Cereal Systems Initiative for South Asia in Nepal (CSISA-NP)

Annual Report
2014

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Cereal Systems Initiative for South Asia in Nepal

International Maize and Wheat Improvement Center (CIMMYT)

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Acronyms and Abbreviations

Acronym	Full Name of Acronym
AFP	Axial flow pump
CA	Conservation agriculture
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CSISA	Cereal Systems Initiative for South Asia
CSISA-NP	CSISA-Nepal
DOA	Department of Agriculture
DSR	Direct-seeded rice
FTF	Feed the Future
IRRI	International Rice Research Institute
KISAN	Knowledge-intensive Sustainable Agriculture and Nutrition project
MOAD	Ministry of Agricultural Development
MT	Mechanical transplanting
NARC	Nepal Agricultural Research Council
NARES	National agricultural research and extension system
NAMEA	Nepal Agriculture Machinery Entrepreneurs Association
NGLP	National Grain Legumes Program
NGO	Non-governmental organization
NMRP	National Maize Research Program
OPV	Open-pollinated variety
RARS	Regional Agricultural Research Station
TPR	Transplanted, puddled rice
SHG	Self-help group
SI	Sustainable intensification
USAID	United States Agency for International Development
VDC	Village Development Committee
ZT	Zero tillage

Executive summary

CSISA's research focus in Nepal is aligned with the staple crop mandates of Feed the Future (FtF): sustainable intensification (SI) technologies for lentil, rice, and maize-based cropping systems. CSISA stages its work in the Mid and Far West development regions from offices in Nepalgunj, Surkhet, Dadeldura, and Dhangadhi.

This reporting period covers Kharif (monsoon season) harvest from 2013, Rabi (winter) season 2013–14, and the pre-harvest period for Kharif 2014. Progress is reported by theme. Highlights from the period include:

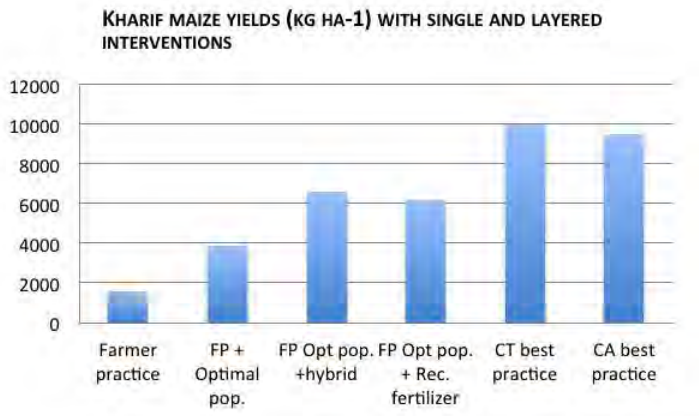
The **Cereal Systems Initiative for South Asia in Nepal (CSISA-NP)** receives funding from USAID Nepal with a co-investment from USAID Washington. In Nepal, CSISA's focus is primarily on participatory technology development and verification, inclusive of insights into business and market development for machinery and seeds. Disseminating technologies vetted by CSISA is the responsibility of the Winrock-led KISAN initiative, USAID's largest Feed the Future project in Nepal.

RICE GENOTYPES AND CROPS ESTABLISHMENT METHODS: OUT WITH THE OLD, IN WITH THE NEW? Variety replacement rates for grain staples like rice are extremely low in Nepal, and most farmers cultivate varieties that were released decades ago. Field trials in the Terai evaluated newly released varieties and one hybrid against commonly planted 'old' rice varieties. Improved rice varieties included: Tarahara-1, Hardinath-2, Sukha Dhan-1 and -3, Anmol Mansuli, and Swarna Sub-1 (for low-lying, flood-prone areas). The hybrid used was the relatively short-duration, high-yielding DY69. Planting methods (i.e., dry broadcast, dry directing sowing in lines, and conventional transplanting) were also evaluated to assess crop performance and farmer preferences for labor and cost saving technologies. Across the evaluation sites, our data suggests consistent advantages of around 1 t ha^{-1} for adoption of new varieties of similar maturity class if farmers are growing Bineshwari ('Bind'), but little advantage otherwise. Large gains in yield potential are possible with hybrids and longer duration material like Swarna-Sub1, but farmer acceptance appears to be low for the latter because of this variety's very long growth duration, which compromises timely winter season planting in areas where poor drainage conditions do not persist. Based on these data, targeted efforts to replace Bind and increase market availability of hybrids have been initiated.

In general, yields were similar across planting methods for each rice variety, suggesting broad adaptability across management systems for the genotypes evaluated. Both dry establishment methods significantly reduce production costs for labor, diesel and machinery rental. With yields on par with transplanting, cost savings potentially make these novel establishment methods very attractive for the relatively impoverished western regions of the country. In collaboration with private sector and government parnters, CSISA is working to support the emergence of service providers to increase access to rice establishment alternatives.

ENTRY POINTS FOR SUSTAINABLE INTENSIFICATION: At less than 2 t ha^{-1}, maize yields in the mid-hills are persistently low and few efforts have systematically assessed either the production potential in these systems or identified sensible entry points towards sustainable intensification that can be selectively matched to the needs and constraints faced by different types of farmers. In 2014, CSISA began to systematically explore the expected benefits and costs associated with different management interventions. On-farm trials were conducted in two mid-hill districts. Low-cost interventions to maintain optimal plant populations and improve weed management doubled grain productivity to 3.8 t ha^{-1}. Adding either a hybrid or higher levels of fertilizer to these interventions further increased yields to over 6 t ha^{-1}. With all management factors well managed, grain yields of

maize increased to 10 t ha^{-1}, five times higher than those achieved through farmers' practice—an astonishingly large yield gap that can be closed with better management. When best practices were combined with zero tillage crop establishment practices (conservation agriculture—'CA'), similarly high yields were obtained. CA significantly reduces crop establishment costs and can minimize soil erosional losses—a paramount concern in the hills for ensuring long-term sustainability. Production economics and investment costs for these management options are now being assessed, and will be evaluated in the context of farmer preferences, risk bearing-capacity, and ability to invest in intensification before the next maize season (collaborative with Wageningen University), and will help development partners such as KISAN and DOA better prioritize interventions.



MAIZE HYBRIDS FOR THE HILLS? Farmers in the rainfed hill regions of Nepal typically grow maize for household consumption as well as for livestock feed. Despite the importance of maize to food security and livelihoods in the hills, very few farmers grow hybrids. Ten different medium- to short-duration hybrids were tested at five locations in 2014; under the logic that short- to medium-duration hybrids will permit farmers to reliably establish a second crop that will yield well in the dry season based on timely planting. Due to a weaker monsoon and higher levels of solar radiation, the yields attained in these evaluations were exceptional, with Bioseed 9220 (10.9 t ha^{-1}) and Commando (11.4 t ha^{-1}) as the highest yielding hybrids, producing > 4 t ha^{-1} more than the local landrace and 2.5 t ha^{-1} more than the best OPV (Arun-2), respectively, with the same levels of inputs. However, other hybrids were on par with the OPV Arun-2, highlighting the importance of data-driven extension messaging rather than blanket promotion of hybrids in the hills. Farmers also value non-yield related traits such grain color, and CSISA conducted the first evaluations of white-colored hybrids in the hills (K-65). CSISA is working with dealers and KISAN to ensure farmers understand the benefits of cultivating elite maize hybrids and OPVs and that market availability of hybrids increases.

CREDIT FOR INNOVATION AND INCLUSIVE GROWTH: Nepal has one of the highest out-migration rates in the world, which has led to a rapid feminization of the agricultural workforce. Dr. Sumitra Gurung recently established the first for-profit banks in Nepal providing rural women micro- and meso-credit. The bank is headquartered in Chitlang, Makwanpur, with one of the five branches located in Rolpa district in the Mid West. Dr. Gurung approached CSISA to explore the possibility of demonstrating and training hill women to enable them to effectively own and operate small machinery. A catalog of small farm agro-machinery tools and equipment especially suitable for Nepali women entrepreneurs has been completed by CSISA in consultation with Dr. Gurung and her colleagues. This catalogue will to help guide policies and lending practices for banks that are unfamiliar with loans for agricultural machinery, including scale-appropriate options for women and smallholders, thereby enabling more women to purchase machinery and to form small business.

