmi, Dil Sherchan, Himalaya Subedi, Anil Khadka, Lokendra Khadka, Salin Acharya, Timothy J. Krupnik, DP Pandit, Shafiq Islam, Subal Chandra Mondal, Moksedul Arafat, Apurba Roy, Mohammad Shahidul Haque Khan, Humnath Bandari, Alam Murshedil, Sudhanshu Singh, Virender Kumar, Ansar Ahammed Siddiquee, and Zia Uddin Ahmed

With support from Andrew McDonald and Cynthia Mathys

Date Submitted: June 30, 2016
Mobile Phone: +977 9808040992 (Cynthia)
Email: c.mathys@cgiar.org

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Acronyms and Abbreviations

Acronym	Full Name
2WT	Two-wheel tractor
4WT	Four-wheel tractor
ARS	Agriculture Research Station
AVRDC	The World Vegetable Center
CIMMYT	International Maize and Wheat Improvement Center
CSISA-NP	Cereal Systems Initiative for South Asia, Nepal
DADO	District Agricultural Development Office
DOA	Department of Agriculture
DSR	Dry-seeded rice
FtF	Feed the Future
GoN	Government of Nepal
ha	Hectare
HH	Household
IRRI	International Rice Research Institute
ICM	Integrated Crop Management
Kg	Kilogram
KISAN	Knowledge-intensive Sustainable Agriculture and Nutrition project
LLL	Laser Land Leveler
MoAD	Ministry of Agriculture Development
NARC	Nepal Agricultural Research Council
NAMEA	Nepal Agriculture Machinery Entrepreneurs Association
NGLP	National Grain Legumes Program
NWRP	National Wheat Research Program
OPV	Open-pollinated variety
PQR	Premium quality rice
RARS	Regional Agricultural Research Station
SEAN	Seed Entrepreneurs Association of Nepal
SI	Sustainable intensification
SP	Service provider
ST	Strip tillage
SMEs	Small and Medium Enterprises
SQCC	Seed Quality Control Center
TL	Truthful Label
USAID	United States Agency for International Development
ZT	Zero tillage

From its inception, CSISA has been a complex initiative with many interventions, partners, and moving parts to coordinate. Entering Phase III, our focus has sharpened with fewer core areas where we will hold ourselves and our partners accountable for achieving progress against clearly defined metrics. We believe that technological change can be classified along a continuum that starts with co-innovation with potential end-users and scaling intermediaries, and culminates with self-sustaining systems that are mainstreamed within the institutional mandates and business interests of public and private sector partners, respectively. The end stage of development efforts, achieving a critical mass of new adopters, generates the momentum that supports future dissemination at scale. In Phase III, CSISA aims to catalyze sustainable intensification at scale through three themes: **innovation**, **systemic change**, and **achieving impact at scale.** CSISA selectively pursues opportunities where critical mass and mainstreaming with partners is possible.

CSISA's '**innovation towards impact**' theme, centers on two sub-themes related to addressing areas for innovation where bio-physical or economic risks have constrained adoption of ostensibly useful technologies and improving the quality and accessibility of recommendations for precision irrigation and nutrient management within existing extension and agro-advisory systems. CSISA's priorities for **achieving systemic change** through partnerships and strengthened scaling pathways center on building novel partnerships to propel inclusive growth around opportunities that otherwise would not be accessible to smallholders and the mainstreaming of participatory and quantitative technology evaluations to drive district-specific extension messaging and investment prioritization with NARES partners**.** CSISA's priorities for **achieving broad impact at scale** in Phase III will center on expanding the input and service economy for sustainable intensification technologies and also scaling interventions that help farmers cope with climate extremes.

CSISA Phase III started in December 2015, which meant that the project was not able to fully capture the 2015–16 winter (wheat) season. During the reporting period, therefore, CSISA's work in Bangladesh centered on directly sown rice (DSR), rice fallows development, healthy rice seedlings, integrated weed management, precision nutrient management, mechanization options including reapers and seeders, increasing the capacity of NARES, and the deployment of better-bet agronomic messaging. Two activities related to wheat include responding to the expanding wheat blast epidemic in preparation for the next winter season.

In Nepal, CSISA similarly focused on directly sown rice and providing support for DSR service providers through innovation for risk-reduction and value chain strengthening, production technologies for maize and area expansion of maize hybrids, the deployment of better-bet agronomic messaging through development partners, and the project's expansion into new districts where incentives for cereals intensification are strong.

BANGLADESH

- Despite considerable pressures from labor scarcity that favor mechanization, **directly sown rice** (DSR) is essentially a non-existent technology in Bangladesh in part because few farmers or service providers own seed drills. This scenario is changing with the rapid progress made through CSISA-MI's efforts to commercialize scale-appropriate seeders for the two-wheel tractor – more than 900 seeders have been sold by private sector partners since October, 2015. CSISA is taking advantage of drills newly purchased in Jhenidah and Narail Districts to introduce DSR and to create a critical mass of first adopters for this technology.
- For the first time in South Asia, **wheat blast** emerged in Bangladesh as a critical challenge to crop productivity and food security, infecting over 15,000 hectares and reducing wheat production by 30% in the Feed the Future Zone. Blast is a devastating disease that may threatened the viability of Bangladesh's $180 m per year wheat crop as well as adjacent areas in India and Nepal that similarly experience relatively warm and wet winters. The CSISA team assisted GoB partners first identify blast in farmer's fields. With NARES partners, CSISA is now conducting a risk assessment based on historical climate data in order to understand the nature of the threat to wheat in Bangladesh under current and projected climate scenarios, and to identify risk-reducing planting date and varietal choices accordingly. These research outcomes will inform management recommendations for the 2016-17 wheat crop.
- At present, fertilizer subsidies account for approximately 6% of all Government of Bangladesh expenditures. CSISA's is forging a new alliance with partners in the Soil Resource Development Institute (SRDI) and Bangladesh Agricultural Research Institute (BARI) **to mainstream low-cost soil scanning technologies that will permit the creation of fine-scale digital soil maps to drive a new generation of precision nutrient management recommendations.**
- Northwest Bangladesh is the center of agricultural commercialization in the country, but outside the FtF zone. To enhance the **scale-appropriate mechanization** efforts of CSISA-MI at a national scale, it is essential to engage in the NW so that importers and dealers make money in the near-term. With our value chain partner IDE, CSISA has begun activities in the Dinajpur region to accelerate the commercialization of seeders and reapers for the two-wheel tractor.
- Most rice farmers in Bangladesh lose money on crop production if the value of household labor is taken into account. The one exception, however, are **premium quality rice** (PQR) producers who sell their crops to mills. CSISA is leveraging the momentum created by the mission-supported rice value chain project to increase the area and profitability of PQR in Bangladesh where economic incentives exist for intensification.

NEPAL

- In Nepal, Rupandehi and Nawalparasi Districts also fall outside the FtF zone of influence but are instrumental for strengthening the value chains for **scale-appropriate mechanization** at a national level. Working with public and private sector partners (including the CSISA-support NAMEA private sector trade group), we have facilitated linkages between District Agriculture Development Offices, local machinery suppliers, and 28 existing direct seeded rice (DSR) service providers who were supported by the project in Phase I to address machinery-related constraints to DSR, including availability of seed drills, spare parts, and advanced practical training on production practices. The unavailability of machinery spare parts has been identified by our stakeholders as a core constraint that impedes the spread of sustainable intensification technologies in Nepal and our private sector partners have agreed to aggressively resolve this weakness in the value chain with support from the DADOs.

- In Nepal, the nascent private sector engaged with agricultural inputs has often played a passive role in market development and looked exclusively to development partners to invest and to set strategy; this has reduced the effectiveness of development assistance by 'crowding out' rather than 'crowding in' private sector investment. By developing and sharing market intelligence, CSISA is playing a critical role in making the **private sector active players in market development**. Our research results demonstrate that adoption of hybrid maize can increase productivity by 50% with no other changes in management. By sharing these insights with NIMBUS (private sector input supplier) and ensuring that high-performing hybrids are officially registered in the FtF zone, NIMBUS used their own funds to implement 111 demonstrations of new maize hybrids and supplied more than 3 tons of seeds with discount pricing schemes through agro-dealers in the FtF zone with support from CSISA.
- The KISAN project is USAID's flagship FtF investment in Nepal. One of the systemic weaknesses of agricultural 'R for D' at the innovation systems level is the lack of coordination between development and research partners. CSISA has been working with KISAN to close this gap. As a result of this collaboration, the KISAN project has collaborated with CSISA and NARES partners to produce accessible guides for **better bet agronomy for rice and maize** – information that is generally not available to smallholders. KISAN has reproduced these guides with their own resources and they provide the back-bone of their technical training programs for maize and rice, the two core staple crop value chains for the project.
- Agricultural development projects often falter because they fail to identify pocket areas where farmers value intensification and are poised to adopt new technologies. This dynamic is particularly acute in areas where markets are weak such as the mid-hills region of Nepal. To capitalize on the recent emergence of feed and machinery value chains, CSISA has established a new office in Dang District where the **incentives for cereals intensification are strong.**

Bangladesh

INTRODUCTION

Phase III of CSISA began in December 2015. This phase builds on previous efforts convened by CSISA in Bangladesh (e.g., Phase I and II activities, the CSISA expansion project in Bangladesh (CSISA-BD), the Rice Value Chain project, and the CSISA-Mechanization and Irrigation project). In CSISA's third phase, the project aims to scale up CSISA's most promising technologies and crop management methods, including improved and stress tolerant rice, wheat, maize, and legume varieties, with emphasis on supporting market-led initiatives. CSISA Phase III will achieve its scaling goals only through working with partners. To this end, we have already developed active collaboration with ongoing USAID-supported scaling projects – especially those concerned with extension and inputs provision – as well as building on our strong history of government and private sector collaboration.

Several important changes should be noted in Phase III. First, development efforts focus primarily on Jessore, Faridpur, and Barisal hubs within the Feed the Future zone of influence. Mymensingh and Khulna hubs, were closed at the end of CSISA-BD. Phase III will however support limited and strategic investments in Dinajpur hub in northern Bangladesh, particularly because our private sector partners' interest in expanding sales of scale-appropriate seeding and reaping machinery in this maize and wheat dominated areas.

This report details the first six months of CSISA Phase III activities in Bangladesh, with emphasis on three thematic areas. These areas include (1) innovations towards impact, systematic change towards impact, and (3) achieving impact at scale. Despite several challenges in the initial months of Phase III, which included a project start date that prevented us from capturing the winter *rabi* wheat season and the advent of wheat blast disease, CSISA has used this time to critically evaluate progress achieved so far, and to focus remaining activities on high-impact, best bet interventions.

Above: In Phase III, CSISA will place substantial emphasis on adapting wheat to emerging climate change related risks, including combatting wheat blast disease.

Theme 1: Innovation towards impact

Sub-theme 1.1 – Reducing risk for sustainable intensification

Directly sown rice to address labor and energy constraints to precision rice establishment

In Bangladesh, the most common and popular method of rice crop establishment is transplanting rice seedlings into fields that have been repetitively tilled. This practice is cost and time intensive: in the Feed the Future (FtF) zone farmers generally spend more than US$ 100/ha for wet tillage land preparation and manual transplanting. Moreover, farmers often encounter constraints in sourcing enough agricultural laborers to transplant their fields in a timely manner. Manual transplanting also requires a considerable amount of water and energy in the form of tractor fuel, as fields are repetitively wet ploughed to prepare them for crop establishment. Direct dry sown rice (DSR), conversely, generally requires 1–2 passes only, and can also be practiced under zero-tillage, with considerable time, cost, and energy savings for farmers. The success of DSR however depends on good crop establishment and proper weed control, which are often difficult in the monsoon season due to unpredictable rainfall patterns. The availability of appropriate machinery for crop establishment also plays a vital role in the success of DSR.

Considering these factors, DSR is likely to be best suited to *aus* rice in the pre-monsoon season and in areas where good machines for sowing (power tiller operated seeders – PTOS) are becoming increasingly commercially available through the public-private linkages forged in the Cereal Systems Initiative for South Asia – Mechanization and Irrigation (CSISA-MI) project funded by USAID/Bangladesh. CSISA-MI has yet to strongly focus on use of machinery for rice direct seeding, and activities conducted though CSISA III will fill this gap, while also adding another season to which machinery service providers can work with farmer clients to generate income. For *aus* rice to be successful under direct seeding, farmers can reduce the number of irrigations compared to wet tillage preparation for transplanted rice, taking the number of tillage passes from 2–3 to a single pass during which seed is directly sown by machine. In response to mounting concerns over irrigation water availability in parts of Bangladesh, the Government has recently endorsed policy priorities to expand semi-rainfed *aus* rice cultivation in the pre-monsoon season, with emphasis on the FtF zone.

CSISA III has therefore targeted Jessore and Dinajpur hub for DSR *aus* rice in the pre-monsoon season where approximately 101,000 hectares of transplanted *aus* rice could be shifted into DSR, and where 400+ two-wheel tractor-based direct sowing machines are now in use by service providers and another 500 units now being imported to Bangladesh by company partner RFL as a result CSISA-MI's commercialization efforts.

Because CSISA III started in December 2015, the 2016 aus season was missed, although strategic plans for DSR for in the pre-monsoon season (*aus*) 2017 season are as follows:

- CSISA, in collaboration with the Bangladesh Rice Research Institute (BRRI) and Department of Agricultural Extension (DAE) will conduct machinery service provider trainings, including business training to improve the profitability of DSR enterprises. At least half (100) of the two-wheel tractor-based direct seeding machine service providers in the Jessore region will be trained.

