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ANNUAL REPORT 2015

The Cereal Systems Initiative for South Asia in Nepal

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

Annual Report
November 2015

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International Maize and Wheat Improvement Center (CIMMYT)

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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
Kg	Kilogram
KISAN	Knowledge-intensive Sustainable Agriculture and Nutrition project
LLL	Laser Land Leveler
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
RARS	Regional Agricultural Research Station
SEAN	Seed Entrepreneurs Association of Nepal
SI	Sustainable intensification
SP	Service provider
ST	Strip tillage
SWOT	Strengths, Weaknesses, Opportunities, Threats
TPR	Transplanted rice
USAID	United States Agency for International Development
ZT	Zero tillage

SUSTAINABLE INTENSIFICATION

- Quantitative field evaluations demonstrate that **rice hybrids consistently yield 0.5 – 2 t ha^{-1} more than elite varieties**, **even under farmer management** where input levels are low. Hybrids not only improve yield but also **nitrogen use efficiency**, which is a critical concern in Nepal where fertilizer usage in staple crops is the lowest among South Asian countries.
- Hybrid rice matures **7- 10 days earlier** than most varieties, thereby helping to ensure timely winter crop establishment.
- Labor constraints are delaying critical field operations like rice transplanting across the Feed the Future (FtF) zone. CSISA has introduced **directly sown rice (DSR)** technology to the Mid and Far West Terai districts as a means to **save labor and ensure timely establishment**. On-farm evaluation trials demonstrate that DSR yields can be roughly commensurate with transplanted rice, while crop establishment **costs are reduced by $200 ha^{-1}**.
- Evidence suggests that simple changes to rice agronomy such as increasing the planting density for older seedlings hold considerable scope for **increasing resilience to climate extremes** such as delayed onset of monsoon rains – a common occurrence in the last decade.
- Upland rice systems in the hills where yields are less than 1 t ha^{-1} are often consider too stress-prone for intensification. Nevertheless, CSISA data suggests that **upland rice productivity can be doubled or even tripled** with the adoption of modern varieties and judicious fertilizer use.
- Scale-appropriate **mechanized seeding options** for maize help ensure precision stand establishment (increasing yields by 50%) while **reducing planting costs by half**.
- Lentil yields in the Terai were again negatively impacted by significant winter rains, which negated any benefits from innovative agronomy or varietal replacement. Nevertheless, CSISA's network of crop-cut observations demonstrate that **well-drained soils in the Terai have relatively stable yields in wet winters, suggesting that these lower-risk areas can be targeted for intensification**.
- **Lentil yields in the hills significantly out-performed those in the Terai**, and the benefits of varietal replacement were high. Output market development for lentils in the hills will be an important 'pull' factor to incentivize increased production.
- Farmers in the FtF Zone use less fertilizer than elsewhere in Nepal. CSISA data demonstrates that the simple step of investing $60 ha^{-1} in fertilizers can **improve wheat yields by 1 t ha^{-1} while boosting profitability by $140 ha^{-1}.**
- Field evaluations of **precision broadcasting technology** for nitrogen topdressing demonstrates **yield and efficiency gains of 9 – 12% for wheat** while reducing labor costs.
- **Productivity of rainfed wheat production systems in the hills were tripled** with varietal replacement and modest investments in fertilizer.

SEED SYSTEMS

- SWOT analysis was utilized to document the **current status and prospects for growth of Nepali seed enterprises**. Business and technical mentoring are ongoing, including exchange visits with established seed enterprises in India.
- With assistance from CSISA, SEAN (**Seed Entrepreneurs Association of Nepal**) has reviewed and revitalized its visions of success and ambitions.
- With assistance from CSISA, the Ministry of Agricultural Development (MoAD) held the first of its kind **'Seed Summit'** to identify near- and medium-term actions that will lead towards the ambitious goals established in the Seed Vision and ADS strategy documents for the emergence of robust seed systems in Nepal.
- Commercially available maize hybrids are not registered by the GoN for the hills or Terai in the FtF zone, which greatly limits farmer access to technology that can transform yield

potential, even with no other changes in crop management. Based on existing data resources, **CSISA is collaborating with the National Maize Research Program and Seed Quality Control Center to fast-track maize hybrid registration processes for the FtF zone**.