CSISA-Nepal Overview

The Cereal Systems Initiative for South Asia in Nepal (CSISA-NP, henceforth 'CSISA') began in August 2012, with a core mandate to develop, refine, and target agricultural technologies and management recommendations based on applied biophysical and socio-economics research, much of which is conducted jointly with national partners from the Nepal Agricultural Research Council (NARC) and the Department of Agriculture (DOA). One of CSISA's primary 'clients' is USAID's KISAN project, which, like CSISA, is funded by USAID's Feed the Future (FtF) Initiative, and has the core mandate of fostering adoption of improved technologies and management practices at scale across the sixteen FtF districts of Nepal.[1] CSISA's research focus is aligned with the staple crop mandates of FtF in Nepal: sustainable intensification (SI) technologies for lentil, rice, and maize-based cropping systems. Crosscutting work on mechanization, seed systems, training of 'change agents' (e.g., service providers, KISAN staff, extension partners), and community-based technology evaluations for co-learning with farmers underpins CSISA's approach and helps create an enabling environment for innovation.

CSISA stages its work in the Mid and Far West development regions from four strategically located offices in Nepalgunj, Surkhet, Dadeldura, and Dhangadhi.

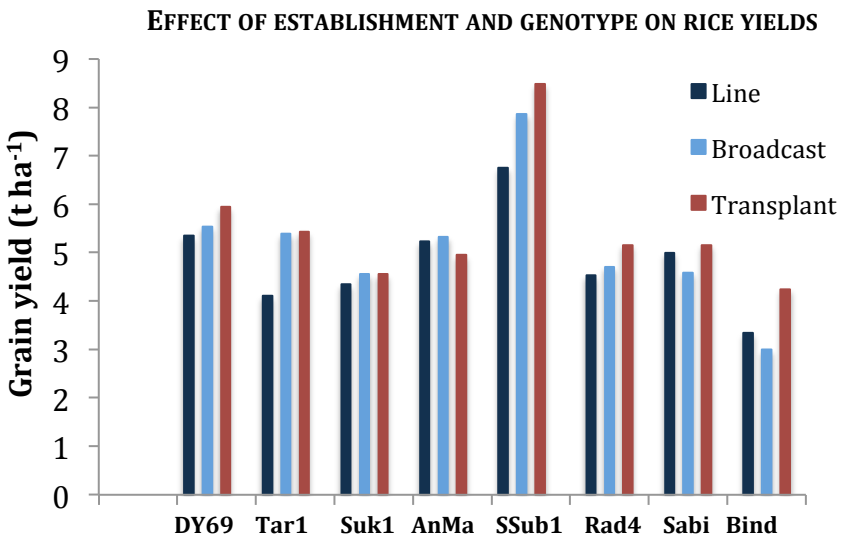
This reporting period covers Kharif (monsoon-season) harvest from 2013, Rabi (winter) season 2013–14, and the pre-harvest period for Kharif 2014. Progress is reported by theme.

1. RICE

RICE: PERFORMANCE OF HYBRIDS AND NEW VARIETIES IN THE TERAI

Although farmers have a diverse set of rice seed choices in Nepal, side-by-side performance comparisons of these choices are limited and **varietal replacement rates are low**, principally because the expected benefits of varietal replacement are either poorly characterized or not well communicated. Screening trials were initiated by CSISA to contribute more information on comparative performance to farmers, seed dealers and producers, and our NARES partners.

During the 2013 rainy season, CSISA conducted on-farm multi-locational testing of different rice varieties and one registered hybrid in the Terai districts of Banke, Bardiya, Kailali and Kanchanpur under better-bet management. Field evaluations assessed the yield performance



[1] The districts are Dang, Pyuthan, Rukum, Rolpa, Salyan, Banke, Bardiya, Surkhet, Dailekh, and Jajarkot in the Mid Western development zone, and Kailali, Kanchanpur, Achcham, Doti, Dadeldhura, and Baitadi in the Far Western development zone.

against commonly planted 'old' rice varieties that were released years or decades earlier. New varieties included: Tarahara-1, Hardinath-2, Sukha Dhan-1 and -3, Anmol Mansuli, and Swarna Sub-1. The hybrid used was the relatively short-duration DY69. Farmer varieties varied depending on location, but included: Radha 4, Sarju-52, Bindeshwari, and Sabitri. Planting methods (i.e., dry broadcast, dry directing sowing in lines, and conventional transplanting) were also evaluated to assess crop performance and farmer preferences for labor and cost saving technologies. Across the evaluation sites, our data suggests consistent advantages of around 1 t ha^{-1} for adoption of new varieties of similar maturity class if farmers are growing Bineshwari ('Bind'), but little advantage otherwise of replacing 'old' varieties with more recently released varieties.

Farmers still growing Bineshwari should constitute the top priority for varietal replacement efforts. For other areas, significant gains in yield potential are possible with hybrids and also with the longer duration variety Swarna-Sub1 (i.e., 'Swarna' background + submergence tolerance gene). However, farmer acceptance of Swarna-Sub1 appears to be limited to poorly drained areas where timely winter crop planting is not possible due to persistently wet soils. In better-drained areas where timely winter crop establishment is possible, adoption of hybrids appears to provide the best pathway for increasing rice yields through seed-based interventions. Farmer preconceptions of poor grain quality with hybrids were alleviated at harvest with no major problems with grain chalkiness or breakage observed. The drought tolerant 'Sukha' varieties did not have any yield advantage over the other newer varieties evaluated and was the second lowest yielding entry in our trials after Bineshwari. These trials are repeated in 2014 to establish the consistency of response across seasons and locations—this year, with very dry early conditions, will provide an interesting contrast to 2013. Crop harvest will be completed in November 2014.

In general, farmers in Nepal do not apply recommended levels of fertilizer. In collaboration with RARS Khajura (NARC), on-station experiments in 2014 evaluate the performance of different registered hybrids and improved rice varieties under different fertility levels to determine if **G x M (genotype by management) interactions** are significant and should inform varietal recommendations.

RICE: ALTERNATIVE ESTABLISHMENT PRACTICES FOR THE TERAI

Traditional rice establishment practices in the Terai transplant rice by hand into puddled (i.e., wet tilled) soil. These practices come at a high cost for labor and energy inputs, and because operations are typically contingent on monsoon onset and the occurrence of inundating rains, rice establishment is often delayed which has yield implications not only for rice but for subsequent crops in the annual rotation such as lentil. Moreover, soil puddling degrades soil quality for non-rice crops, reducing both yield potential and input use efficiencies. CSISA prioritizes research on direct sowing and mechanical transplanting as potential technologies for reducing the energy and labor costs of rice planting while ensuring timely and precise establishment through mechanized sowing. At present, farmers in the FtF zone do not practice these technologies and are unaware of their potential benefits.

SERVICE PROVIDER HARVESTS SEEDING MATS FOR MECHANICAL TRANSPLANTING

Work with **mechanical rice transplanting** (MT) began in the 2013 rice season, with CSISA coordinating trainings, demonstrations, and field performance evaluations with partners including KISAN, DOA, the private sector, and potential service providers. Results from CSISA trials indicate that although

mechanical transplanting did not result in a significant yield increment compared to the conventional manual transplanting method (6.5 vs. 6.4 t ha^{-1}), it did produce significant cost savings (i.e., machine transplanting 1 ha was $70, versus $130 with manual transplanting methods). Evidence from CSISA's work in proximate ecologies in EUP suggests that the cost advantage increases to around $100 per hectare as the service provision market matures.