- Spatial analytics for technology targeting given biophysical and market constraints and applied investigations into profitable business models that can be deployed in support of DSR will also be undertaken. Results will be shared in forums convened with BRRI, DAE, and machinery importers, traders, and dealers, to further discussions on how to support DSR expansion.
- CSISA will work with DAE, NGOs and machinery dealers to raise awareness of DSR technology and aggregate farmer demand for emerging service providers;
- CSISA will facilitate market linkages for herbicide dealers operating in areas in which DSR is expected to expand.

In Focus: *Direct seeded rice takes root in the Jhenidah and Narail*

Above: Dry Seeded Rice (DSR) production at Borobari, Jhenidah Sadar, Jhenidah

Above: Maturing DSR production at Tularampur, Narail Sadar, Narail

As the fourth largest rice producing and consuming country in the world, Bangladesh needs to find innovative ways to respond to the increasingly high cost of labor and energy that make transplanting of rice difficult for smallholder farmers. In the south western region of Jessore in the Bangladesh Feed the Future Zone, where the availability of mechanical seeders for direct seeding of dry season *rabi* crops like wheat and maize has increased with the commercialization efforts of CSISA-MI, CSISA Phase III has stepped in to train partner NGOs and farmers regarding direct seeded rice (DSR). DSR allows machinery service providers to expand the use of seeding equipment outside of the *rabi* season, by adding *aus* rice as an additional crop. By growing *aus* rice using DSR, farmers saved on seedbed, land and transplanting production costs. Line-sown DSR also made it easier for farmers to enter their fields to control weeds.

Farmers commented, "We never thought rice production is possible by this technique. We observed it and finally established by ourselves, we are very happy and wanted to increase our crop production by DSR methods Now, farmers also want to buy a power tiller operated seeder." More importantly, a group of 20 marginal farmers in Naril and Jhenidah districts have become ambassadors for DSR, encouraging other farmers and convincing Department of Agricultural Extension agents that DSR is a viable and profitable option for *aus* rice in the FtF zone.

Agronomic and variety recommendations to reduce the threat of wheat blast

Wheat farmers in Bangladesh's FtF zone encountered an unprecedented threat during the 2015–16 winter *rabi* season. For the first time in South Asia, wheat blast (*Magnaporthe oryzae*), a potentially devastating fungal disease was detected shortly after crop flowering. First sighted in Brazil in 1985, blast is widespread in South American wheat fields, affecting as much as 3 million hectares in the early 1990s and seriously limiting the potential for wheat cropping on the region's vast savannas. Blast reduces yield by shriveling grain and/or by leaving spikes empty. In Bangladesh, the disease appears to have spread because of contaminated seed being sown at high base temperatures with sudden rain events and associated wind patterns that favored spore distribution. During this season, the wheat crop in the FtF zone was reduced by approximately 30%. Blast affected farmers on 15,700 hectares, which is about 16% of Bangladesh's wheat area.

Above: *Wheat blast outbreak could cost farmers up to US$ 180 million per year in lost profits. To the left, an initial outbreak of blast. To the right, infection points on wheat spikes. To the left, a field completely devastated by blast.*

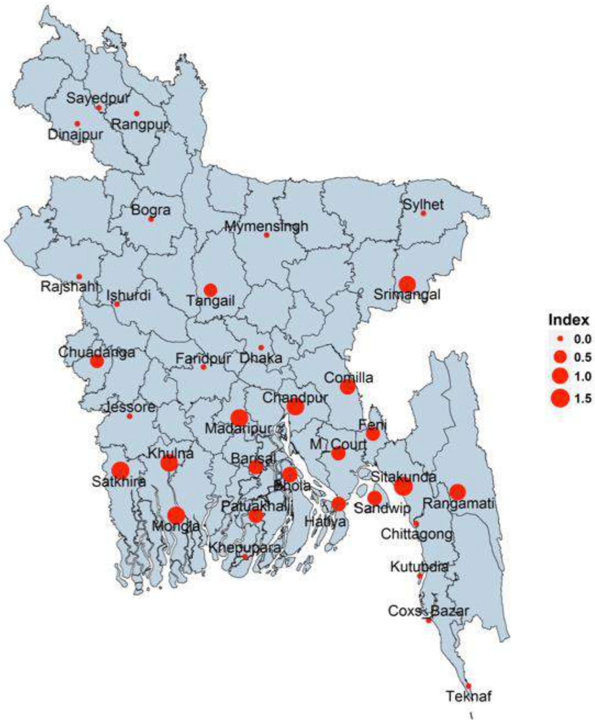
CSISA has been quick to respond to the outbreak of blast, by responding with the following actions:

- CSISA has conducted agro-climatological research to investigate the risk and probability of repeat blast infections, based on currently available and historical weather station data. While we initially estimate that all wheat within the CSISA FtF hubs are at risk, including in Dinajpur in the north, further research is underway in partnership with the Bangladesh Agricultural Research Institute, the Bangladesh University of Engineering Technology, and Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) University to investigate the risk probability of blast spreading. At current infection rates, spread of blast to other wheat producing areas could result in more than US$ 180 million in losses for wheat farmers per season in Bangladesh. Vulnerability analysis will inform policy and government actions in support of wheat farmers coping with blast. Based on results of this analysis, funding allocation and work stream structure will be revised to reflect the size and the importance of the emerging threat. An initial vulnerability analysis is underway (see box below), with completed work expected by the end of Q3 of 2016.

- Working with the Wheat Research Center (WRC) of the Bangladesh Agricultural Research Institute, diseased wheat plants were collected at the early onset of the disease to characterize and assure that blast outbreak had occurred. Samples were quickly sent to the USDA-ARS, Foreign Disease-Weed Science Research Unit laboratory in the US for characterization. *M. oryzae* was confirmed using morphobiometrical analysis, and strains were preserved by the Foreign Disease-Weed Science Research Unit permanent wheat blast strain collection. Confirmation of the disease was reported in the Journal *Plant Science*.
- CSISA is currently working with WRC to develop research plans to identify promising agronomic management techniques that can be easily deployed by wheat farmers to suppress blast. Activities will commence in the 2016–17 *rabi* wheat season, and will include (1) spatially explicit crop cuts in farmers' fields with associated surveys to better understand farmers' management practices and to quantitatively assess the impact of blast. Surveys will also involve seed health testing of representative seed samples collected from blast free areas to monitor the status of seed infection. (2) Trials examining genotype by environment by management effects on yield and blast infection with advanced lines expected to provide the best control against blast. (3) Trials validating the performance of seed treatments and fungicides. (4) Surveys of non-crop refugium (non-crop host grasses) outside of farmers' fields to assess options for management of non-*rabi* season blast refugia. These efforts are targeted to result in at least two scalable agronomic management interventions that can be implemented by farmers to suppress blast by the year 4 of Phase III. Recommendations will be endorsed by NARES partners, and will be deployed using social media campaigns in targeted at risk wheat cropping zones.

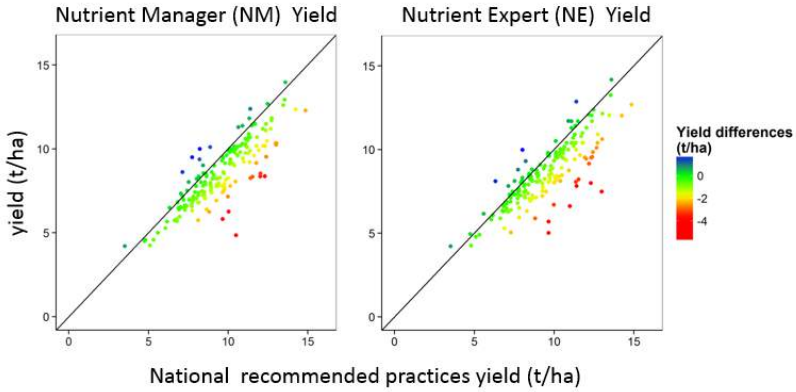
In Focus: *Assessing the probability of continued blast infection*

Wheat blast is a devastating fungal disease that resulted in an outbreak affecting over 15,000 hectares of wheat in the FtF zone in 2016. Collaborating with the Bangladesh University of Engineering Technology, CSISA has responded with applied research to investigate the potential threat for the spread of blast given available climactic data from the Bangladesh Meteorological Service. Outbreaks of diseases are a function of having a susceptible host (in this case wheat), the pathogen (which appears to have arisen from imports of infected wheat seed), and a conductive climactic environment. The exact weather conditions for blast are however poorly defined. In the FtF zone, symptoms of blast became evident in late February, which coincided with an El Niño period with higher than average minimum temperatures all over the country, and two unique spikes in rainfall in the south and west-central regions. Using climactic data from areas that were identified as having blast infection we built a simple model incorporating daily temperature and precipitation data and information on the pre-conditions for inoculum build up. This model results in an index for infection potential, ranging from 0-2 (with 2 indicating high probability). The results of this initial effort appear to indicate that the severity index can be used to predict the risk of blast outbreak for areas where wheat is grown. The model currently projects climactic conditions for the whole of Bangladesh, but we are in the process of thinning the model down to asses only common wheat producing areas in particular. The next steps in this analysis involve using the index to project the probability for occurrence using gridded data from global atmospheric circulation models and historical weather data, to assess how many times in the past 30+ years that conditions suitable for blast were encountered, and to project the threat of outbreak now that the inoculum is present. When completed, this analysis and accompanying decision support tool will enable the analysis of climate change scenarios to assess the risk of blast spreading in Bangladesh.



Above: Initial model results indicating locations in Bangladesh where blast infection might be most severe given 2016 climactic data. Severity is ranked 0-2, with 2 being severe infection. For areas where wheat was grown in 2016, the severity index appears to fit areas of severe blast infection reasonably well.

Building precision nutrient management approaches around established and emerging scaling pathways, adding value to emerging and existing soil fertility advisory services



***Above**: Comparisons of site specific nutrient management (SSNM) decision support tools in Bangladesh indicated mediocre yield advantages compared to existing recommendations for maize. This caused a 'rethink' of the SSNM framework, with new emphasis on improved soil analytical capacity for NARES partners, digital soil mapping, precision nutrient management guidelines that are likely to be more scalable.*

Innovative approaches based on a quantitative understanding of the relationship between nutrient uptake and yield, and the correspondence between nutrient supply and crop demand, are important in developing precision nutrient management approaches that emphasize site-specific nutrient management (SSNM). SSNM integrates field-specific decisions on N, P, and K based on indigenous nutrient supply (INS), recovery efficiencies of applied fertilizer, attainable yield and yield goals. Over time, the SSNM approach evolved into a simplified form to estimate fertilizer requirements based attainable yield and yield responses using omission plot techniques.

To integrate complex SSNM information into decision support systems, two recently developed tools, Nutrient Expert (NE) and Nutrient Manager (NM), have been used to provide location-specific fertilizer recommendations for cereals in South and South East Asia. In collaboration with IRRI and the International Plant Nutrition Institute, CIMMYT recently evaluated NE and NM tools (the latter collaboratively developed with the Bangladesh Agricultural Research Institute (BARI) maize scientists) for hybrid maize in 178 locations in Bangladesh. Although NE and NM increased yield relative to farmers' practices, only a few farmers obtained higher yields in NE and NM over the national recommendation rates. Field technicians also experienced difficulty in inputting data and deploying recommendations even to a limited number of farmers, indicating that larger problems may be experienced if scaling-up of the tool is considered. Compared to national recommendations, the lower yield from NE and NM was largely explained by the uncertainty associated with site characterization and low yield targets, as well as lower N, P and K recommendations calculated each tool based input from farmers and expert's opinions. Because maize is grown in an over a wide range of climates and soil and land types, many different agroecological niches characterize the maize growing regions. Spatial heterogeneity of indigenous soil fertility and maize yield response to nutrients was therefore expected.

While SSNM based decision support tools that focus on farmers' individual fields might be more logical from the standpoint of fine-tuning locally explicit recommendations, they are also likely to be difficult to scale up, especially when the large numbers of emerging maize farmers in the country are considered. Hence while SSNM is in theory a potentially sound agronomic innovation, although the sheer number of farmers in Bangladesh presents an important logistical constraint to scaling-up the use of SSNM practices; for this reason, broader and area-specific 'precision nutrient management' (PNM) recommendations may be more appropriate. Further efforts are also needed to better understand how and why farmers make decisions about investments in fertilizers, in order to judge how likely farmers are to adopt improved recommendation frameworks, especially in more risk-prone production environments, or where input and output markets are well developed.

This intervention focuses on innovation towards impact in nutrient management recommendations in Bangladesh. Investigation is needed to analyze if and how such PNM approaches may encounter trade-offs in recommendation quality and the resulting yields attained when moving to somewhat broader and potentially feasible scales for recommendations, as opposed to individual fields, as these coarser approaches may be more cost effective in terms of extension. To develop precise nutrient management strategies for maize that consider these issues of scale, feasibility, and potential for farmer adoption, a spatial database of farmers' crop management practices, decision making structure with respect to nutrient application, attainable yield, growing environment, soil characteristics, and INS needs to be developed.