MECHANIZATION

- CSISA helped form and continues to support the **Nepal Agricultural Machinery Entrepreneurs Association** (NAMEA) by:
    - supporting study and business linkage tours (China + India)
    - hosting the NAMEA secretariat
    - stimulating critical dialogues between the public and private sectors
    - jointly conducting market development activities through demonstrations and service provider trainings
- CSISA's approach to achieving impact with farmers through markets and public-private partnerships is starting to pay off. From a base of zero, **private sector reaper sales for the 2-wheel tractor exceeded 100 units** during the reporting period with importers adding new stocks of more than 400 units in advance of 2015-16 Rabi season. Similar sales growth has been observed for the electric maize shellers introduced into the FtF zone by CSISA.
- **New marketing arrangements have been formed with Indian companies** for Nepal-based stocking and distribution of zero-till seed drills and laser land levelling equipment. Before CSISA's efforts with the private sector, these technologies were not commercially sold in the FtF zone.

Supported by the USAID-Nepal mission, CSISA's research focus is aligned with the staple crop mandates of Feed the Future (FtF): sustainable intensification (SI) technologies for rice, maize and lentil-based cropping systems. CSISA stages its work in the Mid and Far-West development regions from offices in Nepalgunj, Surkhet, Dadeldhura, and Dhangadhi. This report covers progress and results from Kharif (monsoon) 2014 not captured in the previous year's annual report, the Rabi (winter) season 2014–15, the spring season, and the pre-harvest period for Kharif 2015.

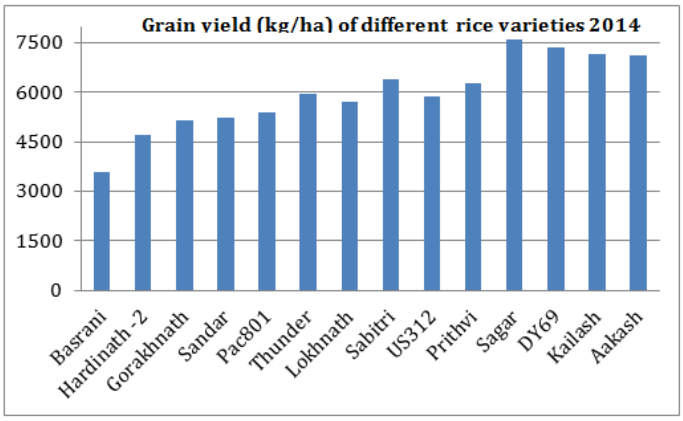
This report is divided in part by funding source for ease of reference by our respective donors, but also by theme in order to show the diverse ways in which CSISA is responding to the major threats and opportunities confronting Nepali farmers. Achievements during the reporting period under CSISA-Nepal, funded by USAID Nepal, are below. Although CSISA-Nepal termed on September 30, 2015, much of its work is being carried forward through an investment in agronomy and seed systems scaling by USAID Washington and an investment in mechanization and irrigation by USAID India. Both of these new investments were launched in February 2015 and achievements are also covered in this report, reflected either as research continuations or out-scaling of technologies verified by the original CSISA-NP.

1 RICE

This section on rice complements and completes the summer rice season activities reflected in CSISA's annual report from November 2014 as all not yield data were available at last year's annual reporting time as well as the pre-harvest period for Kharif 2015.

1.1 Performance of hybrids and improved rice varieties in the Terai

As CSISA has reported earlier, the varietal replacement rates for the major cereal crops, like rice, are very low. Farmers are still growing relatively old rice varieties that have low yield potential and disease susceptibility. Rice yields can be increased substantially with the switch to newer, shorter-duration varieties that also enable the on-time planting of winter season crops. CSISA continues to evaluate promising varieties identified and tested in the previous year (2013), along with new hybrids and improved rice varieties under better bet agronomy. CSISA carried out its activities in Banke, Bardiya, Kailali and Kanchanpur to establish the consistency of yield response across seasons and locations. In 2013, improved rice varieties tested included: Tarahara-1, Hardinath-1, Sabitri, Gorakhnath, Lokhnath and Sandar, which are short- to medium-duration varieties. In 2014, CSISA included new hybrids like DY 69, Kailash, Aakash, Sagar, Prithivi and US 312, which are relatively short duration (see inset). All hybrids produced significantly higher yields compared to other improved varieties. **Among the evaluated hybrids DY 69, Kailash and Aakashhad the highest yields and produced approximately 2.0 t ha^{-1} higher yields than the commonly grown improved variety, Sabitri**. Most farmers expressed a preference for the hybrid due to high yield and short duration. CSISA is also working with seed suppliers and local agro-vets to provide market intelligence on where increased demand of the above variety exists.