In response to the trainings conducted in 2013, 11 farmers from the Kalika Village Development Committee (VDC), Kanchanpur used custom-hire services to mechanically transplant rice on 7.3 ha in 2014. Farmers who adopted were driven to do so by the reduced drudgery and costs associated with MT. CSISA's data from Bihar suggest that the MT rice establishment technique can increase on-farm profitability by 30–40% while creating new jobs for service providers with income generating potential of more than $1,000 per season. Continued testing in 2014 will be used to verify or refine these generalizations for Nepal conditions.

Building on CIMMYT's previous work on technology verification and outscaling through service providers in the central Terai, CSISA is evaluating **dry direct-seeded rice (DSR)** using both two-wheel tractor and four-wheel tractor seed drills in the Terai areas of the Mid and Far West regions, with joint demonstrations with KISAN in several locations. DSR has three major advantatges over mechanical transplanting: 1) the unit cost of the machinery is roughly 75% lower, 2) crop nursery establishment and maintenance is not required, and 3) the seed drills can be used for winter crops as well as for rice. In on-farm trials in Rupendhehi District, CSISA documented net increases in profitability of approximately $150 ha compared to conventionally transplanted systems. Following successful initial demonstrations in 2013, more rigorous evaluations are now reaching harvest in 2014. Visual observations and farmers' perceptions indicate that the yields of DSR are commensurate to conventional transplanted rice–expected benefits will be calculated after harvest. Because DSR allows early crop establishment, DSR crop growth was about 7–10 days more advanced than the conventional transplanted puddled rice crop. Early planting of the rice crop opens the window for the timely planting of the subsequent winter crop.

CSISA is working closely with manufacturers, dealers, and service providers to develop the market for, and increase dissemination of, DSR technology in the Terai. With assistance from CSISA, Nepal now has its first national distributer for seed drills whereas farmers used to have to purchase equipment in India and bring it across the border. With KISAN's small grants program for machinery, CSISA is improving access and awareness of the seed drills required for DSR.

RICE: AGRONOMY IN HILL ECOLOGIES

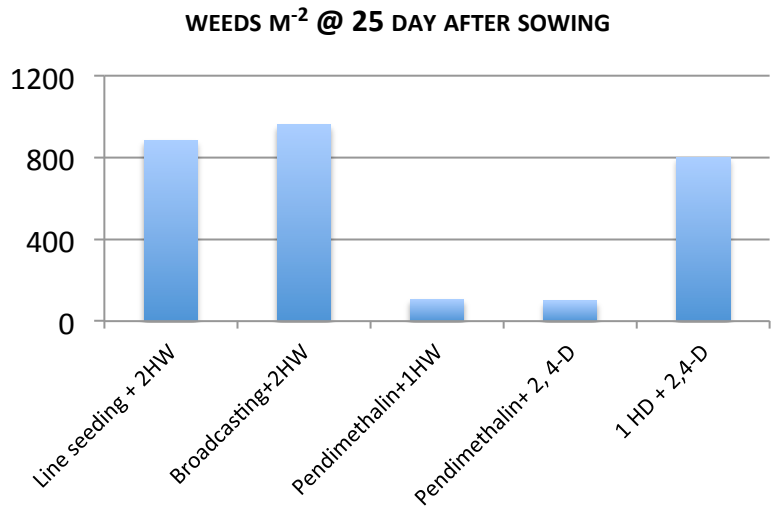
Farmers cultivate **upland rice** in the hills of Nepal under rainfed conditions on soils with low water-holding capacity. In these **risk-prone conditions**, farmers almost exclusively use local varieties without applying fertilizes and, consequently, yields are extremely low (ca. 1 t ha^{-1}). In collaboration with the Regional Agricultural Research Station (RARS) Surkhet (a NARC station), on-station experiments in Kharif 2014 assess the performance of different rice varieties under different fertilizer levels. The rice varieties used for the experiment were Kalanathre (local check), Ghaiya-2 (national released variety for upland

conditions), and Sukhkha Dhan (drought tolerant variety evaluated previously in lowland ecologies), grown under four levels of nitrogen: 0, 40, 80, 120 kg N ha^{-1}.

Due to the absence of persistent flooding, weed infestation is one of the major problems in upland rice. In collaboration with RARS Surkhet, on-station experiments evaluating efficient weed control options for upland rice are also being conducted in 2014. Treatments include:

1. Broadcast seeding with two hand weedings (25 and 55 DAS)
2. Line seeding with two hand weedings (25 and 55 DAS)
3. Pre-emergence application of Pendimethalin + single hand weeding (HW)
4. Pre-emergence application of Pendimethalin + post emergence application of 2,4-D
5. Single hand weeding (at 25 DAS) + post emergence application of 2, 4-D.

Early weed control is vital for reducing competitive losses and weed populations were reduced by a factor of five when modern classes of safe and effective herbicides (i.e., Pendimethalin) are combined either with a single hand weeding or with the most commonly used herbicide in Nepal (2,4-D). When 2,4-D is combined with hand weeding or when only hand weeding is used, early weed control is poor. Yield losses and production economic will be calculated after harvest.



RICE: TRAINING AND OUTREACH

KISAN and CSISA have held several joint field demonstrations of improved rice technologies and conducted exposure visits and trainings in several Feed the Future districts. One of the successes that emerged from this collaboration is that CSISA-NP, KISAN and The Habi Auto, the first national dealer of zero-till (ZT) seed drills for the four-wheel tractor, organized field days for DSR in Kapilvastu before the start of the 2014 rice season. As an outcome of this event and with technical support from CSISA, 26 farmers in this area implemented DSR on 17 ha of land. Four service providers from the area have already expressed interest in purchasing their own seed drill for the coming season, and will be aided by KISAN's small grants program to machinery dealers.

DSR AWARENESS TRAINING FOR KISAN STAFF, SERVICE PROVIDERS, DOA PERSONNEL AND FARMERS IN KAPILVASTU, 2. DSR MACHINERY DEMO 3. DSR FIELD IN KAPILBASTU

TIPS FOR RICE INTENSIFICATION

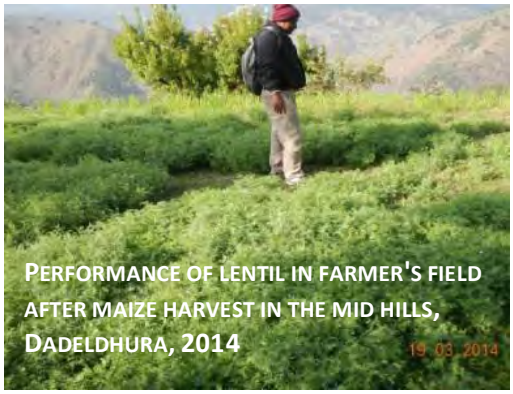
In Nepal, **basic guidance on better-bet agronomic and post-harvest management practices** is either lacking or only available in piecemeal fashion, often in inaccessible formats. To increase the capacity of extension agents, development partners and others to advise farmers on good practices that are proven to increase yields and profitability of rice production, CSISA produced a simple guide to rice production that covers management aspects from 'seed to seed'. This guide draws on regional expertise from IRRI and CIMMYT and was localized for Nepal conditions in consultation with KISAN and NARC partners. It has been distributed through KISAN's networks. With IRRI, CSISA and CIMMYT also helped produce guidelines for DSR production that have been translated into Nepali and circulated widely among research and development partners.