Field activities were hampered by the start date of CSISA III, in December of 2016. The winter *rabi* season during which such investigations and extension work would be required commences in November, with the majority of farmers already having established crops and applying fertilizers and manures at that time. As a result, activities have focused on developing work plans and experimental protocols for the following 2016–17 winter season, with simultaneous efforts to engage national partners in precision nutrient management. These activities include:

- Completed agreements with the BARI to conduct experiments **in** 180 farmers' field in Chuadanga and Dinajpur Districts to map indigenous nutrient supply capacity of macronutrients for rice-maize systems. Under this study, innovative digital soil mapping technology using modern spectroscopy instrumentation in combination with available remote sensing data, farmers' yield and management information will be used for developing a spatial decision support system for PNM.
- Discussions have been held with the leadership of the Soil Resources Development Institute to establish spectral laboratory instrumentation and transfer knowledge of use of spectral methods for soils analytics to laboratory technicians. CSISA III will establish equipment during the second half of 2016 and to train their scientists to increase capacity and speed of soil sample processing.

Theme 2: Systemic change towards impact

Sub-theme 2.2 - Partnerships with the NARES to bring participatory science and technology evaluations to the landscape and back again

Increasing the capacity of NARES to conduct participatory science and technology evaluations

CSISA's NARES partners in Bangladesh consistently request CGIAR institutes to provide educational and training services to increase technical capacity, particularly with respect to on-farm and participatory research, application of advanced methods, and extension techniques. DAE, for example, focuses on front-line demonstrations, while BRRI and BARI tend to focus on on-station and research-controlled experimental work. Demonstrations could be utilized to collect spatially explicit data on technology performance under farmer management, or farmers' preferences for particular technologies and crop management practices to provide actionable information to decision makers working to align agricultural investment priorities.

The on-farm research wings of both BARI and BRRI conversely have a mandate for replicated on-farm agronomic trials, although in practice, initiatives often result in a low level of farmer involvement (often by re-creating research station conditions in an on-farm setting). Technology evaluations also tend to focus on yield and partial budget analyses alone, without more informative multi-criteria analyses that address sustainable intensification objectives and indicators (e.g., labor demand, energy consumption, environmental footprint assessment, sustainability). DAE and Bangladesh Statistical Service (BSS) also participate in seasonal crop-cut yield assessments and collect data from thousands of farmers throughout the country. These efforts could benefit by improving the spatial integrity of their sampling frames, and to combine crop-cut information with diagnostics for best-bet management practices that improve production efficiency that can be broadly implemented by farmers. Each of these partners are also expected to benefit from improved knowledge of more advanced multivariate and spatially oriented data collection and analysis, as well as methods to assess farmers' decision making processes in technology selection and application, which can in turn help to guide further intervention efforts.

In the early months of Phase III, the following activities have been implemented:

- Efforts are underway to provide targeted proof of concept that advanced scientific methods can be mainstreamed into NARES partners by boosting the capacity of all on-farm research-mandated scientists in BRRI and BARI with ten lead scientists trained and who will begin using new methods in the NARES programs under their leadership. CIMMYT maintains an MOU and 40-year relationship with the Bangladesh Agriculture Research Institute (BARI). CSISA scientists have participated in national research planning and review meetings, and have introduced this concept, with the On Farm Research Division, the Farm Machineries and Post Harvest Engineering Division, and the Wheat Research Center wings of BARI. Selection of scientists for the above mentioned training efforts is under way, with initial mentoring commencing in the *rabi* season of 2016–17.

- Discussions are under way with the FAO and the Bill and Melinda Gates Foundation funded Agricultural Market Information System (AMIS) project, as well as with the DAE, to develop pilot project surveys cataloging farmers' crop management practices and decision making criteria (with respect to crop management and investment decisions) in a targeted sub-set the farmer upon which DAE conducts crop-cut yield monitoring in the FtF zone.
- CIMMYT's long-standing relationship with BARI will be changing with the formation in the coming year of the Bangladesh Wheat Maize Research Institute (BWMRI), which will become CIMMYT's primary GOB partner in Bangladesh, although strong working relationships with BARI will be maintained. We have consequently been in discussions on CSISA with the presumptive DG and others of the new institute, and once it is formed they will become a major CSISA III partner, with core support for training machinery service providers in Dinajpur and wheat blast monitoring activities in the FtF zone.
- In order to boost the project's strategic partnership with GoB partners, CSISA III has engaged Dr. Sattar Mondal as a partnership consultant. Dr. Mondal is one of Bangladesh's most eminent economists, a former Vice-Chancellor of the Bangladesh Agriculture University and the former Member of the Bangladesh Planning Commission responsible for agriculture and water planning. In addition to his work with CSISA III he is a senior advisor to FAO. In addition, he has recently been appointed to the 3-person expert's committee of the Minister of Agriculture. Dr. Mondal is assisting CSISA to better understand the directions of the Government of Bangladesh and offers CSISA an opportunity to insert information from technical expertise expert opinions influence those deliberations by the Minister and other senior staff of the Ministry of Agriculture.

Sub-theme 2.1 – Unconventional partnerships for inclusive growth around potential commercial pockets, neglected niches

Rice-fallows development in coastal Bangladesh

Food requirements in South Asia are projected to increase for at least four decades before they plateau, with at least a doubling of staple crop production required by 2050. Average wheat, maize and rice yields have however increased by only 2.2 percent, 1.4 percent and 1.3 percent, respectively, since the 1960s. Rather than raising yield, crop production can be increased by expanding cultivated land area, though this has undesirable environmental outcomes such as biodiversity loss. The potential for agricultural expansion in South Asia is also limited because most arable land is cropped for at least part of the year, usually during the monsoon. Farm area per capita in South Asia has also shrunk by 63 percent since 1961, to approximately 0.1 hectare per person.

Above: farmers in Barisal benefit by using efficient pumping machinery to irrigate formerly fallow land.

Sustainable intensification has been proposed as an alternative to area expansion. It aims to augment land productivity by increasing resource use efficiency while minimizing environmental trade-offs An important sustainable intensification strategy is increasing the number of crops grown per year on the same land, thereby raising yield per unit of area-time, while minimizing land expansion. Achieving such 'double cropping' will often require irrigated dry season cropping to overcome moisture constraints to adequate yields.

The Government of Bangladesh, which recently adopted policy calling for investment of over US$ 7 billion to support agricultural development in southern Bangladesh. Of the funds requested by the GoB, US$ 500 million is to be allocated for surface water irrigation to transition farmers from monsoon rice–fallow or rain fed systems into double cropping. Further emphasis is placed on increasing dry *boro* season rice production, to offset increasing production and energy subsidy costs in existing boro areas reliant on groundwater. Precise geospatial assessments of where freshwater flows are most prominent, or where viable fallow or low-production intensity cropland is most common, however, remain lacking. CSISA made use of remotely sensed data to identify agricultural land, detect the temporal availability of freshwater in rivers and canals, and assess crop production intensity over a three-year study period in the 33,750 km^2 FtF zone in southwestern Bangladesh.

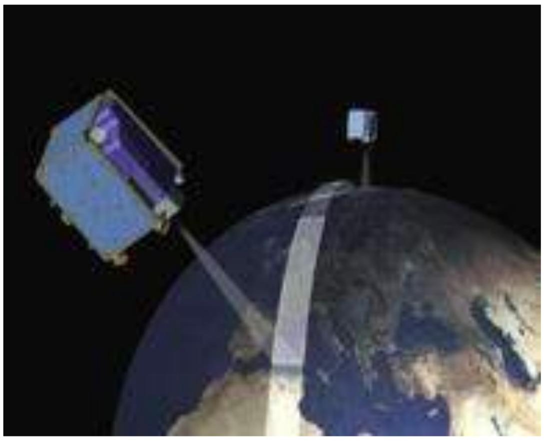
Out of 1.93 million hectares of agricultural land in the FtF zone, 12 and 45 percent, respectively, were identified as fallowed or under low-production intensity rain fed crops during the *rabi* season. 47,066 and 132,470 hectares were identified as fallow and rainfed low-production intensity cropped land, respectively. The largest concentration of fallow land that could be brought under surface water irrigation was located in central southeastern half of the FtF zone.

We also analyzed the aggregate production potential of wheat, maize and *boro* rice were they to be established on the combined fallow and low-production intensity cropland identified as suitable for conversion to cropping using surface water irrigation, by applying scenario analysis using observations from the inter-quartile range of yield data from the observed probability distributions from 510 irrigated wheat, 550 irrigated maize, and 553 irrigated *boro* rice farmers in the FtF zone were measured over the three study seasons. Based on these distributions, the yield data used are reliable at levels equivalent to P = 0.25, P = 0.50 and P = 0.75. The resulting data was applied to one-quarter, one-half and three-quarters of the observed fallow and low-intensity cropland within buffer areas, in order to leave land remaining area for alternative uses.

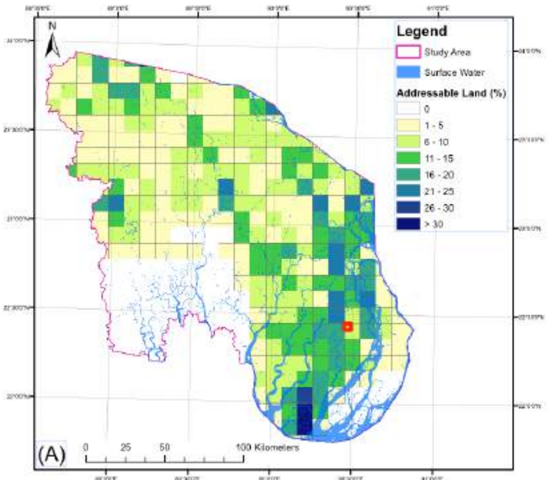
***Above**: Strategic and targeted use of surface water for irrigation holds considerable potential for boosting cropping intensity, with estimated annual profits to farmers of up to $100 million per year.*

Considering the more conservative 75th probability level for yield, the estimated aggregate production potential for maize ranged from 166,659 – 499,976 tons within one season, assuming the crop were planted on one- to three-quarters of the land area suitable for surface water irrigation. Were the same areas established with wheat at the same probability level, an estimated 85,671 – 257,012 tons could be produced, while the range of production for boro was 167,659 – 502,977 tons. The least conservative estimate used data from the 25th probability level, resulting in an estimated range of 237,729 – 713,188 tons of maize, 101,648 – 304,994 tons of wheat or 198,126 – 595,381 tons of *boro* rice from one- to three-quarters of the buffered land area, respectively. Modeling the potential economic consequences of surface water irrigation, our data indicates that farmers could generate US$ 9.07 – US$ 108.2 million (at P = 0.25), using one- to three-quarters of the buffered land, depending on the crop chosen, with the order of profitability ranges following maize > wheat > *boro* rice at all probabilities.

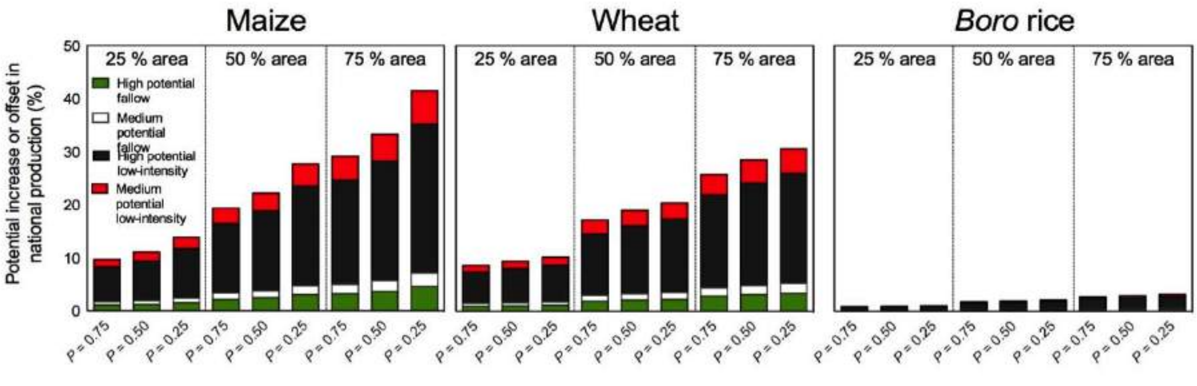
We next modeled the potential contribution of each crop grown using surface water irrigation to national cereals aggregate production in Bangladesh. Although 167,659 – 594,381 million tons more *boro* rice could be produced on the land suitable for surface water irrigation in the FtF zone, the potential contribution to national production is unlikely to exceed 3.2 percent unless yield gaps are diminished. Cultivation of maize on one- to three-quarters of the area identified as suitable for surface water irrigation would conversely contribute between 10 – 29 percent more maize nationally at the 75th probability



Above: *CSISA research teams used Landsat satellite imagery and remote sensing, alongside historical hydrological data and crop cuts to quantify the potential for surface water irrigation and sustainable intensification in Bangladesh's FtF zone.*



Above: *Agricultural land suitable for surface water irrigation expressed as percentage of total cropland area in 100 km^2 imposed grids. Low- and marginal-potential lands were excluded.*



Above: *Modeled results describing the potential contribution of surface water irrigated boro rice, wheat, and maize to national aggregate production in Bangladesh. Data depict three high and medium suitability land coverage scenarios, including projections using one-quarter, one-half, and three-quarters of all fallow and low-intensity cropland identified within riparian buffers. Probability values indicate the probability of contribution from surface water irrigated cereals at the probability (P) of 0.25, 0.50, and 0.75 derived from farmer observations used to construct probability distributions.*

level, or 14 – 42 percent at P = 0.25. Between 9 – 26 percent more wheat could be produced from the same area at P = 0.75, or 10 – 31 percent at P = 0.25.