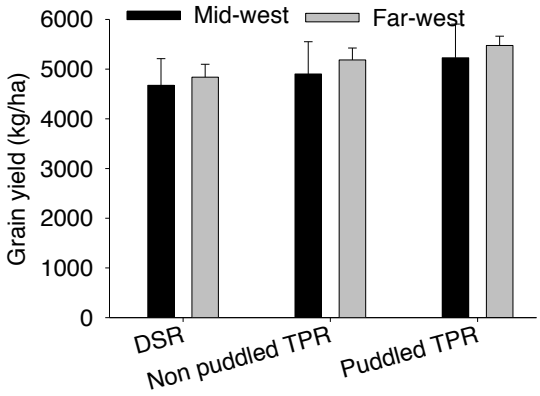
To test the hypothesis that hybrids are only suitable for wealthier farmers that can afford high levels of fertilizer inputs, CSISA collaborated with the Regional Agriculture Research Station, Khajura (NARC) to evaluate the yield performance of registered rice hybrids and improved varieties under low (75:30:30 kg NPK/ha) and high (150: 60:60 kg NPK/ha) fertility levels. Compared to the improved

varieties (Sabitri and Sukkha-3), **all tested hybrids produced 1–2 t ha-[1] higher yield under both high and low fertility level**, suggesting gains in grain productivity and fertilizer use efficiency are attainable for all type of farmers through adoption of rice hybrids. The magnitude of these gains far outweighs the addition costs for purchasing hybrid seed.

To further evaluate cultivar performance at different fertility levels across years (Genotype x Management x Year), an on-station trial in Khajura, NARC station, and several on-farm evaluations in different farmers' fields in Kailali and Kanchanpur, were conducted in the 2015 summer season. Crop harvest will be completed in November 2015. Recent visual observations in the field show that the expected responses will be similar to the ones recorded in 2014.

1.2 Alternative rice crop establishment practices for the Terai

The traditional rice establishment practice of manually transplanting seedlings into puddled fields costs farmers time, labor, energy, and money. Furthermore, research conducted in different South Asian countries shows that puddling degrades soil quality and causes adverse effect on the successive winter crops. Machine-sown dry direct seeded rice (DSR) is fast emerging as a cost-effective technology that allows the direct line sowing of rice seeds into un-puddled fields and avoids the cost for raising rice nurseries and transplanting seedlings. Building on CIMMYT's earlier work on technology verification and out-scaling through service providers in the central Terai, CSISA is evaluating DSR using both two-wheel tractor and four-wheel tractor seed drills in cooperation with KISAN, conducting joint demonstrations for the last three years in mid and far western Terai.