DSR GUIDELINES FOR NEPAL

2. LENTIL

LENTIL: INTRODUCTION IN THE MID-HILLS TO IMPROVE NUTRITION AND INCREASE INCOME

In the mid-hills of Nepal, lentil has the potential to provide a much-needed source of dietary protein and income for farmers through staple crop diversification. At present, production is not very widespread. In CSISA's target domains in the hills, maize + soybean–wheat, maize + soybean–tori, and rice–fallow systems are the most common cropping patterns. CSISA has introduced lentil cropping in these areas as an alternative to wheat,



PERFORMANCE OF LENTIL IN FARMER'S FIELD AFTER MAIZE HARVEST IN THE MID HILLS, DADELDHURA, 2014

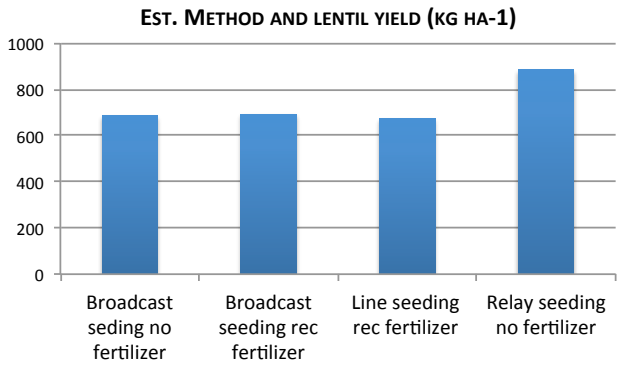
tori, or fallow in these systems. In Rabi season 2013–14, lentil productivity in the Dadeldhura areas was exceptional at around 2 t ha^{-1} grain for the best performing varieties, which is approximately double the national average. There were, however, important **varietal differences in yield potential** with a 0.5 t ha^{-1} advantage achieved with Shital and Shikhar over the varieties Khajura-1, Khajura-2, and ILL7723. It is important to note that these yields were achieved under farmer managed conditions. Participating and surrounding farmers expressed excitement that lentil can be produced under upland conditions in the hills, and are eager to expand the area under lentil this Rabi season.

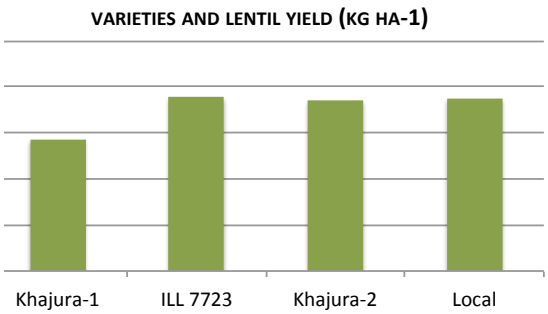
Variety interactions (Khajura-1, Khajura-2, ILL 7723 and local) with planting methods (broadcast vs. line seeding) at two levels of fertilizer application (farmer's practice, i.e., no fertilizer application vs. NARC recommended rate) were also assessed in 2013–14. On a small plot basis, grain yield differences between broadcast and line sowing were not significant, however grain yield increased by 17% with recommended fertilizer rates in Dadeldhura's maize-based systems and 14% in rice-based systems. While these gains are not transformative, they do point to the importance of fertility managment in the hills where soils are largely nutrient depleted—even for legume crops.

LENTIL: IMPROVING PERFORMANCE IN THE TERAI

The western Terai is the most important area for lentil production in Nepal. In CSISA's network of on-farm evaluations, contrary to expectations, 2013–14 lentil yields were significantly lower at 700 kg ha^{-1} than the yields achieved in the novel ecologies where lentil was tested in the mid-hills. Low yields were caused by the occurrence of three sizeable **winter rain events, which negatively affected Terai lentil production** due to the waterlogging and disease pressures associated with wet conditions that persist after rains on the heavier textured soils in the Terai. On the other hand, these same winter rains were beneficial for the lentil crops in the hills because of the sloping nature and coarser textured soil that facilitate drainage.

Establishment practices, fertilizer management, variety performance, and their interactions were also assessed in the Terai. Significant yields gains (> 200 kg ha^{-1}) were observed with relay establishment that entails surface broadcasting into the standing rice crop. Fertilizer application did not impact yield, perhaps because yield potential was low due to waterlogging and disease pressure. Surprisingly, the released varieties ILL 7723 and Khajura-2 performed on par with the local landraces and Khajura-1 was significant lower yielding. These experiment are being repeated in 2014–15 to assess response consistency across years. With a drier winter, we anticipate different dynamics will emerge; moving forward, agro-climatological analysis and seasonal forecast information will be leveraged to refine 'best bet' management options for different ecologies, soil types, and years.





LENTIL: MOBILIZING PARTNERSHIPS TO ACCELERATE IMPACTS

CSISA and the DOA jointly organized a workshop in Nepalgunj on December 12–13, 2013 to discuss options for scaling improved lentil production technologies, and to increase lentil exports through enhanced marketing systems.

Several gaps and needs were identified during the workshop, and included:

- Lack of farmer knowledge regarding best practices for lentil production
- Limited varietal choice, with most farmers growing old varieties with low productivity
- No ecological domain and cropping system-specific recommendations
- Farmers adopting relay production system with no or extremely low inputs
- Lack of postharvest technologies such as seed cleaning or processing
- Weeds, especially *motha* and *bethe* are extremely pernicious in lentil fields, but appropriate herbicide types/usages have not been identified

Some technologies that have been proposed to address these gaps:

- Seed priming, nutrient loading and *Rhizobium* inoculation have also been recommended by the National Grain Legumes Program (NGLP) of NARC. There are, however, problems with inoculum quality that must be addressed.
- NGLP recommends a seed rate of 30–40 kg ha^{-1}, cautioning that there is likely to be higher levels of disease/pathogen infestation at higher plant populations (seed rate > 40 kg ha^{-1})
- Fungal and bacterial diseases such as *Stemphylium*, *Fusarium* wilt, and root rot are major lentil problems and are largely associated with weather, with high temperature (> 30° C) and humidity being favorable for most lentil pathogens. Some control can be achieved via seed treatment with 3 g kg^{-1} Bevistin.
- Black lentil is currently being evaluated for its resistance to *Stemphylium* and other fungal diseases, and breeding efforts with it are in progress.

Some seed sector issues that were identified for lentil are:

- Availability of quality seeds for seed production and general cultivation is a great problem. Seed bags are typically not properly tagged, restricting the certifying process. Specifically, production of foundation seed and certified seed (C1 or C2) are adversely affected.
- The inability to prepare a balance sheet is due to lack of proper planning. Usually the balance sheet is prepared during April–May. Lentil harvest and production estimation have usually not been completed by that time.

Marketing, processing, export and policy issues were discussed, with the following key points noted:

- The open India–Nepal border makes it difficult to control and maintain export and import, or to accurately determine statistical figures
- Processing mills are limited in number, and do not have varietal preferences. The only preference is that half of the grain delivered should be 1.5 mm in size
- The quality of lentil from Nepal is considered to be good with high Fe and Zn concentrations
- It is difficult to obtain the Country of Origin certification, which is mandatory for export, or to meet international norms.

3. MAIZE

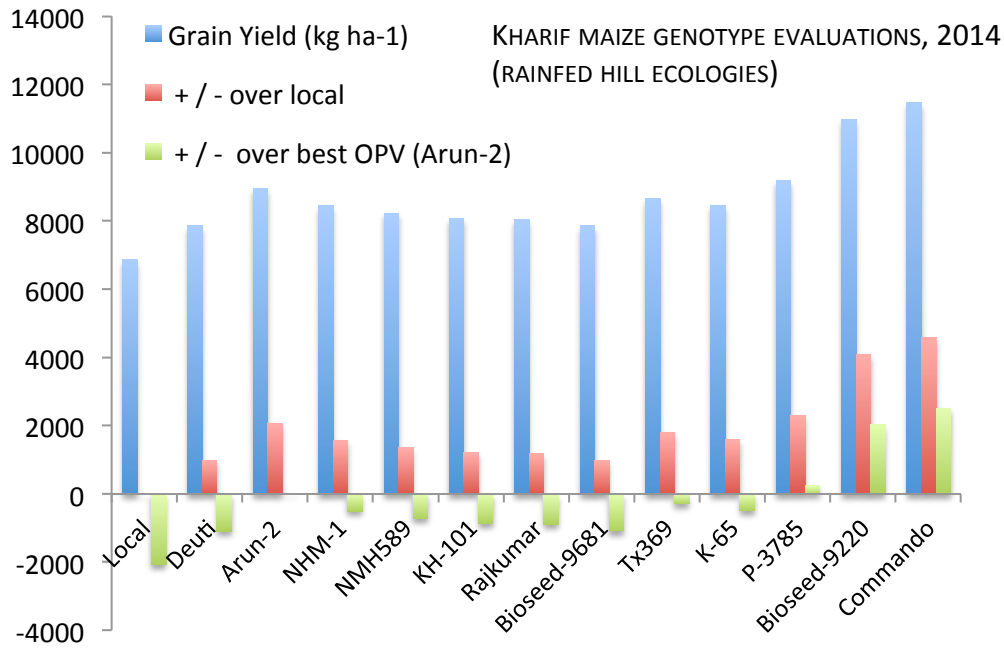
MAIZE: COMPARATIVE PERFORMANCE OF HYBRIDS AND OPVS IN SPRING (TERAI) AND KHARIF (HILLS) SEASONS