These results indicate substantial scope for surface water irrigation to intensify cropping, even in the face of soil and water salinity constraints, although the potential for *boro* production appears to be more limited than anticipated. Dry season cultivation of wheat or maize cropping, however, appears to result in significant production increases, with important implications for national food security. These crops also address income generation constraints while minimizing water pumping and withdrawals and hence, environmental risks. These results should however be interpreted cautiously, as studies into alternative crop and land use options and best-bet policy mechanisms to align risk reduction, finance provision and market access for farmers will be needed, alongside improved water governance measures. Further studies to model crop productivity, salinity and land availability are also needed in consideration of climate change scenarios. Emerging risks such as wheat blast disease, which appeared in 2016, must also be considered in future simulations.

Building this work, in Phase III CSISA will assess how to most effectively create an enabling environment for intensification, and to sequence development interventions to enable farmers to increase cropping intensity. Issues of free animal grazing, credit and financial services, output markets, seasonality of labor availability, and the opportunity costs associated with fallows cultivation are important issues to be addressed alongside water resources development, mechanization, and cropping systems design. Farmers' preferences for and understanding of potential interventions to support the expansion of irrigation are also being researched.

In Phase III, CSISA will work in a convening role with NARES, government and private sector partners, and key livelihoods and market development oriented NGOs (e.g., the EUR 35 million Blue Gold project in Bangladesh) to create an enabling environment for both surface water irrigation and rainfed legume crop intensification, with explicit work to address the factors that condition farmers' decision processes with respect to the adoption of new crop management practices. Working with these partners, CSISA will facilitate stakeholder engagements to identify and facilitate a logical sequence of market and policy interventions to support an enabling environment for intensification in these neglected environments of the FtF zone. Issues of free animal grazing, insufficient or high-interest credit, weak output markets, seasonality of labor availability, and the opportunity costs associated with fallows cultivation will be being considered in tandem with technical innovations in water resources development, drainage, mechanization, and cropping systems design.

In the second half of 2016, the following actions have been planned to convene governmental and private sector partners to align and create an enabling environment for intensification in the fallow and rainfed areas of the FtF zone indicated as high- and medium-potential by our analysis. The following activities will be undertaken with accompanying results achieved:

- In order to combine the above-described biophysical assessment for the potential of crop productivity, participatory experiments will be completed at the community and household level identify the perceptions and decision processes around fallows intensification across resource and socio-economic gradients (farm 'types') in the FtF zone.

- Convening of national stakeholders in policy workshops to discuss the most logical sequence for sequence development interventions to enable farmers to increase cropping intensity. Discussions are underway with the FAO to co-sponsor such an event and to assist in consequent policy formulation.
- Low-to-medium risk pathways will be identified for fallows development and intensification and associated convening and catalytic roles will be further defined for CSISA.

Deployment of better-bet agronomic messaging through private sector partners and dealer networks

Both NGOs and Bangladesh's Department of Agricultural Extension faces difficulties in reaching all farmers – estimated at approximately 25 million – within the FtF zone. Farmers therefore obtain most crop management advice from neighbors, family members, and also through agricultural inputs dealers. Dealers in particular outnumber extension agents and NGO staff considerably. Where input dealers however give imprecise or biased information in order to sell products, there is a risk of moral hazard that can result in farmers paying more for products that work less efficiently, or in worst case scenarios, are also environmentally damaging and risky to human and animal health. Conversely, the sheer number of dealers in the FtF zone also presents considerable opportunities to intervene, correct these practices, and to use dealers as information points for expanding farmers' awareness of improved crop management practices and technologies.

This intervention there leverages partnerships with other USAID projects and partners operational in the FtF zone to sensitize dealers on the efficient use of inputs and associated agronomic management practices, while avoiding the risks of moral hazard posed by prescriptions for excessive and environmentally unsound input use. In addition, this extension oriented intervention will increase DAE and government department use of CSISA generated training modules and informational materials, providing for other opportunities for spreading and scaling-out farmers' knowledge of CSISA supported crop management practices, varieties, and technologies.

Initial headway into this work stream has been made in the first six months of Phase III. Highlights include:

- By partnering with the USAID/Bangladesh Agricultural Extension Support Activity, CSISA generated extension materials (including farmer guides to improved maize and wheat production, intercropping, and weed management) have been placed on the Government of Bangladesh's Agriculture Information Service (AIS) website for free download. AIS is the governmental body responsible for producing extension media that is used by the Department of Agricultural Extension. By posting the materials on the AIS website, CSISA has gained government endorsement has enabled us to further discussions with the Director General of DAE who has requested the project to develop detailed dissemination plans and to present ideas on how CSISA materials can be more widely used by DAE field officers. Further discussions to leverage these partnerships are now underway.

- CSISA has also entered into partnership with the Agricultural Input Retailer Network (AIRN), which is convened and supported by the USAID/Bangladesh funded Agricultural Inputs Project (AIN), led by CNFA. AIN has agreed to disseminate CSISA extension materials through the AIRN, which is comprised of close to 3,000 dealers in the FtF zone. Materials on safe use of herbicides, PQR rice varieties, and other informational leaflets will be made available through dealer networks. Alongside the distribution of materials, AIRN dealers will be trained in the use of scale appropriate machinery and the principles of integrated weed management using standardized training materials (see training and outreach materials). CSISA is now working to train AIP staff so they are capable of using these materials to train dealers at a large scale.
- CSISA Phase III's strategic linkage with AIP and AIN is already proving successful. Day-long intensive trainings conducted in the Jessore and Faridpur regions have resulted in over 100 dealers who now have improved knowledge of innovative and efficient crop management techniques and scale-appropriate agricultural machinery. Through AIP, CSISA is also working to follow up on trained dealers to assist in remaining knowledge gaps and to with technical backstopping.
- CSISA is also in the process of forging collaborative agreements with Bangladesh's Title II Development Food Aid Programs (DFAPs), which aim to improve capacity in the agricultural and governmental sectors, while also improving nutrition and maternal and child healthy. Advanced discussions are underway with World Vision and Winrock International (WI), which leads the agricultural activities within World Vision's Nobo Jatra DFAP. The agricultural components led by WI are intended to reduce food insecurity and vulnerability for 856,116 direct households in 42 Unions in four Upazilas, Shyamanagar, Kaliganj under Satkhira District and Koyra and Dacope under Khulna District, the Southwestern Coastal area of Bangladesh. We expect to be able to leverage WI's collaboration to distribute extension materials to these households, while also working to provide training of WI's trainers in agricultural mechanization, healthy rice seedlings, and opportunities in income generation through premium quality rice.

Healthy rice seedlings for higher yields

***Above**: Use of healthy rice seedlings are a simple agronomic method to boost yields.*

Transplanted rice covers more than 80% of Bangladesh's total rice area. Although transplanting is so common, many Bangladeshi rice farmers are knowledge, labor, or resource constrained and do not follow optimal nursery management. Nurseries are a critical but often forgotten aspect of the agronomic production cycle. How a crop is treated in its early stages has an important influence on later performance and yield. Practices such as optimum seeding density, balanced nutrient supply, proper seedling age (the planting of 20–25 days old healthy seedlings can increase yield by 0.25–1.0 t/ha compared to 45-day old seedlings, where fields are not excessively flooded), careful handling, and rapid transplanting can help mitigate some of these problems.

A variety of better-bet nursery management options are however available, for example including seed treatment before sowing (to reduce the potential for diseases), optimum sowing dates for different cultivars in different environments, correct seed densities, balanced use of organic and inorganic nutrients, and optimum transplanting age and density. The latter is particularly important for avoiding transplanting shock, which in addition to causing yield losses can also result in delayed crop maturity and later harvests, which in the case of monsoon *aman* rice can set back sowing of the subsequent dry season *rabi* crop, further reducing yields and exposing crops to increased risk pre-monsoon storm damage. If just 5% of target niche areas (20,000 ha) for this knowledge-based intervention were planted to healthier rice seedlings by the completion of Phase III in Bangladesh, additional production of at least 50,000 tons paddy per year, which has economic value of US$ 12.4 million, is possible.

Improving aman nursery management is however difficult in Bangladesh, especially when monsoon rains come late or are intermittent, which also delays the transfer of seedlings from nurseries and transplant them into the fields. Abiotic stresses such as cold, drought, flood, and salinity also frequently damage seedlings and result in poor seedling growth and seedling mortality, leading to the use of unhealthy and old age seedlings. We estimate that up to 500,000 tons of paddy per year are lost due to poor transplanting practices in CSISA's FtF working areas.

Unfortunately, the late transfer of funds to Phase III in December of 2015 meant that we were unable to roll out significant activities in the dry *boro* rice season (as seedbeds are established in November–December). Activities in the half have therefore focused on strategic planning and partnership development to position the project for scaling-out the use of improved nursery practices in the 2016 *aman* season. Efforts are now focusing production and use of healthy rice seedlings in the Faridpur, Jessore, and Barisal regions focusing on two approaches: (i) production and use of healthy rice seedlings through better nursery management practices and (ii) by assessing the potential to promote rice nursery enterprises to ensure large-scale production and supply of healthy seedlings alongside income generation through rural enterprise creation. Initial agreements have been reached with Department of Agricultural Extension (DAE) field agents, local NGOs, other development partner, to create large-scale awareness and adoption among farmers.


***Left:** A poorly managed nursery with overly dense planting and unbalanced nutrient management, evident from yellowed leaves.* ***Right:** well managed seedbeds.*

At the same time, studies of the potential for rice seedling nursery enterprises are under implementation, the results of which will be used to develop further workplans and target promotional activities during the *dry* boro season of 2017. The nursery enterprise is a novel concept with limited awareness among farmers, DAE, NGOs, the private sectors, and the development partners. Initial efforts will focusing on creating demand for the provision of quality nursery services for high-potential regions, with emphasis on submergence tolerant varietal nursery enterprises in flood prone regions. This will allow nursery entrepreneurs to grow and younger seedlings with less risk of transplant shock, and reduced risk of inundated related losses.

An initial survey of a few rice nursery entrepreneurs in Rajbari District was under taken to get a better sense of their nursery management practices and business model. Initial entrepreneurial efforts are already evident among farmers, indicating potential to scale up what is an emerging and indigenous practice. Nursery entrepreneurs however showed a low level of knowledge regarding improved nursery management practices. Scope therefore appears to exist to expand nursery enterprise businesses and to improve quality of seedlings being sold by adopting improved management practices, especially where these messages are deployed at a large scale by development partners and livelihood initiatives (e.g., the DFAPs), and through inking entrepreneurs to markets (see associated premium quality rice activity). The observed a rice nursery entrepreneurs currently supplies seedlings to farmers at distances up to 80 km, caters the need of 50–100 farmers per season, and earns an income of up to US$ 640 per year. By establishing new entrepreneurs and linking them to dealers of new and improved varieties, backing them with training and awareness raising through development partners, we anticipate that incomes of both farmers and entrepreneurs can be increased.

During the *aman* season of 2016, CSISA will focus on (i) producing healthy rice seedlings guidelines (leaflets and farmer-to-farmer videos) and distributing them to farmers through partners with an emphasis on the USAID Mission funded Agricultural Inputs Project, which has established a network of 3,000 dealers in the FtF zone, (ii) ToTs on healthy rice seedlings for strategic development partners, and (iii) business diagnostics and partner consultations to determine the feasibility of creating small and medium rice nursery enterprises at scale. CSISA aims the following outcomes through activities during the Aman season 2016 (which commences in July):

- Media (printed and social) on healthy rice seedlings developed for remaining years of the project. At least 10,000 gender-sensitive leaflets will be distributed through development partners and input dealers. A social media campaign using village video showings will boost farmers' demand for, and use of healthy seedling practices in the subsequent *boro* season.
- Farmers will use healthy rice seedlings in 500 hectares, with at least another 1,500 added in the *boro* season.
- NGO partnerships will be formally established, with agreements to see healthy rice seedling materials circulated to farmers on predominantly an in-kind.
- At least 45 NGO trainers and 100 DAE agents will be trained to supply direct farmer training at increasing scale in healthy rice seedling principals.

A thorough business case study of healthy rice seedling enterprises will be completed. Where enterprises indicate promise, a scalable business model will be developed by working with government organizations (e.g. BRRI and DAE), development partners (e.g. ACDI-VOCA and NGOs such as Winrock and Dhaka Ahsania Mission (DAM)), private organizations (e.g., Syngenta and Lal Teer), seed producers, local service providers, and farmer self-help groups. Nursery enterprise models for quality rice seedlings will be popularized through livelihood-oriented development organizations and e-agriculture.

High-value, premium quality rice in expansion Bangladesh

Low and volatile prices and low profit are critical problems faced by Bangladeshi rice farmers. Building on research and development activities in the now closed CSISA-Bangladesh project, and USAID/Bangladesh funded Rice Value Chain project, production of premium quality rice (PQR) has been demonstrated to be a viable solution to increase profit from rice cultivation in the FtF zone. Bangladesh rice farmers currently grow more than 70 PQR varieties, which are characterized by long, slender and fine grain; with or without aroma; and higher price than popular rice varieties. These varieties have a 20–60% price advantage and 50% higher profit over popular rice varieties, indicating their potential for expansion. The total demand for PQR is growing at 5% per year because of rising per capita income leading to increased consumption of PQR, urbanization, growth of modern food supply chains (supermarkets), and growing investment of private companies in the rice value chains. In addition, farmer awareness, access to improved technologies, improved milling systems, and market access for premium rice has greatly improved. This provides great potential to increase production of PQR in FtF Zone and improve rural livelihoods in the zone.