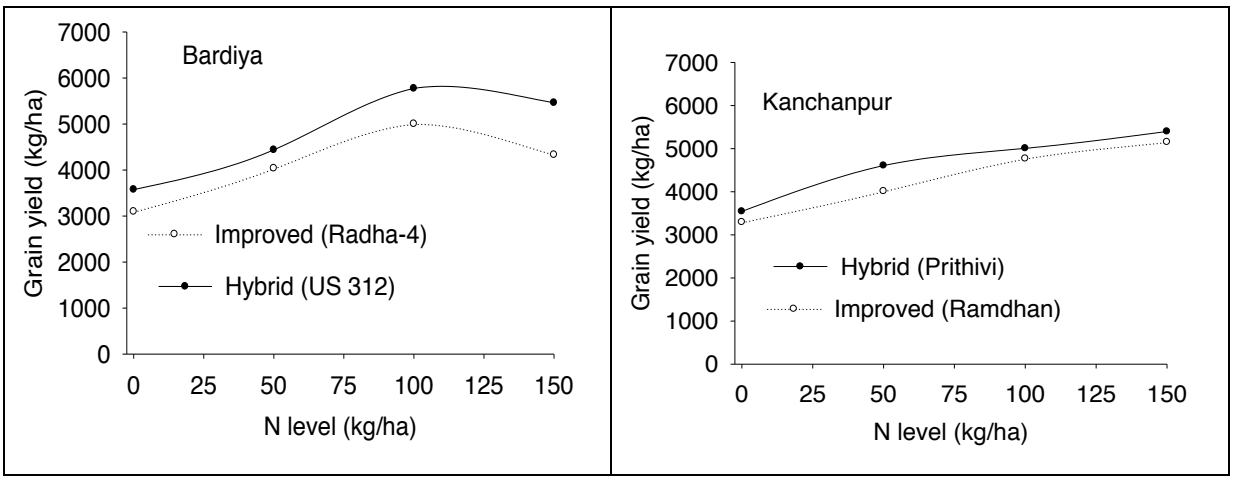
Across the evaluation years and sites, our data suggests that there was no difference in grain yield between DSR and transplanted rice (TPR). However, **there were savings of around $200 per ha in crop establishment costs with DSR.** Similarly, in all sites rice planted under DSR matured 7–10 days earlier than TPR, which increases the window for the timely seeding of winter crops. Therefore, DSR is a suitable alternative to conventional TPR in the mid and far western Terai, if managed properly. Farmers in the region have been impressed with the technology and have begun to adopt DSR without assistance or incentives from CSISA. In 2015, the area under farmer-managed DSR was approximately 15 ha, an important first step for mainstreaming this technology. Custom hire networks for DSR establishment are being backstopped by CSISA and already a small but growing cadre of well-trained service providers are found in the FtF target areas of the Mid and Far West.

DSR MATURING 7 DAYS EARLIER THAN THE TRANSPLANTED RICE IN BHURIGAUN, BARDIYA DISTRICT

1.3. Fertilizer management for rice

Nutrient management recommendations based on on-station research trials may not be relevant to on-farm conditions. Further, extension practitioners often perceive that hybrids need a higher fertilizer than improved varieties. Promising hybrids (DY-69, Arize, US 312 and Prithivi) were evaluated under four different levels of N (i.e., 0, 50, 100, 150 kg ha-1) and compared with the improved varieties commonly grown in each location. At every input level, the response to applied nitrogen was higher for hybrids across evaluation sites as compared to the improve varieties. Our

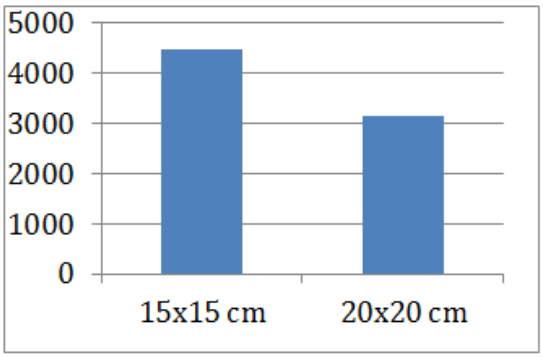
data suggests a **consistent advantage of 0.5-1 t ha^{-1} for the adoption of hybrids with fertilizer application above 50 kg N/ha compared to improved varieties.** For hybrids and improved varieties, nitrogen application beyond 100 kg ha^{-1} results in diminishing economic returns suggesting that the selection of crop cultivar has less influence on optimum fertilizer rates than originally anticipated. Nevertheless, fertilizer response significantly varied across location, soil type and source of irrigation water. To derive domain-specific fertilizer recommendations, experiments were repeated in Kharif 2015. Crop harvest will be completed in November 2015.



GRAIN YIELD OF HYBRID AND IMPROVED RICE VARIETIES KG HA-1) UNDER DIFFERENT N LEVELS, 2014

1.4 Exploring options for improved coping strategies for early season drought

In the 2014 summer season, the monsoon started very late and farmers were not able to transplant rice on time, planting seedlings that were more than 40 days old. This led to a reduction in crop yield and an overall decrease in rice production in 2014 due to the early season drought. Under increasingly unpredictable weather conditions, coping strategy for early drought is becoming increasingly important.