The varietal registration process for hybrid maize in Nepal is governed principally by crop performance in the Rabi (winter) season where most of Nepal's commerically-oriented maize crop is produced in the

central and eastern Terai. This leaves important knowledge gaps about the comparative perfomance of registered hybrids in the summer Kharif season (hills) and also the spring season (Terai). With potential profitability of > $1,000 ha^{-1} (CSISA 2013), the latter provides an exceptionally promising entry-point for cropping systems intensification for income generation in the western Terai by moving from double cropping to tripple cropping systems. In the hills, CIMMYT's prior work in Palpa and adjacent districts suggests consistent advantages for hybrids over improved OPVs (ca. 1 t ha^{-1}) but with significant performance variation across hybrids. For these two very different seasons and environment in the FtF zone of western Nepal, CSISA conducted on-farm trials in 2014 with the goal of characterizing the comparative yield peformance of registered commercial hybrids, hybrids developed by the Nepal Agricultural Research Council, and improved OPVs that are popular in Nepal.

For spring season evaluations in the Terai, five different hybrids (Rajkumar, Kanchan, TX 369, P3785, HY 9220) and two commonly used OPVs (Rampur composite and Arun-2) were tested at four locations with best management practices. Irrespective of the location, Rajkumar (4.4 t ha^{-1}) and TX 369 (4.3 t ha^{-1}) were the highest yielders, with lower productivity observed with P3785 at 3.1 t ha^{-1} which was out-performed by the OPV Arun-2. Rampur Composite did not perform well in this season at just over 2 t ha^{-1}. Due the very warm conditions this past spring, yields were lower across the board than in 2013. Experiments will be repeated in 2015 to assess G X E (genotype by environment) interactions and performance stability across years with different levels of heat stress.

For Kharif season evaluations in the hills, ten different medium- to short-duration hybrids, including two hybrid's developed by NARC, were tested at five sites in Dadeldhura and Surkhet Districts under best management practices. In these rainfed production systems, the rationale for working with the short- to medium-duration hybrids is to permit farmers to reliably establish a second crop that will yield well in the dry season based on timely planting. Due to a comparatively weak monsoon and higher levels of solar radiation, **mazie yields attained in 2014 were exceptional**, with even the local variety yielding 6.5 t ha^{-1} under sound agronomic management. Irrespective of location, Bioseed 9220 (10.9 t ha^{-1}) and Commando (11.4 t ha^{-1}) and were the highest yielding hybrids, respectively producing 4 and 4.5 t ha^{-1} more than the local landrace and 2.0 and 2.5 t ha^{-1} more than the best OPV (Arun-2). However, other hybrids were on par with Arun-2, highlighting the importance of data-driven extension messaging rather than blanket promotion of hybrids in the hills. Farmers also value non-yield related traits such grain color, and CSISA conducted the first evaluations of white-colored hybrids in the hills (K-65). In areas like Dadeldhura where maize is directly consumed as a food security crop, farmers

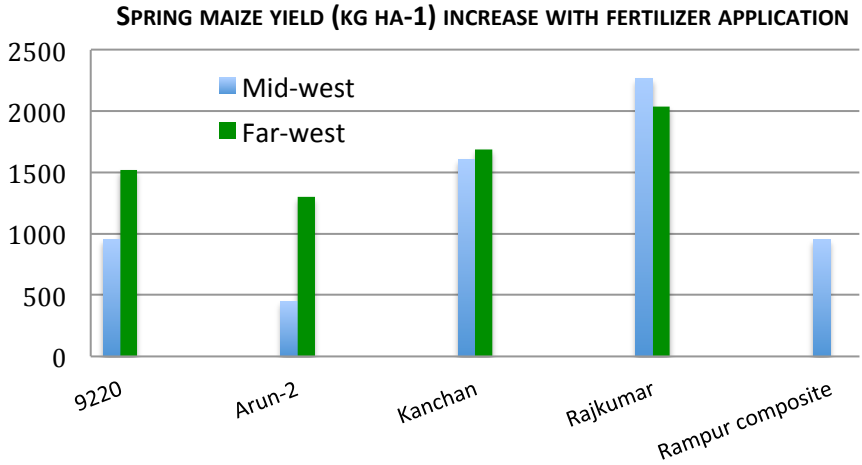


expressed a preference for this hybrid and plan on planting it next Kharif season. Since the climate this Kharif season was atypical, so perhaps were our results. Similar trials will be conducted in 2015.

CSISA is working with dealers and through KISAN ensure farmers understand the benefits of cultivating elite maize hybrids and OPVs and that market availability of hybrids increases.

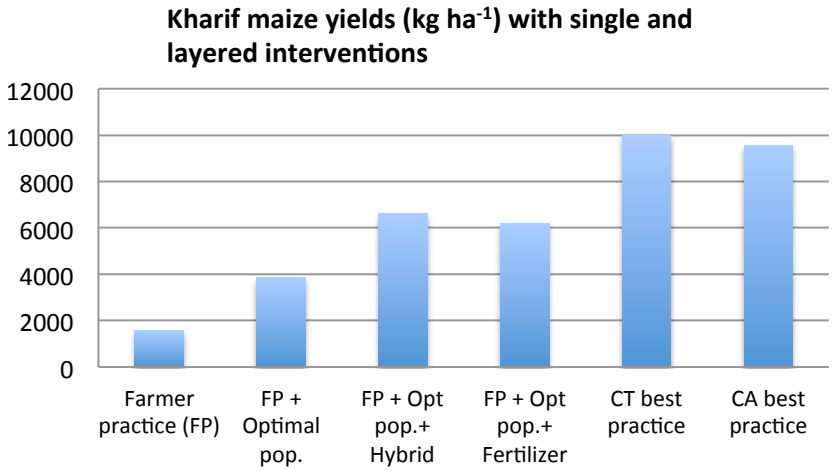
MAIZE: NEW ECOLOGY, NEW PRACTICES → AGRONOMY FOR SPRING MAIZE

Spring maize is largely a new crop in Nepal with a niche in irrigated areas of the Terai. Existing **management guidelines are not geared towards increasing productivity and profitability for this season**. In 2013 and continuing in 2014, CSISA initiated a series of participatory on-farm research trials to define best bet management practices for spring maize. On carefully managed plots, results indicate no difference in grain yield between the line-seeded and the broadcast-seeded maize, but farmers reported that under line seeding, intercultural operations such as weed management, irrigation and fertilizer application were easier and less expensive than under broadcast seeding. Under farmer-managed fertilizer and a research guided rate derived from experiments 2013, grain yields increased substantially (0.5 to 2.0 t ha-^{1}), but responses were not consistent across genotypes or sites, highlighting the importance of accounting for these factors for deriving precise, efficient, and profitable fertilizer recommendations. CSISA is leveraging these trials to build robust decion support frameworks for soil management in maize systems.



MAIZE: DECOMPOSING YIELD GAPS IN THE HILLS

In general, maize yields in the hills are persistently low and few efforts have systematically assessed either the production potential in these systems or identified sensible entry points towards sustainable intensification that can be selectively matched to the needs and constraints faced by different types of farmers in the region. In 2014, CSISA-NP started to systematically



n Person: *Scale-appropriate mechanization benefits women in the hills*

BY TIMING PLANTING THOROUGH SCALE-APPROPRIATE MECHNANIZATION AND ADOPTION OF HYBRID SEEDS, LAXMI KHADKA IS CONFIDENT THAT SHE CAN MEET HER FAMILY'S FOOD SECURITY NEEDS.