In the whole of Bangladesh, PQR accounts for one-third of the total rice area, but in the CSISA Hubs of the FtF Zone, PQR accounts for only 10% of the rice area, with just 15 PQR varieties grown. The low coverage of PQR in CSISA Hubs is partly because of farmers' lack of awareness about available PQR varieties, available new stress tolerant varieties with grain quality similar to existing PQR varieties, and higher profit from PQR, in addition to the unsuitability of many varieties to saline and overly flooded field conditions. Out of the 15 PQR varieties grown in CSISA III's working locations, five are improved varieties with average yield of 3.0 t/ha in the *aman* season, which is about 30% lower yield than popular high yielding varieties. Profits, however, are considerably higher. Not can only better crop management practices increase yield of existing PQR, but several anticipated PQR varieties such as BINA 12 are also likely to have higher yield potential and abiotic stress tolerance traits to help withstand flooding, drought, and salinity. This provides great opportunities to increase area and yield of PQR, which in turn can lead to improved rural livelihoods in the FtF Zone.

***Above**: Excellent PQR performance in Jessore.*

***Above:** Preliminary market studies indicated considerable potential for new PQR varieties.*

In Jessore District, CSISA has conducted two planning studies in RVC villages where farmers are growing PQR. This was contrasted with a village where farmers are not growing PQR to understand the potential of area expansion and yield improvement of PQR varieties. In addition, we interviewed millers and traders to understand the market size and future market potential of PQR. In 2015 *aman* season, PQR variety (BRRI Dhan3 4) had an average yield of 3.3 t/ha and fetched the farm-gate price of US$ 0.35/kg, resulting in gross return of over US$ 1,150 ha. After deducting production cost of US$ 705/ha, farmers earned a net profit of US$ 474 ha from PQR cultivation. On the other hand, farmers growing popular non-PQR variety (Swarna) obtained an average yield of 4.2 t/ha that fetched the farm-gate price of US$ 23/kg, resulting in gross return of US$ 974/ha. After deducting production cost of US$ 879ha, they earned a net profit of only $76/ha from non-PQR cultivation. This underscores the potential driver for scaling up PQR.

Above: The long-grain and high-value PQR rice variety BRRI Dhan 50

More than 4,100 rice mills are operating in the CSISA working regions. Of these, 95% are husking mills, 3% are semi-automatic mills, and 2% are automatic mills. The number of husking mills is decreasing, while the number of automatic mills is increasing. The average per hour milling capacity is 0.5 ton for husking mills, 2.0 ton for semi-automatic mills, and 5.0 ton for automatic mills. Most mills operate in full capacity for about six months, but they are underutilized for the rest six months in a year due to lower supply of rice in the lean period. Rice traders and millers indicated that the demand for PQR is growing quickly and they are ready to be linked to farmers selling these varieties, especially as there is a substantial gap in supply. Millers also showed interest to visit PQR field sites where new varieties are being tested.

In Phase III, CSISA is the process of cementing its catalytic role to increase the production of PQR in Faridpur, Jessore, and Barisal. Collaborative plans are being built with the DAE, local NGOs, other development partners, the private companies, agro-input retailers, seed dealers, and farmer groups to improve farmers' knowledge and skills on PQR production, to increase the availability of PQR seeds, to increase area of PQR, and to link PQR farmers with upstream value chain actors such as traders and millers. Because of the late start of CSISA III (in December of 2016 when seedbeds for *boro* season rice were already established). As such, efforts are focusing on *aman* 2016 to (i) increase knowledge of best management practices for PQR consolidated into training modules and extension materials, (ii) field trials to verify technical and economic performance of different management options for new PRQ varieties, (iii) key informant studies to identify adoption constraints and investment priorities among PQR farmers, and (iv) location intelligence identifies areas for PQR area expansion and the information are shared with millers, traders, and seed companies.

Through partners, CSISA will implement the following activities in are now being initiated in the *aman* season 2016 to increase area and yield of PQR, and to strengthen production capacity of PQR farmers.

- Production and dissemination of 5,000 leaflets about BMP guides on PQR through DAE and development partner NGOs.
- Establishment of partnerships with NGOs and support in terms of seed production and technical backstopping to spread PQR through NGO groups.
- Training of at least 300 Sub Assistant Agricultural Officers (SAAOs) of DAE on better agronomic practices and marketing of PQR.
- Production of one 5-10 minutes video on BMPs for PQR in *boro*, which will be used for social media campaigns to promote PQR in the following seasons. Traveling video road-

shows will be used to reach at least 20,000 farmers with messaging on the economic advantages of PQR.
- Roundtable discussions with concerned stakeholders will be organized to determine seed demand for 2017 Aman season and provide this information to seed producers and traders for their planning.
- In collaboration with BRRI, CSISA is now establishing 24 on-farm trails of new PQR varieties to identify best varieties in terms of yield and liking by millers and consumers. We will also organize field days for traders, millers, farmers, DAE officials, and NGO officials to sensitize them on new PQR varieties.
- Organize roundtable discussion and key informants surveys with millers and traders to estimate the total demand for PQR.

The following major outcomes are expected with aforementioned activities:
- Productivity/profitability gain in Aman and ability to claim area expansion and production increase under better-bet PQR, with 5,000 tons of new PQR produced and traded to millers by farmers in the FtF zone by the end of *boro* season in 2017.
- NGO partner staff and input dealers trained (45 and 100, respectively on how to advise farmers on BMP for PQR, and marketing of PRQ.
- Through on-farm, farmer-managed trials, new high yielding PQR varieties identified for the next year of promotion with expanded farmer, trader, and miller awareness of new varieties and economic data generated to help promotional efforts.

Theme 3: Achieving impact at scale

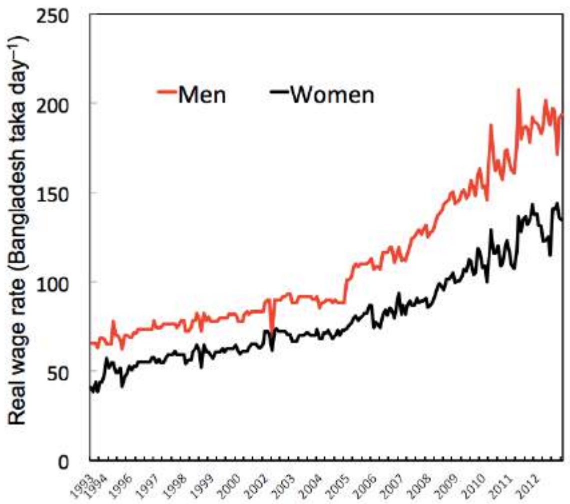
Sub-theme 3.1 - Growing the input and service economy for sustainable intensification technology

Integrated weed management

Labor is becoming increasingly scarce and costly in entire South Asia in general and in Bangladesh in particular. This increase in labor cost and scarcity is negatively affecting the effectiveness and cost of weed control in rice as weed management in rice is primarily by manual weeding in the region. Because of rising labor scarcity and non-availability at critical times, hand weeding is generally delayed and is insufficient, exacerbating yield losses and weed control costs.

Rice farmers in FtF zone generally spend about USD 115–140/ha for weed control in aman-season rice. Research studies conducted in Bangladesh showed that weeds reduce rice grain yield by 68–100% in direct seeded aus rice, 14–48% and 22–36% in transplanted T. aman and dry season Boro rice, respectively. On an average, the rice yield gap in farmers' fields due to poor weed control was estimated as high as 1 t/ha. Using conservative estimates, such losses result in profitability losses of at least US$ 800 million per year. Moreover, weed control is major biological constraints in wider scale adoption of sustainable intensification technologies such as direct-seeded rice (DSR), an increasingly important alternate rice establishment method to address labor constraints and rising cost of cultivation.

Based on CSISA II work in India, integration of new classes of safe and effective herbicides with other cultural practices complimented by hand and mechanical weeding, can reduce both weed control cost and yield losses by achieving timeliness of weed control and reducing dependence on labor. Additional weed control benefits can be achieved through cultural control methods involving novel tillage practices, and use of weed competitive rice genotypes. Use of herbicides, however, is beginning to spread in Bangladesh. Farmers nonetheless generally lack knowledge on selection of right product, their time of application and doses, and safe handling and proper application technologies. Moreover, many new, more environmentally safer and effective herbicide products are not available in the market because of poor market development in FtF zone. Therefore, where herbicides are necessary in addition to cultural weed control options, efforts are urgently needed to get the right products into the right production environments, where particular weed species pose the most consistent threat, and where effective and less environmentally damaging chemicals can benefit integrated weed management for rice.



Above: Rapidly increasing rural wage labor rates generate economic growth but also squeeze smallholder farmers, making it difficult for them to afford hired labor for manual hand weeding.

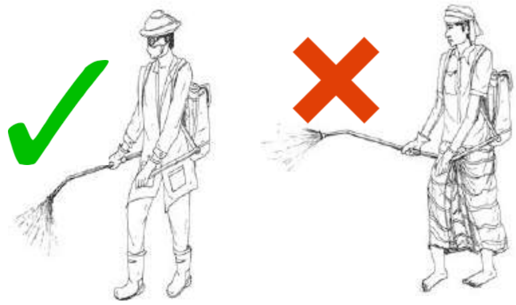
To address these challenges, CSISA III has planned activities to address above-mentioned issues and to improve weed control and reduce weed control cost in rice by developing and deploying effective integrated weed management options. Integrated weed management activities for *Boro* rice were unable to proceed due to the late fund transfer and commencement of CSISA Phase III after the start of the winter season in Bangladesh. Activities are however currently under way for the monsoon *aman* rice season of 2016, with the following activities currently being implemented:

- Development and dissemination of simple and actionable 1-page integrated weed management guides: 6,000 leaflets are being printed. These guides are being distributed through input dealer's network of the USAID/Bangladesh funded Agricultural Inputs Project, the Department of Agricultural Extension, the USAID/Bangladesh Rice Value Chain project (which currently mobilizes farmers but does not advise on weed management), and development partners (e.g. through collaborative agreements with the Rural Reconstruction Foundation in the Jessore region). CSISA through TOTs will provide trainings to 200 AIP associated input dealers/retailers using Experiential Training Module on IWM, developed by CSISA.

- On-farm performance evaluation of IWM options for yield and economics in collaboration with the Bangladesh Rice Research Institute (BRRI): About10 on-farm trials (each farmer as replicate) on IWM will be conducted in each hub (a total of 25–30 trials in all three FtF hubs). These trials will be implemented by BRRI with back stopping by CSISA. Treatments of these trials consist of new and old herbicide products with one hand weeding to estimate relative yield losses due to weeds compared to predominant farmers' weed management practice and weed free conditions. Data on grain yield, labor use and economic performance will be collected to identify diversified options for weed control in rice and to sharpen our messages/communication for adoption of IWM options. These trial sites will also serve as locations for field day/exposure visit of farmers/DAE staff/input dealers/ private sector partners, and will be used to generate both data that can be used to leverage new herbicide markets, as well as to create additional awareness of, and demand for, IWM among farmers and input market actors.

Above: *Poor weed control causes rice yield gaps of up to 1 ton ha^{-1} in Bangladesh.*

- A transect weed survey study and crowd sourcing study through input dealers is underway assess predominant weeds in *aman* rice – *boro* rice, *aman* rice – wheat, and *aman* rice-wheat-Jute cropping systems in Jessore and Faridpur hubs.
- Standardized, hands-on experiential learning training modules in integrated weed management have been developed in collaboration with the Bangladesh Agricultural Research Institute and Department of Agricultural Extension, both of whom have officially endorsed the modules. These modules will be used to train at approximately 200 agricultural inputs dealers in cooperation wit the USAID/Bangladesh Agricultural Inputs Project in preparation for the *boro* rice season. Aligning these with the above efforts is targeted to result in farmers on 3,000 ha (new and continuing) using IWM practices in Bangladesh.



Above: *Example of grapical illistration from IWM training modules on herbicide safety designed for low literacy farmers.*

Commercial expansion of two-wheel tractor based machinery and associated service provision models for reapers and seeders

CSISA-Mechanization and Irrigation (CSISA-MI), the value chain-oriented CSISA sub-project funded by USAID/Bangladesh, has successfully facilitated commercial growth and private sector investment in the marketing and sale of multi-crop seeders, axial flow pumps, and rice and wheat reapers, all of which attach modularly onto two-wheel tractors (2WT), of which there are over 700,000 in Bangladesh. The project's private sector partners, which have invested over US$ 2.2 million of their own funds in importing, manufacturing, marketing, and selling efficient agricultural machinery in partnership with CSISA-MI include multi-million dollar a year businesses such as Advanced Chemical Industries (ACI), Rangpur Foundry Limited (RFL), the Metal Ltd. and smaller Bangladeshi enterprises such as Junata Engineering have been keen to expand commercial sales of these resource-conserving machines outside of the FtF zone, where they anticipate significantly larger market potential and sales, and hence scalable impact on improving farmers livelihoods. Seeders and reapers in particular have captured these companies interest. Both machines respond to rural labor constraints experienced during crop establishment and harvesting – both of which are critical to complete quickly to free fields for subsequent planting to increase cropping intensity (the number of crops sown per year).