Grain yield of rice planted with old age seedling under different planting geometry

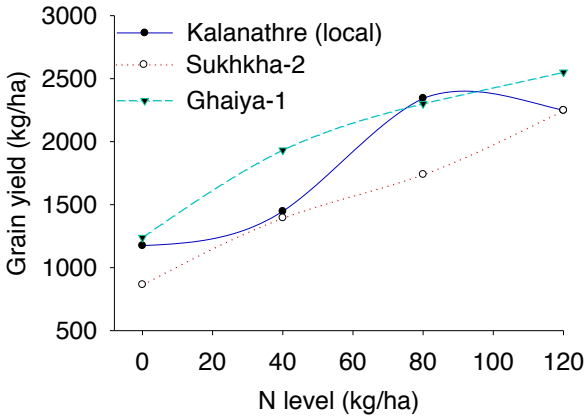
In 2014, we conducted preliminary research on the performance of rice transplanted with 45-day old seedlings under different planting densities. Preliminary results indicate that increasing plant density from 20 cm x 20 cm to 15 cm x 15 cm increased yield by about 1.5 t ha^{-1}, which is important for farmers who must use older seedlings. This trial was repeated in the summer of 2015 while considering densities, different varieties (short and medium duration) and age of seedlings to establish the consistency of response across season and location. Crop harvest will be completed in November 2015. Visual observation in the field indicates that we can expect a similar response as was observed in 2014, and that simple changes in planting density offer a low-cost and highly effective risk mitigation strategy for Terai farmers.

CSISA also conducted a household survey among farmers (N=98) in order to understand farmers' perceptions of various coping strategies for drought. Based in part on their association with CSISA, farmers now perceive that there are three major coping strategies for drought in rice production: short duration and drought tolerant varieties (32%); supplemental irrigation (28%); and adjusted crop geometry for late transplanting (16%).

1.5 Rice agronomy for the hills

1.5.1 Proper fertilizer management and varietal replacement increases upland rice yield

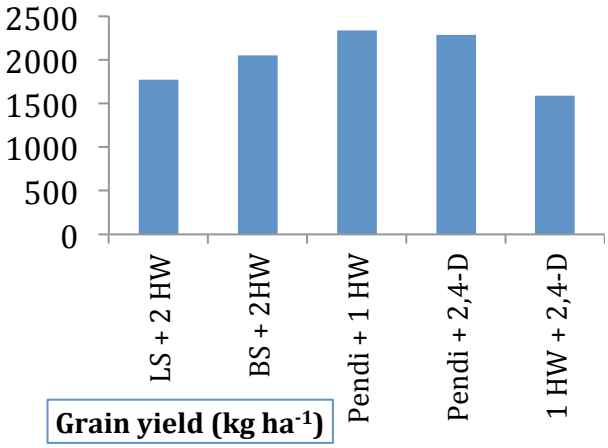
In the hills, upland rice is grown under rainfed conditions on soil with low water-holding capacity. Farmers almost exclusively use local varieties without applying fertilizers or weed management practices, and consequently, yields are extremely low (ca.1 t ha^{-1}). With the dual objectives of identifying adapted varieties and assessing the performance of those varieties under different fertilizer management regimes, CSISA began collaborative on-station research with Agriculture Research Station (ARS) Surkhet in 2014. Three varieties – Kalanathre (a local variety) and two recently released varieties (Sukhkha-3, a drought tolerant variety released for the Terai, and Ghaiya-1, released for upland conditions) were evaluated under four different N levels (0, 40, 80, 120 kg N/ha). Ghaiya-1 produced consistently higher yields at all N levels compared to other tested varieties, except at 80kg per ha where the yield was similar to that of the local variety. These results validate the importance of breeding efforts that specifically target upland rice production systems in the hills.



The CSISA-NARC on-station evaluation of the variety X fertilizer management (see inset), shows that **it is possible to double the yield of upland rice** with application of 80kgs of N per ha as compared with no fertilizer application (prevailing farmer practice), highlighting the importance of improving fertilizer value chains in the hills. This experiment was repeated in Kharif 2015 and crop harvesting is ongoing. From visual observations, similar results can be expected in comparison to 2014.

1.5.2 Early weed management reduces losses in upland rice

Intense weed competition in upland rice is very common due to a favorable environment (high temperature and enough soil moisture) and the absence of persistent flooding. Manual weed management, which is typical farmers' practice in upland rice, is difficult and highly labor intensive. In collaboration with ARS Surkhet, on-station experiments evaluating efficient weed control options for upland rice were conducted in 2014. The treatments included for evaluation were:



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.