CSISA IS WORKING WITH DOA, KISAN, FINANCIAL INSTITUTIONS, MACHINERY IMPORTERS, AND OTHER DEVELOPMENT PARTNERS (E.G., SAMARTH) TO INCREASE ACCESS TO SCALE-APPROPRIATE MACHINERY IN NEPAL

Mrs. Laxmi Khadka, 30, is a progressive farmer based in Amargadi municipality-9, Littrigaun, Dadeldhura. She lives with her husband, two sons and daughter. Their farm is a mixed crop–livestock enterprise where they cultivate upland rice, wheat, maize and vegetables. In the mid-hills of Nepal, seasonal and semi-permanent male outmigration occurs at one of the world's highest rates, which creates labor bottlenecks that erode profitability and compromise the timing of key agricultural operations. A present, Laxmi spends most of her time tending to her agricultural fields and livestock, and struggles to balance her farm work with the needs of her family. Across the mid-hills, the burdens of farm management are falling increasingly on women household members like Laxmi who remain behind. Further, the number of bullocks has declined precipitously, which also delays key farm operations like ploughing. For both reasons, the niche for scale-appropriate mechanization is strong, but beyond the reach and current experience of most farmers.

In Laxmi's community, CSISA introduced the mini tiller as low-cost option for rural traction and identified a group-based service provision model to recoup costs and share the technology across the village. Although initially apprehensive, community members quickly realized that the mini tiller saves time and money, and Laxmi observed she was able to plant her maize with the onset of the spring rains as she didn't need to wait to hire labor or bullocks.

"From now on, we will not have to depend on the men for ploughing," said Laxmi.

Farmers did observed that it can be difficult to carry the mini tiller from one terrace to another, especially when terraces are at different heights and separated by bunds. These small problems have been solved through the collective action of the group with 2–3 farmers coordinating planting and machinery transportation from field-to-field. Farmers have also learned that operation of the mini tiller is relatively easy with most women trained in the technology by CSISA expressing and demonstrating confidence in its operation.

With timely planting assured with the mini tiller, Laxmi was also eager to evaluate additional productivity-enhancing technologies and planted maize hybrids for the first time in 2014. Her productivity levels tripled from 2013, and she produced a marketable surplus (30% of production) that was a importance source of cash income for her family.

explore the expected benefits and costs associated with different management interventions. On-farm trials were conducted in two mid-hill districts (Dadeldhura and Surkhet) in six farmers' fields. The average yield of maize under farmer management was less than 2 t ha^{-1}. The low-cost interventions of maintaining optimal plant population and improved weed management practices doubled grain productivity to 3.8 t ha^{-1}. Adding either a hybrid or higher levels of fertilizer to these interventions further increased yields to over 6 t ha^{-1}. With all management factors well managed, grain yields of maize increased to 10 t ha^{-1}, five times higher than those achieved through farmer practice. When best practices were combined with zero tillage crop establishment practices (conservation agriculture–'CA'), similarly high yields were obtained. CA significantly reduces crop establishment costs and can minimize soil erosional losses—a paramount concern in the hills for ensuring long-term sustainability. Production economics and investment costs for these management options are now being assessed, and will be evaluated in the context of farmer preferences, risk bearing-capacity, and ability to invest in intensification before the next maize season (collaboration with Wageningen, see Victoria Alomia's PhD work description at the end of this report). This work will help development partners such as KISAN and DOA better prioritize and target interventions.

4. MACHINERY

MACHINERY: SELECTED TRAININGS AND DEMONSTRATIONS

CSISA's machinery trainings, demonstrations, and participatory evaluations with farmers and service providers focus on expanding the palette of machinery options so that different land management, crop establishment, harvest, and post-harvest technologies can be well matched and prioritized for particular geographies or groups of farmers. In 2014, CSISA emphasized the following mechanization options for field demonstration, training, and evaluation: multi-crop seed drills (including no-till), laser land levelers, bed planters, reapers, threshers, maize shellers, and axial flow pumps for efficient irrigation.

DEMONSTRATIONS OF SCALE-APPROPRIATE TECHNOLOGIES

For example, trainings for a two-wheel tractor-drawn reaper were conducted during wheat harvest in Malakheti-7, Khairana VDC, in Kailali district, and Maina Pokhar in Bardiya-where a potential service provider was also identified; CSISA supports small- and medium-sized enterprises for mechanization whenever possible. In Kailali there were 38 attendees, including 14 women.

Several trainings-cum-demonstrations of four-wheel tractor-drawn seed drill were conducted for farmers growing maize in Malakheti (Kailali District) and Dodhari, Neulapur, and Bansgadhi villages in Bardiya District. A two-wheel tractor seed drill was demonstrated to farmers in Nauvastha, Banke District, where four-wheel tractor are not common. Maize sowing with a mini-tiller seed drill attachment was also evaluated with farmers in Kailali and in Gadhi VDC (mid-hills), Surkhet, respectively.

To facilitate regional cross-learning with farmer from India, CSISA made it possible for 6 progressive farmers from Bardiya to attend a travelling seminar through CSISA sites in Eastern Uttar Pradesh, India on May 8 and 9. Participants saw and heard about laser land leveling technology, zero till (ZT) wheat, machinery, and interacted with local farmers and service providers to understand the service

n Focus: *Combines as a case study of technolgy introduction in NP*

The rice–wheat cropping system is the dominant cropping pattern in Nepal's Western Terai. In this area combine harvester (CH) use has been increasing since late 1990s when Indian owned combine harvesters began to cross the India–Nepal border.

A study was conducted from May–September 2014 on the spread of combine harvesters in three districts of Nepal's Western Terai namely Nawalparasi, Rupandehi and Kapilvastu. One hundred combine owners, along with 100 of their clients, and 30 non-users were randomly selected from these three districts.

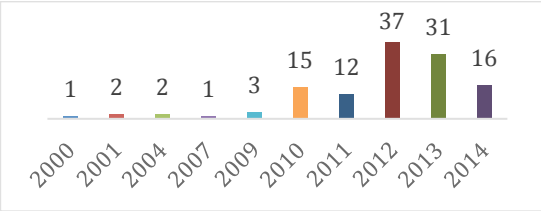
The study of combine harvesters was undertaken in order to understand better the issues, benefits and problems associated with the spread of combines—including the issue of residue burning, which farmers often practice after adopting this technology. The Nepal government banned burning of crop residues in April 2014.

RESULTS AND DISCUSSIONS

The study showed that combine harvester availability and use has greatly increased from 2010 onwards. Presently, there are about 150 CHs in the three districts. It also showed that combines reduce labor costs by $116 and $88 in wheat and rice, respectively. Users also report that they decrease the risk that bad weather could damage or destroy the ripening grain by ensuring timely field operations.

Interestingly, there are many CH users who still harvest a significant percentage of their total area manually (63% in rice and 32% in wheat). Nearly all combine users report they needed this hand harvested residue for livestock feeding as there is a perceived quality loss of the combined residue (e.g., from 'stink bug' contamination), as well as difficulty in collection of the residue itself after the combining. The study showed that 87% of all CH users are burning combine residue while approximately 22% of farmers, are also collecting some of the residue. Ninety percent of this collected residue is wheat residue due to the availability of a wheat straw reapers/harvesters (there is no similar rice straw reaper/harvester).

Combine harvester use in these districts is approximately 10% of the rice and 20% of the wheat area. Despite the relatively small area being harvested with this technology, combine owners report that there is increased competition in getting customers and that payback is getting longer and more difficult.



Combines purchased in different years (n=120)

CONCLUSIONS AND RECOMMENDATIONS

Despite clear economic benefits and market availability of combine technology in these three districts, most farmers are still not adopting. One of the main reasons behind this is that small and fragmented holdings keep the large horsepower combines prevent access to an estimated 70% of farmers' fields. Smaller scale machinery like mini-combines, two- and four-wheel tractor reaper harvesters, etc. could increase access to mechanized harvesting.