***Above**: Breaking the finance bottleneck to rapid reaper machine adoption. New two-wheel tractor attachable reapers are over 60% less expensive than previous self-propelled reapers in Bangladesh, opening new doors for large-scale scaling and adoption through private sector led commercial channels. In Phase III, efforts to encourage the adoption of at least 600 reapers through commercial pathways will be implemented in Dinajpur. This number of reapers has the capacity to serve farmers on 6,000 + hectares per year.*

In Phase III, CSISA will work with the Bangladesh Agricultural Research Institute and International Development Enterprises (iDE) to expand the business models and joint venture agreements developed through CSISA-MI to Dinajpur in the country's northern wheat and maize belt. Despite the late start of CSISA III after the cropping winter cropping season, considerable efforts have been put into place to examine the potential for the private-sector led commercialization of resource conserving, scale appropriate machinery. Efforts have focused on Dinajpur, where preliminary market studies highlight considerable potential, which has captured the interests of CSISA's private sector partners. Preliminary assessments of the market size potential in the Dinajpur region show a US$ 5 million market size per year for service providers utilizing 2WT driven seeders annually, alongside

US$ 15 million total market size for dealers, importers, and manufactures, with up to US$ 57 million/year in crop establishment cost-savings for farmers. Considering rice and wheat reapers, we estimated a US$ 20 million total market size for dealers and importers, and in excess of US$ 20 million of yearly profit potential for service providers, alongside and US$ 3 million of cost-savings for farmers per year. Such figures have clear weight, and are currently being used to facilitate discussions with the above-mentioned companies regarding activity and sales expansion in the country's north.

This intervention leverages existing farmer groups already exposed to both mechanization options through CSISA's earlier engagement in the USAID/Bangladesh Expansion project (CSISA-BD) in Dinajpur, this low-investment but high-potential intervention will aggregate farmer demand and expand machinery and service provision sales in northwestern Bangladesh, providing a base from which our private sector partners are expected to further develop independent markets throughout the north. Planning underway to develop agreements with iDE to leverage pre-existing business logic and experience from CSISA-MI, including Joint Venture Agreements developed by the project's core value-chain facilitation partner, International Development Enterprises (iDE), to spread machinery adoption and the expansion of service provision in Dinajpur hub in northwestern Bangladesh. Efforts will focus on growing markets and dealer sales of 2WT-attachable direct seeding and reaping equipment, with technical support and backing facilitated trough BARI's Maize and Wheat Center located in Dinajpur. The following outcomes are anticipated in the second half of 2016, which will result in excess of 950 hectares coming under mechanized rice and wheat sowing and harvesting in 2017, all using the platform of readily available two-wheel tractors to power machinery.

- Partnership with iDE for expansion of commercial sales areas formalized
- Joint venture agreements with at least two companies developed and/or extended to include Dinajpur
- Mass media campaigns using video showings accompanied by private sector sales agent pitches to farmers implemented with at least 20,000 additional farmers becoming aware of the commercial availability of reapers and seeders

By the completion of Phase III, the envelope of adoption will scale to 6 and 400 reapers and seeders, respectively, resulting in at least 20,000 ha of land coming under scale-appropriate and resource conserving machinery, propelled by at least US$ 0.5 million of private sector investment.

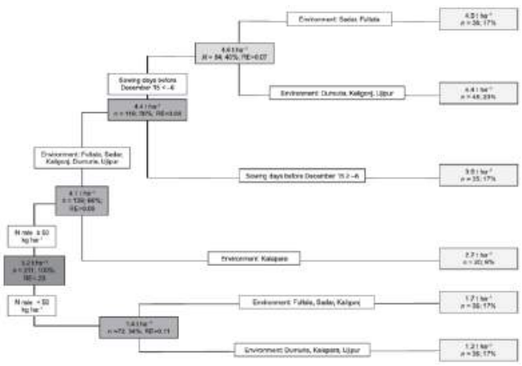
Sub-theme 3.2 - Managing risk by coping with climate extremes

Early wheat for combatting heat stress

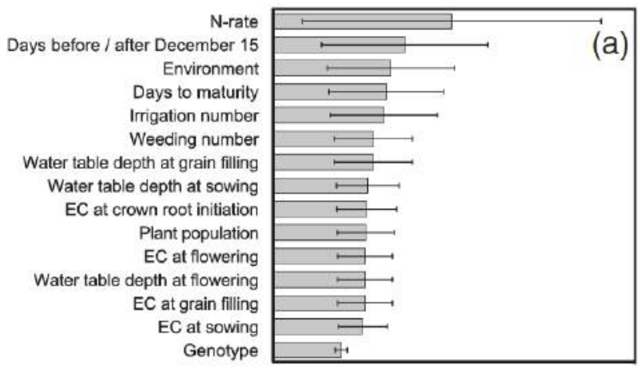
Above: *Early wheat sowing leads to bountiful harvests*

Following rice, wheat is Bangladesh's second most widely grown and consumed cereal, with consumption increasing at .3% a year. Average yields in Bangladesh are however 67 kg/ha below the regional mean of 2.75 t/ha, though estimated attainable yields for the FtF zone are higher, at ~5 t/ha. Per capita wheat demand is currently 17.3 kg/year, approximately 20% that of rice. With 3% more protein than rice, wheat makes an important contribution to protein intake at 4.3 g/day. While Bangladesh's wheat production decreased by 34% in the last decade, aggregate demand jumped by 13% in the same period. In 2014–15 wheat demand in the country was 4.85 millions tons, production was 1.35 million and imports were 3.5 millions ton costing over US$ 750 million.

A key challenge to improving wheat productivity in Bangladesh and in much of the tropics and sub-tropics is extreme heat. Exposure to temperatures above 30°C can damage the wheat leaf photosynthetic apparatus and accelerate senescence, resulting in reduced grain filling. At critically high temperatures > 32°C prior to and during flowering, photosynthetic decline is more pronounced. In the mid 1980s, research conducted by the Bangladesh Agricultural Research Institute indicated a 44 kg/ha yield loss for each day wheat was sown late. As temperatures have increased, losses are now more significant, with an average of 105 kg/ha lost in stress prone environments in the FtF zone. Further work was done to understand what environments different heat tolerant wheat genotypes tend to perform best in, through large-scale farmer-managed trials. Multivariate analysis provided a strong indication of the importance of early sowing alongside nitrogen management (see Figure).



Above: *CART model describing wheat grain yields (t/ha) for 66 farmers' fields considering*



Above: *Percent decrease in mean square error (MSE) accuracy for prediction of wheat grain yields (t/ha)*

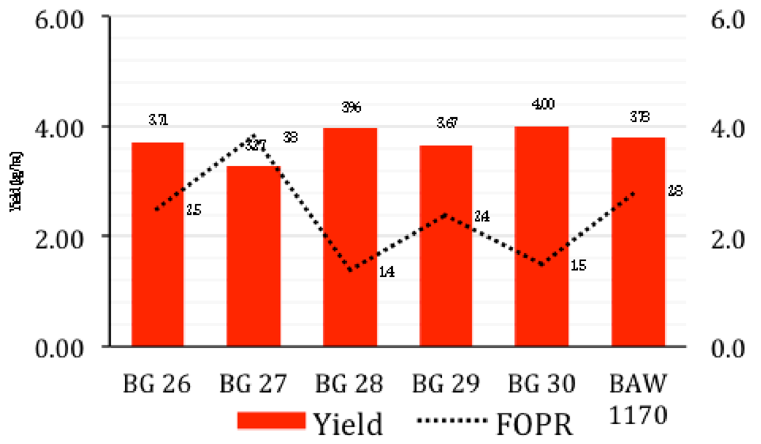
environmental and agronomic management variables.	*following Random Forests modeling. Sowing date and nitrogen management are the most crucial factors for high yields as evidenced from 66 farmers' fields.*

From a farmers' participatory multi-location trials with six new varieties under three tillage systems-conventional, bed and strip tillage they identified few preferable varieties in 2015–16 in Jessore, Faridpur and Dinajpur areas suitable in their agro-ecological conditions. BARI Gom 28, BARI Gom 30 were the highest yielding and their highest preferred varieties. These varieties are shorter in duration to escape from late heat. BARI Gom 26 was also their next preference, although performance is variable and the variety appears to be increasingly blast susceptible. Conversely, farmers who shifted planting just 5 days earlier were able to capture at least half a ton per hectare greater wheat yields. Building on known agronomic methods to advance sowing dates and the successful media campaigns and governmental endorsement of earlier wheat sowing recommendations facilitated by CSISA in Bihar in Phase II, this intervention will raise farmers' awareness of the importance of early sowing and introduce techniques to achieve timely sowing in Dinajpur, Faridpur, and Jessore Hubs, in which farmers on 110,000 wheat hectares stand to benefit. Wheat is grown in around 110,000 hectares in Jessore and Faridpur alone, with 66,000 ha (60% of total whet) is grown later than recommended date. If timely seeding is adopted then there will be at least 33,000 tons additional production which will contribute to food security and reduce import cost of US$ 7.07 million (if wheat blast does not pose significant threat).

As with other activities, the late start of funding for Phase III has meant that it was not possible to fully implement activities for the wheat season, which begins from November onwards. As such, activities in Phase III have focused on strategic preparations for the coming 2015–17 *rabi* season during which a large scale campaigns on the importance of early wheat sowing are anticipated.

In Phase II, CSISA initiated efforts to advance of wheat sowing in India, with highly impactful results. Relevant insights from this work stream will be carried forward in Phase III to Bangladesh, to gain endorsement through the Ministry of Agriculture and Department of Agricultural Extension, and to raise awareness and popularize messages around early planting through mass media campaigns and development partner initiatives. Between 2013–15, CSISA was successful in spreading farmers' awareness of, and demand for scale-appropriate machinery through a training video village road show and television screenings. Over 110,000 farmers and tens of millions of television viewers saw the videos in a two-year period, greatly raising awareness of newly available agricultural technologies. Similar media campaigns are envisioned to widely popularize early wheat sowing, in addition to distribution of extension materials through partners (e.g., through Agricultural Inputs Project's dealer networks). These activities will prime the pump for subsequent scaling, with an anticipated 6,000 ha of wheat falling under more timely sowing in the winter season of 2016–17.

CSISA will also continue to play an important role by engaging with various private and public sector partners to achieve an overall systems optimization, encompassing both the wheat and rice components, and by recommending and expanding awareness of how use of short-duration rice can help to advance wheat sowing dates (see premium quality rice below). Of key importance in deploying messaging on early sowing it the potential for the practice to help overcome emerging and significant threats to wheat productivity such as blast (*Magnaporthe oryzae*) disease (see associated wheat blast intervention).



Above: Yield and farmers' overall preference rank (FOPR) of wheat

Outreach materials developed and under development

As noted above, activities are under way to make a series of videos to reach out to farmers through village-level film showings highlighting premium quality rice, the principles of healthy rice seedlings, and on the importance of early sowing in wheat. Two page leaflets detailing the benefits of PQR and regarding best management recommendations for rice nurseries have also been produced and are in the process of being distributed to the DAE, who has enthusiastically endorsed their extension officers' use of CSISA extension materials at the level of the Director General, and to NGO partners and related agricultural development projects.

Above: *Experiential learning modules for integrated weed management in South Asia*

In addition, a guideline on how to improve mungbean management was produced in partnership with the Bangladesh Agricultural Research Institute (DAE). A comprehensive experiential learning training module was also developed with DAE and BARI on integrated weed management. Then modules, which come in book form, covers critical topics for the principles and practice of integrated weed management in the context of smallholder farming in the tropics, with emphasis on experiential and hands-on learning. This document provides a guide for facilitators of a rapid one-day training on integrated weed management, including detailed instructions on how to facilitate a training, training material requirements, flip charts to facilitate discussions, and pre- and post-tests for training participants.

Nepal

Introduction

Phase III in Nepal operates in conjunction with two other complementary USAID investments: CSISA-NP Agronomy and Seed Systems Scaling (USAID Washington) and CSISA-NP Mechanization and Irrigation (USAID India). The geographic footprint of CSISA III is also influenced by one additional investment – the Earthquake Recovery Support Program, which was implemented in response to the 2015 earthquakes under the CSISA umbrella. Together, these investments compose a coordinated investment for sustainable intensification in Nepal. Although CSISA-Scaling and CSISA-Mech focus on Feed the Future districts in the Mid West and Far West Development Zones, CSISA III allows us to expand into more commercial pockets in the Western Development Zone, as well as earthquake-affected districts where CSISA has distributed mini-tillers, storage bags, hand tools and agronomy information. The EQ district also constitute the newly-expanded FtF 'zone II' for Nepal. During the reporting period, CSISA opened a new office in Dang Valley, which has tremendous potential for scaling up interventions in a variety of crops due to market and road network connectivity. Crops covered by CSISA in Nepal include maize, rice, wheat, lentil and mungbean, all of which have a mechanization component. CSISA III contributes additional focus areas to the overall program, including coping with monsoon variability and work on precision nutrient management.

For research activities, CSISA partners closely with the Nepal Agricultural Research Council, the Department of Agriculture and District Agriculture Development Offices, as well as private sector agricultural input dealers, machinery traders and seed companies. USAID flagship FtF investment in Nepal is the KISAN project, and CSISA continues close collaboration with KISAN for technology demonstrations, training, and market development activities. As is the case in India and Bangladesh, CSISA supports the emergence of a variety of service providers who are the cornerstone for bringing sustainably intensification technologies to smallholder farmers at scale.

This report details the first six months of CSISA Phase III activities in Nepal, with emphasis split across three broad thematic areas: (1) innovation towards impact, (2) systematic change towards impact, and (3) achieving impact at scale. Despite several challenges in the initial months of Phase III, including a five-month economic blockade at the India-Nepal boarder that severely limited supplies of critical inputs and hindered staff and partner mobility, CSISA has used this time to critically evaluate progress achieved so far, and to focus remaining activities on high-impact, best bet interventions.

Theme 1: Innovation towards impact

Sub-theme 1.1 – Reducing risk for sustainable intensification

Directly sown rice to address labor and energy constraints

Due to out-migration and an aging rural workforce, seasonal scarcity of agricultural labor is one of the biggest challenges to the viability and profitability of Nepalese agriculture.

Traditional rice establishment practices of manually transplanting seedlings into puddled fields cost farmers time, labor, energy, and money. Furthermore, research conducted by CSISA in Nepal shows that puddling degrades soil quality and causes adverse effects on successive winter crops. Machine-sown dry direct seeded rice (DSR) is a cost-effective technology that allows the direct line sowing of rice seeds into non-puddled fields and avoids the cost of raising rice nurseries and transplanting seedlings. In this context, DSR can be a suitable alternative to conventional transplanted puddled rice. Although DSR can also be riskier than transplanted puddled rice due to higher weed pressure and the possibility of stand mortality with early rains. The selection of suitable land, deployment of trained service providers, timely crop establishment and utilization of integrated weed management practices are pivotal for reliably obtaining good yields with DSR. Innovation also plays a role, with the 'dust mulching' approach to stand establishment along with investment in early irrigation now being evaluated across landscape gradients in Nepal from the perspectives of risk-reduction, yield stability, and yield potential.

CSISA III's DSR-related activities function synergistically with the machinery focus of the CSISA-Nepal Mechanization and Irrigation program, and also expands beyond the FtF zone into areas where machinery value chains are the strongest (e.g. Nawalparasi and Rupandehi Districts). For a technology that is radically departure from conventional practices, it is essential to help create a critical mass of first adopters – a co-emphasis in these districts will aid this process. In the past six months, the following DSR-related activities were undertaken:

Co-ordination Meeting with Machinery Traders, DADO's, Service Providers and Champion Farmers

As the foundation for our DSR scaling strategy, CSISA is forging new linkages between District Agriculture Development Offices (DADO's), local machinery traders, DSR seed drill service providers (SPs) and farmers in Rupandehi and Nawalparasi Districts, where CSISA had initially worked in during Phase I (2009–2012). In the past, linkages between SPs and local machinery traders were weak, causing shortages of spare parts for critical equipment such as seed drills that can sow both zero tillage wheat and DSR. During this linkage event, 28 SPs from Nawalparasi and Rupandehi, along with local machinery traders, participated. The event was organized by CSISA and the respective DADOs in each district. The interaction program focused on the major problems associated with the adoption of DSR and ZT wheat, major driving forces for the adoption of DSR technology and how to overcome

INTERACTION PROGRAM IN NAWALPARASI

> Nawalparasi and Rupandehi are two of the major rice and wheat growing districts, with potential for converting > 70 thousand hectares to DSR and ZT wheat.

problems associated with those technologies. There was also discussion on how to ensure the timely availability of spare parts. In the discussion, The Habi Traders assured farmers that they would supply spare parts for the drills from the branch offices. CSISA also played a vital role in the discussion between the seed manufacturers (National Agro Industry, Ludhiana) and machinery suppliers (The Habi Traders) about supplying spare parts for the seed drill. In this discussion, agronomists from the respective DADOs assured the farmers that DADOs would prioritize the extension of DSR and zero tillage wheat in their districts.

Refresher training for DSR Service providers in Nawalparasi and Rupandehi

After getting feedback from the interaction program described above, CSISA organized a one-day refresher training on DSR for the service providers and key farmers in Rupandehi and Nawalparasi in collaboration with the seed drill supplier (The Habi traders) and the DADO. In this training, discussion of major problems associated with the adoption of DSR and ZT wheat and how to overcome these problems was the major focus. Experienced service providers showed others how to calibrate the seed drill and discussed how to use these technologies optimally – including suitable land selection, land preparation, seed depth, variety to be used and timely weed management. Experts from CSISA explained how to minimize risks associated with crop establishment in DSR, including pre-sowing irrigation and how to manage weeds along with safe-handling measures for herbicides. After this refresher training, farmers and service providers expressed that their confidence has increased for the adoption of DSR.

> In 2016, service providers in Rupandehi and Nawalparasi have established DSR on more than 200 ha. Since demand and awareness of DSR is increasing, an expansion of the number of seed drills through CSISA's market development efforts will allow greater land coverage. It is important to acknowledge that weather has a strong bearing on the success of DSR. Early onset of the 2016 monsoon restricted the sowing window for DSR.

Radio jingle for promoting DSR

Across the CSISA countries, a recurring theme is that basic awareness of new technologies constrains adoption. In collaboration with the respective DADOs, CSISA produced a radio jingle to spread awareness of the benefits of DSR in Western, Mid Western and Far Western Terai districts. The jingle was aired on popular FM radio stations at the start of the *Kharif* season for about three weeks in our working districts. In the jingle, the name and contact number of the service provider was included so that interested farmers could directly contact the service providers. Service providers have since indicated that they have received phone calls from different parts of their districts. CSISA has also been promoting DSR and laser land leveling in the region through different awareness-raising programs, for example participation in agriculture fairs, mobilizing service providers to conduct village level trainings, etc.

In Focus: *Farmers increase water use efficiency with direct seeded rice*

Picture a Nepali farmer waiting for rainfall to transplant rice in his 18 ha farm. With increasing labor shortages, unpredictable rains and no irrigation, he finds it difficult to cultivate rice through transplanting, which demands substantial water. Now picture this same farmer using a seed drill to directly sow rice in his field. It not only reduces his drudgery but also saves water, time and labor.

Compared to the traditional method of rice sowing, direct seeding avoids nursery establishment, puddling and transplanting, thus reducing cultivation costs and water consumption. Dry direct seeded rice (DSR) is becoming popular in the Mid West districts of Banke and Bardiya, thanks to CSISA's efforts.

Talking about farming challenges, Bhabhisara Giri, a farmer in Bardiya, explains how hard it is to find labor needed to transplant rice. "We offer a package of lunch, snacks, dinner and NPR 450 per day, yet we cannot find many takers. With direct sowing, I don't have to worry about walking long distances and spend time searching for labor and planting my crop late. "

Giri received training on DSR from CSISA last year and learned about its benefits. She also attended a training on weed and fertilizer management in DSR, which helped him understand the proper technique of spraying herbicides and applying urea.

Many farmers in this region still rely on hiring bullocks for land preparation. Kharka Pun, a farmer from Banke, says that it is difficult to hire bullocks because of high demand during the peak planting season. This season, CSISA helped him connect with a machinery trader and he bought a two-wheel tractor and a seed cum fertilizer drill for direct sowing. "I didn't have to puddle my field, prepare seed beds or transplant seedlings for the first time in 20 years," Pun says with a smile.

Karka Pun implementing DSR on his field

Farmers are pleased that DSR requires much less water. "Water is scarce in our area and load shedding hinders timely irrigation. DSR has helped me to meet the water needs for planting rice," said a fellow farmer Narendra Yadav.

The area under DSR has increased drastically as compared to last year's rice season. **One hundred five ha was covered during this monsoon in Banke and Bardiya – a 90% increase in DSR over last year.**

CSISA is also supporting local service providers to promote DSR. Krishna Chandra Yadav, a local service provider from Bardiya, learned technical and operational details of the seed drill at a CSISA training. "Driving the tractor at a low speed and maintaining proper seed depth is a must for successful DSR,' says Yadav. Yadav serviced 27 farmers to cultivate DSR on 47 hectares.

However, direct seeded rice needs more management than transplanted rice. According to Anil Khadka, Research Associate in CSISA, crop establishment and weed management are big challenges in the success of DSR. 'Maintaining proper seeding depth at one inch, timely application of herbicides and seeding before the monsoon rains are crucial for getting good yields,' Khadka added.

In Focus: *Scaling out DSR, a priority of the Rupandehi DADO*

DSR SEEDING USING SEED DRILL IN RUPANDEHI

CROP ESTABLISHMENT UNDER DSR

The traditional rice establishment practice – manually transplanting seedlings into puddled fields – is labor and energy intensive. In the context of labor scarcity, DSR, which is labor and energy efficient, has significant potential in Nepal's Terai. Machine-sown DSR is fast emerging as a cost-effective technology that allows the direct line sowing of rice into un-puddled fields and avoids the cost of raising rice nurseries and transplanting seedlings.

Rupandehi is considered one of the major rice and wheat growing districts of Nepal, and is a district where seed drills and trained service providers are available, as CSISA had worked in this district during Phase I (2009–12). As CSISA Phase III expands into more commercial areas, the project has re-entered Rupandehi to capitalize on the growth that has occurred since Phase I.

CSISA organized a coordination meeting with service providers, key farmers, the District Agriculture Development Office (DADO), and machinery traders for scaling out DSR (as described earlier in this report). After this interaction program, the DADO Rupandehi decided to conduct 25 DSR demonstrations of the DSR in new areas while mobilizing the service providers developed by CSISA. DADO Rupandehi acknowledged CSISA's contribution to initiating and scaling DSR in the district.

In this season, with support from the DADO's initiatives, DSR was seeded on 20 ha while mobilizing the existing SPs and technical support from CSISA. In Rupandehi in total, around 50,000 ha are suitable for DSR and ZT wheat.

CSISA also has provided technical training for the DADO technicians and provided booklets containing DSR guidelines, published in Nepali. The DADO has already allocated budget to purchase new seed drills for DSR and zero tillage wheat in his region, a good example of the institutionalization CSISA-supported technologies into the DADO technical priorities at the field level.

Mechanization for upland rice

In the upper valley of Surkhet, most land in rice cultivation is rainfed. Maize and upland rice (*Ghaiya*) are the major crops grown during summer and are considered a major source of food in the area. The hand broadcasting of rice seed into ploughed land followed by planking is the major upland rice cultivation practice practiced by farmers in the region. Rice productivity is very low, i.e., less than 1 t/ha under farmers' practice. Weed management is the major challenge and is a tedious job for upland rice farmers, as it consumes a large amount of labor, and is done largely by women farmers. Realizing the importance of mechanical line seeding, CSISA has organized a training on better bet agronomy for upland rice, as well as the weed-management benefits of mechanical rice seeding. In the 2016 summer season, in collaboration with the local DADO and a farmers' group, CSISA initiated mechanical DSR demonstrations in Surkhet. Compared to hand broadcasting, mechanical rice seeding provides good early crop growth vigor due compared to the farmers practice. Farmers have observed good early growth and crop uniformity. Farmers have realized that labor required for weed management can reduced by 50% if seeded in lines compared to conventional hand broadcasting. CSISA has also provided training for local service providers on mechanical line sowing for upland rice in Surkhet.

FARMERS PRACTICE OF UPLAND RICE CULTIVATON IN SURKHET

MECHANICAL DRY SEEDED RICE FIELD AT 16 DAS IN RAMGHAT, SURKHET

Planned activities for the 2016 rice season:

Baseline survey for developing an integrated weed management strategy for sustainable intensification of cereal production in Nepal

Weed infestation can reduce cereal production up to 80% if not managed properly and on time, as farmers in Nepal have to invest huge amounts of labor on manual weed management. Sustainable intensification of cereals therefore means the judicious use of herbicides and other weed management measures. In some of the Terai district, farmers have recently started to use herbicides especially for rice and wheat, often relying on recommendations from local Agrovets (pesticide dealers). However, the source of scientific information for these recommendations is unclear. How these recommendations are derived, how they are made, and how they are followed remain important questions.

In light of the spread of DSR and zero tillage wheat, it is essential to develop an integrated weed management strategy for the sustainable intensification of cereals in Nepal. CSISA will conduct a baseline survey to collect information on problematic weed species, current control strategies, herbicides are being used, where they are obtained, what types of recommendations and use directions are being provided by suppliers, and how farmers perceive herbicide use. Information generated from this study will provide valuable insights for the development of integrated weed management strategies. Outcomes will be presented in the annual report.

Evaluation of new high-yielding rice hybrids

In collaboration with National Rice Research Program-NARC and the private seed company NIMBUS, CSISA has been evaluating different short-duration pipeline national and multinational rice hybrids in different farmers' field in Banke, Bardiya, Kailali and Kanchanpur districts. This data will illuminate the varietal performance and yield potential of those hybrids under best management practices in western districts. The data generated from this evaluation could support the domain expansion of these already-registered hybrids west of the Narayani River and provide support for the varietal registration of the new hybrids. This evaluation also helps for the market development of those varieties for the coming season.

Coping with drought and variable monsoon for rice cultivation

In the 2014 and 2015 summer seasons, the monsoon started very late and farmers were not able to transplant rice on time, typically planting seedlings that were more than 40 days old. This led to a reduction in crop yield and an overall decrease in rice production due to the early season drought. Under increasingly unpredictable weather conditions, devising coping strategies for building resilience for rice is becoming increasingly important. In response to this threat, in collaboration with Agriculture and Forestry University (AFU) CSISA has planned to evaluate simple agronomic practices that may build resilience to drought such as changes in planting densities and the number of seedlings per hill for short and medium duration varieties to compensate for the reduced tillering capacity of old seedlings. The result of this initiative will be presented in the annual report.

Theme 2: Systemic change towards impact

Sub-theme 2.1 – Unconventional partnerships for inclusive growth around potential commercial pockets, neglected niches

New Geographies

CSISA has set up a new office in Dang in order to capitalize on the richness and potential of this Feed the Future district. Dang lies in the Mid West development region and has diverse geography, as altitudes range from 300-2000 m.a.s.l. and consist of Terai, inner Terai and mid-hills. The lower valley has year-round irrigation and high potential for rice, spring maize, wheat, lentil and mungbean cultivation. The upper valley covers 70 percent of the total area and maize-based systems are dominant, with great scope to increase maize productivity through the application of best-bet management practices. Dang also offers a huge scope for scaling out mechanization, while strengthening emerging local traders and service providers.