The other looming problem is residue management and burning of valuable residues. Increasing the numbers of residue management and collection machines like straw reaper/harvesters, balers, rakes, mowers and conservation agriculture seeders and planters could greatly decrease the need for burning.

interactions with the local farmers and service providers about ZT technology and use of machinery in these more developed districts. The Bardiya farmers were impressed with the technologies they encountered, and requested CSISA staff to provide technical knowledge, training and machinery that would enable them to replicate some of what they saw.

MACHINERY: INTRODUCING AND BUILDING MARKETS FOR ADVANCED TECHNOLOGY

SMALL PLOTS DOMINATE IN THE WESTERN TERAI

Proper land leveling is a key component of good agronomic, soil and crop management, all of which contribute to crop yield and economic returns. In the absence of good technologies for levelling, farmers in the mid- and far-western Terai resort to dividing larger fields into small ones through bunding. The elimination of bunds increases the cropping area and reduces the labor burdens associated with bund maintenance and repair. CSISA introduced the first laser levellers in Nepal into the central Terai in 2010; this advanced technology has scope to significantly change land and resource productivity in the west through land aggregation and water control achieved through precision levelling rather than bunding.

LASER LEVELING CAN TRANSFORM LAND AND WATER PRODUCTIVITY

With NARC and other partners, CSISA has undertaken on-farm demonstrations of laser land leveling. CSISA is also working to develop linkages between manufacturers, traders, service providers and farmers. As part of this approach, CSISA hosted a visit and stakeholder consultation with TRIMBLE in May 2014. On the back of that engagement, TRIMBLE is exploring the development of distribution channels in Nepal—at present this advanced technology is not commerically available and must be purchased from India.

In 2014, CSISA conducted the first demonstrations of **axial flow pump (AFP)** technology in Nepal in with farmers in Banke and Bardiya Districts. In areas with surface water resources, CSISA has demonstrated that AFPs can increase the energy efficiency of pumping by 50%. One of the demonstrations in Banke was organized on the auspicious day of Asar-15, which is known as Rice Day, and involved Department of Agriculture District Officers, representatives of the KISAN Project, male and female farmers and media. Participants were impressed with the efficiency of the AFP and expressed that the axial flow pump could be a boon to small farmers in Terai and inner Terai regions of Nepal.

BREAKING THE ENERGY-WATER NEXUS WITH EFFICIENT PUMPING TECHNOLOGIES

CSISA has also facilitated the manufacturing of two AFPs in Nepal, at the Agriculture Engineering Division of the National Agriculture Research Council, Kulmaltar, and through an NGO, the National Agricultural and Environmental Forum in Bhairahawa. A brochure and flier have been created on the use of the AFP, and are ready for dissemination. CSISA is placing AFPs with dealers in the Terai to jump-start market development for this technology on a commercial footing.

MACHINERY: SUPPORTING 'INTERMEDIATE' TECHNOLOGIES

Hand broadcasting of fertilizers is a common practice in Nepal, which, unfortunately results in patchy distribution and inefficient use. As **a low-cost ($25) approach to precision management**, CSISA demonstrated fertilizer application using the manually operated Earthway® spreader

(http://earthway.com/product/2750-nylon-bag-seeder-spreader.ashx), which results in uniform application of fertilizers—or broadcasted seed—in the field. During the 2014 rice season, 30 farmers from Kailali district used the spreader for topdressing urea on about 20 ha. Farmers reported a high level of comfort using the spreader, and observed that farmers of all ages (elderly men, women and youths) can use this technology. Farmers also expressed that the spreader reduces field time, is easy to operate, can regulate the amount of fertilizers distributed, and improves uniformity in application. Yield and production economics achieved with precision fertilizer application will be estimated based on rice 2014 harvest data.

MACHINERY: SUPPORT TO THE PRIVATE SECTOR

After being formed with assistance from CSISA in 2013, **Agricultural Machinery Merchants Association** was renamed Nepal Agriculture Machinery Entrepreneurs Association (NAMEA). Continued core support for this initiative has been provided by CSISA and its partners in NARC Agricultural Engineering Division and DOA Engineering Directorate.

MEMBERS OF NEPAL AGRICULTURE MACHINERY ENTREPRENEURS ASSOCIATION MEETING WITH HON. HARI PRASAD PARAJULI AT HIS OFFICE SINGHA DURBAR ON JUNE 11TH, 2014.

On June 11th, NAMEA met with the Hon. Agriculture Development Minister Hari Prasad Parajuli and presented an eight-point memorandum for improving the business climate for mechanization in Nepal. The MOAD response to this dialog has been extremely positive the many of the ideas put forward are likely to be included in the forthcoming *Agriculture Entrepreneurship Promotion Act* and *Agriculture Act*.

IMPROVING SHELLER DESIGN
WITH KN TRADERS, DHANGADHI

CSISA has identified a few niches where **Nepali machinery manufactures** may have a competitive edge, including post-harvest technologies for maize. Scott Justice, CSISA's rural mechanization expert, has been working with KN Traders in Dhangadhi to design and fabricate single-cob and high-volume maize shellers. Encouragingly, these shellers are both price competitive and of higher build quality than shellers from Chinese manufacturers. Evaluations have been conducted in farmer's field and with national research partners (NMRP and the Agriculture Engineering Division of NARC) and further design improvements are being implemented. Nepal has one of the highest out-migration rates in the world, which has lead to a **rapid feminization of the agricultural**

workforce. Dr. Sumitra Gurung recently established the first for-profit banks in Nepal providing rural women micro- and meso-credit. The bank is headquartered in Chitlang, Makwanpur, with one of the five branches located in Rolpa district in the mid-west. Dr. Gurung approached CSISA to explore the possibility of demonstrating and training hill women to enable them to effectively own and operate small machinery. A catalog of small farm agro-machinery tools and equipment especially suitable for Nepali women entrepreneurs has been completed by CSISA in consultation with Dr. Gurung and her colleagues. This catalogue will to help guide policies and lending practices for banks that are unfamiliar with loans for agricultural machinery, including scale-appropriate options for women and smallholders, thereby **enabling more women to form small business**.

MACHINERY: STRATEGIC COLLABORATIONS WITH NARC, DOA, AND KISAN

NARC and DOA are CSISA's key national collaborators for research, trainings, and demonstrations related to the identification of adapted mechanization options for different ecologies in Nepal. The following activities highlight some of the areas of collaboration with NARC, DOA and KISAN to support scale-appropriate agricultural mechanization.

Support for trainings on laser land leveling: CSISA and NARC organized a laser land leveling training for service providers in Birgunj on April 10–12, 2014. Attendees for this training included potential service providers, operators from NARC, and CSISA staff and scientists.

Support for the 1st National Agro Machinery Fair: CSISA worked with the Engineering Directorate and other partners (e.g., Agro Enterprise Centre of the Federation of Nepalese Chambers of Commerce and Industry) to help organize and support the first national Agro Machinery Fair held February 21–24, 2014 in Narayanghat, Chitwan District. Fifty companies participated in the fair, and there were many firsts, including the first four-wheel tractor ZT drill (National Agro) being offered for sale by a Nepali company, The Habi Auto.

With input and guidance from CSISA, KISAN designed a **small grants program** for agricultural mechanization. The grants program promotes agricultural mechanization through demonstrations and trainings on mini-tiller, two-wheel and four-wheel tractor attachments and facilitates the availability and repair of these machines through commercial channels in order to strengthen markets while awareness and demand are generated. These grants target registered Nepali dealers and importers of agriculture machinery in selected KISAN districts.

5. Seed Systems

Towards sustainable seed systems in Nepal: do we need a 'summit'?