Income- generating maize production in neglected hill and plateau ecologies

Capacity building for hybrid maize seed production

In Nepal, about 2500 t of hybrid maize seed is imported from India annually. Market availability of quality seed is a challenge as many hybrids being used by farmers are not registered under the government system and the quality of some hybrids is not consistent across years. To address this issue, the Nepalese government has prioritized hybrid maize variety development in Nepal and some work has already started by the National Maize Research Program. Four hybrid maize varieties have been released. However, one of the constraints in this initiative is the limited number of plant breeders in the country. Private seed companies interested to start hybrid maize production are lagging behind due to the absence of technical manpower to handle hybrid maize. In collaboration with Hill Crop Research Program (HCRP/NARC), ARS Surkhet and the local DADO, CSISA organized a one-day hybrid maize seed production training at Birendranagar, Surkhet. A total of 20 technicians from different public and private sectors attended: NARC, DADO, KISAN project, seed companies and seed producer cooperatives. The major objective was to train seed company technicians and seed producer cooperatives on Khumal maize hybrid (a hybrid released for the mid hills) seed production techniques in the hills and river basins. After this training, Pabitra Co-operative has started to produce hybrid seed on 0.5 ha with the technical support from the co-operatives technicians and CSISA.

HYBRID SEED PRODUCTION TRAINING IN SURKHET

Scaling out elite cultivar of maize in collaboration with NIMBUS

NIMBUS is a leading international agri-business, is the largest animal health and nutrition company in Nepal, and represents many multinational seed companies. With the objective of increasing farmers' access to improved agricultural inputs including seeds, bio-fertilizers, machineries and advisory services, and output markets, NIMBUS has opened an agriculture service center in some districts and has planned to expand to 200 agriculture service centers across the country. NIMBUS is the largest buyer of maize grain in the country and has the capacity to consume about 200 t maize per day, most of which is currently imported from Bihar, India. In Nepal, the company is collecting maize grain from the central and eastern development regions but its outreach is expanding in the Western region in recent years. CSISA is closely working with NIMBUS for the market development and evaluation of the new maize and rice varieties in order to support the out scaling of better-bet agronomic practices and elite genotypes. In the 2016 summer season, 111 demonstrations for recently domain expanded maize varieties (with support from CSISA) have been conducted in

CSISA's project districts. These demonstrations will help increase farmer awareness of, and interest in, growing high-yielding varieties, expanding and input/output markets in the region.

Initiatives to control stalk rot disease in maize

In summer, maize is the dominant crop in the upper valley of Dang and Surkhet, which are the main food and income sources for that development region. In the last 2–3 years, maize production was severely affected due to stalk rot disease and production was reduced up to 100% in some areas. Stalk rot is becoming a serious threat for most of the Terai and inner Terai region of Nepal. Very little or almost no research has been conducted on how to control this disease in the region. In response to this threat CSISA organized a consultation meeting with the local DADO, National Maize Research program (NMRP) and different farmers' groups to identify possible entry points to overcoming/minimizing the problem. It appears that irrespective of maize variety, the disease infestation has been observed in almost all farmers' fields. We have also found that the practice of applying imbalanced chemical fertilizer, i.e. only urea, also helps to induce a favorable environment for disease outbreak. Therefore, to understand if there is any interaction in disease infestation between balanced and single fertilizer application, CSISA has established several on-farm experiments on fertilizer management in different farmers' fields in Surkhet and Dang districts with the combination of major and micronutrients.

STALK ROT DISEASE IN MAIZE

Similarly, in collaboration with NMRP and Agriculture Research Station (ARS) Surkhet, CSISA has initiated research on integrated disease management (i.e., varietal screening for stalk rot resistant genotypes and a combination of different cultural, biological chemical means of disease control) both on farm and on station in Dang and Surkhet. Success in identifying suitable varieties and/or management practices to overcome stalk rot disease would be a very important outcome for the region.

Theme 3: Achieving impact at scale

Sub-theme 3.1 - Growing the input and service economy for sustainable intensification technology

Mechanical maize seeding: A new initiative in Dang

FIELD DEMONSTRATION OF MAIZE SEEDING USING MULTI CROP SEED DRILL IN DANG

Maize is the major summer crop grown in upper valley of Dang district. CSISA has established its office and started some activity on a few selected sites from summer 2016. Summer maize seeding is highly dependent on pre monsoon rainfall. Generally, farmers prepare their land for maize seeding by ploughing their land 2–3 times using a tractor-drawn cultivator in the beginning of April, and maize seeding starts immediately after rainfall begins. Soil in the region is well drained and light textured with low water holding capacity, hence there is a small window for seeding maize while capturing appropriate soil moisture. **More than 85% of farmers sow maize by dropping seeds behind the plough, which takes significant time. Also, very few bullocks are available in villages these days and farmers have to wait in a queue to get a bullock plough for seeding maize on time.** Farmers reported seeding maize with a bullock is time consuming and costly.

Pawannagar VDC is one of the major maize growing VDCs of Dang where maize is grown on more than 300 ha in summer. Realizing the importance of mechanized maize seeding in the region in collaboration with DADOs and farmers groups, CSISA organized a training before the season start, i.e., in April, on mechanical maize seeding using different machines. CSISA also provided training for potential service providers (farmers who already have tractors) on how to operate a seed drill. With support from the local service provider, this was the first time most farmers had seen mechanical maize seeding. After seeing the demo, (dropping seed in line with appropriate spacing) farmers indicated a strong interest in seeding maize using a seed drill.

MAIZE CROP ESTABLISHMENT USING 4 WT MULTI CROP SEED DRILL

Following the training, Prem Kandel, a service provider with a four-wheel tractor immediately started to provide mechanical maize seeding services to other farmers. Demand for his services further increased after farmers saw the good germination in the first demonstration plot, said Mr. Kandel. **Mr. Kandel has since provided mechanical maize seeding services on more than 10 ha in summer 2016.** He stated, “From a single seed drill I could not provide service according to farmers’ demand.” He now plans to buy another seed drill for the forthcoming maize season in order to keep up with farmers’ maize-sowing needs.

Dhaniram Rokka, Chairperson of Suryajyoti Agriculture Cooperative, became convinced of the value of the maize seed drill and said compared to the conventional seeding it has advanced seed germination by two days. Good germination can also be due to the appropriate seeding depth from the seed drill. Mr. Roka added that he was able to save about 50% of the maize seeding cost with machine seeding compared to conventional seeding.

Similarly, Gima Kanta Sapkota, a member of Ananta Memorial Agriculture Cooperatives, observed that due to line seeding, **intercultural operations become simpler and faster, including weeding and fertilizer application. The labor needed for weeding in particular**

FARMERS PRACTICE OF WEED MANAGEMENT IN MAIZE

was reduced by 20%. Mr. Sapkota noticed that under line seeding crop damage during first weeding was reduced by 15%. He also found a 25% higher plant population as compared with the traditional system. Other farmers who used the seed drill also shared the benefits they observed from line seeding, including ease of fertilizer top dressing, weed management, spraying and harvesting.

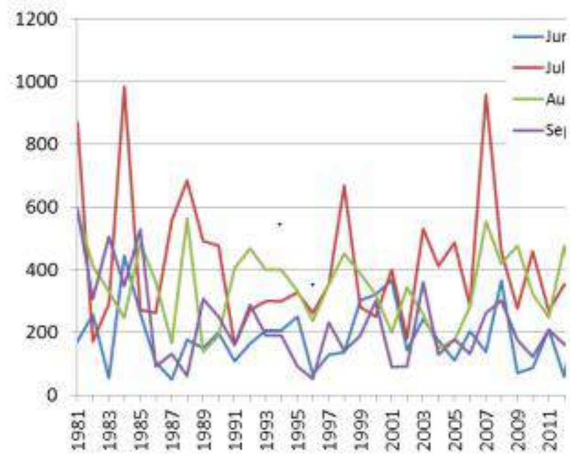
Sridhar Gyawali, DADO Dang, appreciated and acknowledged the effort done by CSISA in the region and expecting to expand the technology in other areas in collaboration with Agriculture Service Center.

Sub-theme 3.2 - Managing risk by coping with climate extremes

Coping with a weak and variable monsoon and avoiding *Kharif* fallow

Maize as an alternative to rice to cope with erratic monsoon in medium to light soil

The productivity of rice in rainfed upland soils is very low and unstable because of erratic monsoons, moisture deficits during dry spells, light textured soils with low water holding capacity and several biological constraints (for example weeds, pests and diseases). To grow rice in such types of soil requires frequent rainfall/irrigation. In the absence rainfall, rice can barely survive and produces extremely low yields, which is not profitable for farmers. Also if the monsoon starts very late farmers are not able to transplant rice on time, and have to transplant old seedlings. This leads to a reduction in crop yield and an overall decrease in rice production due to poor crop growth.



PRECEPITATION RECEIVED IN WET MONTHS (MM) IN BANKE

In light of monsoon variability, crop diversification and the substitution of low-water consuming crops like upland maize may be the best option for mitigating drought and increasing the productivity of upland (previously rice) ecosystem. Maize requires less water than rice and can be grown successfully during the summer in medium to light textured soils, ultimately being more profitable. In the Mid and Far West there are large areas with light textured soil that would be suitable for upland maize. CSISA introduced maize under best bet management practices, comparing it with farmers' method of rice cultivation in the same piece of land. The output of this strategic research will be important for informing farmers' strategies for coping with weak and variable monsoons.

Communication & Knowledge Management

Deployment of better-bet agronomic messaging through input dealer networks and development partners

In collaboration with NARC and KISAN, CSISA has developed factsheets for better-bet agronomy for rice and summer maize. The factsheets explain best-bet technologies from seeding to harvesting to storage. The factsheets have been deployed through KISAN, DADOs, NIMBUS, seed companies and key farmers in the FtF districts. Factsheets were distributed before the season, i.e., at the beginning of April. CSISA has also organized a Training of Trainers (ToT) for field technicians from DADO, KISAN, NIMBUS, seed companies and members of farmers' co-operatives, who reach directly to the farmers and can provide trainings to different farmers' groups in different districts. DADOs have appreciated the training material and asked their field technicians to deploy the material in broadly to farmers. KISAN has their own network and program in all 20 FtF districts, hence these message can reach several thousand farmers in different FtF districts. CSISA will assess the impact of the deployment of the training material at the farmers' level in co-ordination with KISAN when the cropping season is over.

FACT SHEET ON BETTER BET AGRONOMY FOR RICE AND MAIZE

Healthy rice seedlings for higher yields

Initiatives for better rice nursery management for transplanted rice

TIPS FOR RICE NURSERY MANAGEMENT FOR TRANSPLANTED RICE

In Nepal rice nursery establishment and transplanting is highly dependent on the monsoon, as more than 80% rice is grown under rainfed conditions. Poor crop establishment is one of the major constraints to rice productivity, especially early incidences of abiotic stresses, such as drought and flood. Uncertainty around monsoon onset and erratic rainfall patterns also affect the timing of nursery establishment and transplanting. The Use of healthy seedlings grown in properly managed nurseries to ensure good crop stand following transplanting can be one of the major adaptive strategy in response to this threat. Research conducted in different areas shows good seedbed management and right seedling age and careful handling at transplanting lead to significantly higher rice yields. Realizing the importance of healthy seedlings, CSISA developed a factsheet on better nursery management for healthy seedlings and provided training to the technicians from DADOs, KISAN, seed companies and some key farmers in different districts with the objective to disseminate the information to different farmers which could help to grow healthy seedlings results leads to a higher yield.

Challenges faced during the reporting period

Bangladesh

- The primary challenges encountered in the first half of year I of CSISA Phase III relate to the start date of the project, which began on December 1, 2015. The winter *rabi* crop season in Bangladesh is sown from October through early December, and as such we were unable to implement planned activities during this season because of the a-synchronicity in project start date and the start of the season.
- Additional challenges were encountered with respect to the movement of field staff given the heightened security precautions in Bangladesh following terrorist attacks on foreigners. Despite these setbacks, the project was able to utilize the winter season to sensitize new and continuing staff members with respect to the CSISA III intervention plan, and to prepare for *aman* 2016 rice activities. Farmers are currently preparing their fields for transplanting of *aman* rice, and further outcomes from the intervention activities detailed in this report will be detailed in the subsequent end of year report.

Nepal

- Nepal suffered a five-month violent trade and energy blockade starting in the third week of September, 2015. While Nepal normally receives over 300 fuel tankers per day, for much of the blockade newspapers reported tankers crossing in single digits spurning a massive growth in smuggling and black-marketed fuel. CSISA field staff were greatly hindered and even blocked from getting to the fields due to lack of fuel and violence that affected the Mid and Far West Regions. Fertilizer and even seed for trials was difficult to obtain and finding fuel for project vehicles and tractors was always an adventure usually in the black market. The private sector was not able to supply key machinery on time as their trucks and containers were stuck for 3-5weeks at the border. Fuel shortages for tractors and irrigation pumps obviously had a significant effect on farmers and overall production as well.
- The early onset of monsoon rains hindered spread of DSR, whereas a slightly later start date would have allowed additional hectares to be covered.
- A December project start date meant that CSISA missed the winter season, and only began to pick up speed during the summer/*Kharif* season.