June 30, 2014
Ministry of Agricultural Development
Government of Nepal

"A sustainable seed system will ensure that high quality seeds of a wide range of varieties and crops are produced and fully available in time and affordable to farmers and other stakeholders." *FAO*

In collaboration with the Ministry of Agricultural Development, KISAN, and the USAID-Nepal mission, CSISA has drawn together a diverse group of public and private sector partners that are Identifying key areas of weakness or emerging opportunities in Nepal's seed systems that with near- and medium-term coordination, partnership and investment, will likely significantly enhance the performance of both formal and informal seed systems in Nepal. Ongoing consultations and stocktaking will culminate in a Seed Summit by Q2 2015. Crucially, we envision that a roadmap for action will emerge as a key output of the summit. To ensure progress towards the outcomes targeted in the roadmap and as part of this project, CSISA will continue to play a convening role to help ensure broad progress towards roadmap objectives as well as fostering linkages among partners. Crucially, MOAD has assumed full ownership of convening the summit with assistance from development partners.

6. Capacity Development

Capacity Development: Short-term Training

In Nepal, a strong national commitment to high-quality field research is not typically matched by a commensurate commitment and capacity for high-quality data analysis, data archiving with clear meta-data standards, and other best practices required to confidently derive and share research outcomes. In response to these needs, CSISA organized a 5-day training course (September 15–19, 2014) on data management and statistical analysis at NARC's Regional Agriculture Research Station, Khajura, Nepal. The participants for the training included CSISA staff, CSISA funded PhD candidates from NARC and DOA, collborating NARC scientists, and USAID-funded partner organization staff. The main objectives of the training were to acquaint the trainees with the R statistical package (free software) for data management and statistical analysis.

Capacity Development: Adavanced Scholarship with NARC and DOA

To build capacity while broadening and strengthening CSISA's field research, CSISA provides technical and financial support for seven PhD candidates who are current staff members at either DOA or NARC. Research themes include:

1. Assessing options for agricultural farm mechanization in the Terai and Mid-hills of the Mid-western Development Region of Nepal (P. Acharya, DOA).
2. Analysis of seed value chain for maize in mid and far western development region of Nepal (Rajendra Prasad Mishra, DOA)
3. Performance of rice-maize cropping system under conservation agriculture practices in western Terai region of Nepal (K. Dawadi, DOA)

4. Evaluation of local botanicals and storage bins against storage pest of rice, maize & wheat grain in Mid-western development region of Nepal (Pursotam Raut, DOA)
5. Post-harvest pest management for maize in the mid-hills and Terai of Nepal (Ram Babu Paneru, NARC)
6. Conservation agriculture practices for maize-based cropping systems in the far-western hills of Nepal (Hari Prasai, NARC)
7. Maximizing productivity of winter maize through improved agronomy (Nava Raj Acharya, NARC)

CAPACITY DEVELOPMENT: COLLABORATIONS WITH ADVANCED RESEARCH INSTITUTIONS

Two additional PhD scholars (Victoria Alomía, John Laborde) enrolled at foreign universities (Wageningen University, University of Nebraska) are conducting collaborative work with CSISA in Nepal. Victoria's program spans on-farm field work at CSISA's sites in the Mid and Far West development regions, whereas John's experiments are conducted at NARC Agronomy Division (Khumultar) with additional trials in place at National Maize Research Program (Rampur).

#1 SUSTAINABLE INTENSIFICATION OF CEREAL-BASED AGRO-ECOSYSTEMS THROUGH CROP-LIVESTOCK INTEGRATION AND DIVERSIFICATION IN THE TERAI AND MID-HILLS OF NEPAL (VICTORIA ALOMÍA, WAGENINGEN UNIVERSITY)

The research seeks to evaluate crop–livestock integration and systems diversification as pathways to achieve sustainable intensification at different spatial and temporal scales. In the mid-hills, the emphasis in on system interactions at the farm scale with respect to nutrient cycling, crops diversification and viability of fodder crops; while in the Terai, the study looks at sustainability from the village to regional scale, e.g., feed and animal production for market integration. Parallel to that, the study explores farmer perceptions and objectives in term of adoption of innovative practices. The research will provide options to redesign farming systems with the direct involvement of farmers in all stages.

Methods

The methodology follows four steps: (1) Diagnosis: to explore the diversity of farming systems and farmer objectives; (2) Trade-offs assessment and identification of pathways: to minimize potential trade-offs between livelihood objectives and ecosystem services, and to generate solution spaces for farm configuration, (3) Evaluation of promising configurations through on-farm trials: in order to explore farmers' perceptions towards adoption of innovative technologies. (4) Agro-environmental trade-offs at the community level: to analyze farm configurations effects at village level assessing feasibility and trade-offs.

Progress and preliminary findings

Currently, the steps 1, 2 and 3 are being developed. In the diagnosis phase we used a Rapid Rural Appraisal with 103 farmers and are developing functional typologies of farms in the two different agro-ecologies. At the same time, we selected 10 farms from each location for Ecological Network Analysis and explore trade-offs in different types of farming choices using the FarmDESIGN model. Field trials were conducted on 22 farms (of different types) in 2014: 11 in Dadeldhura and 11 in Palpa under an intercrop arrangement with maize–soybean and maize–cowpea. Additionally, fodder species were planted in marginal fields. The preliminary results show an increase of yields with better agronomy and diversification (kg ha^{-1} in Palpa: Sole maize: 5736.22; Maize–cowpea: 6369.28; Maize–soybean: 5695.99). Besides evaluating options that increase bio-mass production for livestock feed, with the goal of evaluating the trade-offs and drivers of farmers of crop management, we applied a participatory approach using a game board (based on gaming theory concepts) to (1) determine farmers' current activities and preference regarding the innovations tested in the trials; (2) obtain qualitative data of the preference of labor, money and inputs allocation in the cropping configurations in Kharif season, (3) and to assess the effect (if any) of the participatory-experiments on the preferences and views of farmers on the innovations tested in the trials. These results are still in progress.

#2 Extending Nepal's Cropping Calendar Through Conservation Agriculture (John Laborde, University of Nebraska)

Nepal has a monsoon climate characterized by a heavy rainy season lasting approximately four months followed by an eight-month dry season. Scarcity of water resources during Nepal's dry season is the limiting factor for maize-based cropping systems that dominate the agro-ecologies found in the mid-hills of Nepal. Implementing management practices that preserve soil water resources during the dry season could potentially boost crop yields, enable farmers to use longer season maize varieties by extending the planting calendar of secondary crops, or even enable farmers to plant a crop that under conventional practices is not viable because of water scarcity.

Several management practices collectively known as conservation agriculture have been widely cited as providing many agronomic benefits including soil moisture preservation. CA is based on three essential management principles: (1) zero-tillage, (2) residue retention, and (3) crop rotation. On the other hand, CA has come under criticism by some for reducing crop productivity within the first few years of implementation before benefits are seen—a cost many small farmers in Nepal may not be able to afford. However, a gap in the literature exists in regards to quantifying the extent of these detrimental effects (if any) and determining under what conditions transitional years might be significant, negligible or absent.

An experiment is being conducted in order to determine how CA influences crop growth and the underlying biophysical factors driving these changes in the Nepal context.

Methods

With NARC colleagues (Agronomy Division, Khumultar) a field experiment was established in May 2014 in rainfed maize-based system to determine how zero-tillage, residue retention, and maize variety duration influence maize and the subsequent winter crop in the rotation. Complementary trials were established on farm (Lalitpur District) and on-station at the National Maize Research Program. The experiment has three factors with two treatments within each factor: (1) Tillage: conventional till vs. zero till, (2) Maize variety: shorter duration hybrid vs. longer duration OPV, (3) Rotation: wheat vs. tori. Weekly data measurements have included soil volumetric content, the normalized difference vegetation index, and plant stage and height. Approximately every 10 days, biomass (partitioned) as well as leaf area index measurements are taken. Soil physical parameters as well as nutrient and organic matter analysis will be conducted at the end of each year.

Progress and preliminary findings

Preliminary results have shown that the growth and yield of the initial maize crop was modestly reduced in the CA system as compared to the conventional system. However, in the secondary dry-season tori crop, the CA system has shown to be superior in growth parameters, which will likely translate into greater yields. No differences between tillage systems have been observed thus far in wheat during its early growth stages. To extend field findings, the Decision Support System for Agrotechnology Transfer modeling platform is being employed to conduct a multi-year sensitivity analysis to determine how crop performance and technological innovation in these systems may be influenced by site and year factors.