Use of Pendimethalin, a pre-emergence herbicide, was found to be highly effective for controlling weeds during initial crop growth and led to significantly increased grain yield compared to hand

weeding at 25–30 days after seeding. **Gross margin achieved with the use of Pendimethalin doubled (gross margin $300/ha)** compared to hand weeding at 25 days after sowing (gross margin $150 /ha). Depending on how farmers value their own labor, the use of herbicides in tandem with cultural methods offers opportunities to transform the profitability of upland rice production in the hills. The experiment was repeated in Kharif 2015 and crop harvesting is ongoing.

In Focus: *Farmers Make Informed Decisions on Hybrid Rice*

Nathu Ram Chaudhary in his rice field

With the objective of increasing rice productivity in the Terai, CSISA has been using participatory methods to test new rice cultivars, including varieties developed by the National Rice Research Program.

In Gularia ward of Krishnapur village, CSISA employed 'mother-baby' participatory varietal selection (PVS) trials where farmers grow, manage and evaluate 'baby trials' on their own fields – a subset of the larger field experiment or 'mother trial' treatments being managed by CSISA researchers. Since farmers generally hesitate to adopt new technologies until they are confident and can make informed choices based on their perceptions and requirements, these smaller trials can be an effective first step towards large-scale acceptance of new varieties.

Late in the rice season in 2013, CSISA organized a monitoring visit for farmers to the 'baby trials.' One of the visitors was farmer Nathu Ram Chuadhary, who is also the chairperson of the Sayapatri Biu Utpadan Samuha, a local seed production group.

Chaudhary was impressed by the performance of the rice hybrid DY-69 and made a point to independently visit the same farmers later in the year to inquire about their harvest. The farmers informed Chaudhary that their yield was approximately 9 tons per hectare, more than he had expected.

Encouraged by his findings, Chaudhary decided to grow DY-69 himself the following year but was unable to do so due to a shortage in the market. In 2015, he approached CSISA once again, saying, 'I found one of your trial hybrids very good and have decided to grow it this year, but could not find the seeds.' CSISA has worked with Chaudhary's community to link them with Kisan Agro-vet, a provider of agro-inputs, who has started to stock and market hybrids based of farmers' preferences.

Chaudhary transplanted DY-69 on a patch of 0.34 hectares of land, where he had grown the improved Nepali coarse grain variety Radha-4 in 2014. He obtained a yield of 4.5 tons per hectare from Radha-4. Based on how the DY-69 crop looked at the physiological maturity stage, he expects to double last year's yield.

He especially appreciates CSISA's efforts to evaluate rice cultivars side-by-side so that differences are visible to members of the community. More than 20 farmers have transitioned to hybrid cultivation this year in this community based on their experience with PVS and CSISA's market development efforts to increase local supplies of elite cultivars.

In Focus: *Empowering women farmers through participatory research*

CSISA has collaborated with a women farmers' group in Bardiya district to collectively evaluate improved rice and lentil varieties and better bet agronomic practices. These trials have helped bring CSISA researchers closer to farmers' needs and have led to increased adoption of new technologies by women farmers.

Loktantrik Mahila Krishak Samuha women's group at CSISA training

Loktantrik Mahila Krishak Samuha (Democratic Women Farmer Group) was formed in 2011 in the village of Neulapur in Bardiya district of Nepal to economically support poor women members and to improve their skills in new agricultural technologies. The group, with 33 active members, now has a savings fund of NRs 250,000 (US$ 2,500), and is able to make low-interest loans to members. Since 2013, CSISA-NP has been working with this group on research activities, trainings and demonstrations.

Farmers' Choice

Group members participated in CSISA's evaluation of rice varieties, as well as trainings and demonstrations on rice production technologies and crop establishment methods. Among rice hybrids, the group members were able to choose from varieties such as DY 18, DY 69, Arieja, and Prithivi due to their high yielding potential and fine grain quality. The women group members expressed a preference for fine grain rice varieties for home consumption and coarse grain varieties for selling in the market.

In the winter of 2013 and 2014, a large number of farmers from the group also participated in adaptive research trials on lentil varietal selection and different agronomic practices. The group preferred Khajura 2 (released), ILL 7723 (enriched with iron and zinc) and Black Masuro, but did not express a preference for the other varieties produced. The average yield of improved varieties of lentil is 1,200 kg ha^{-1} in farmers' fields, which is nearly 50% higher than the commonly used variety. The group members also made income by selling lentil seeds, which were produced from these new varieties.

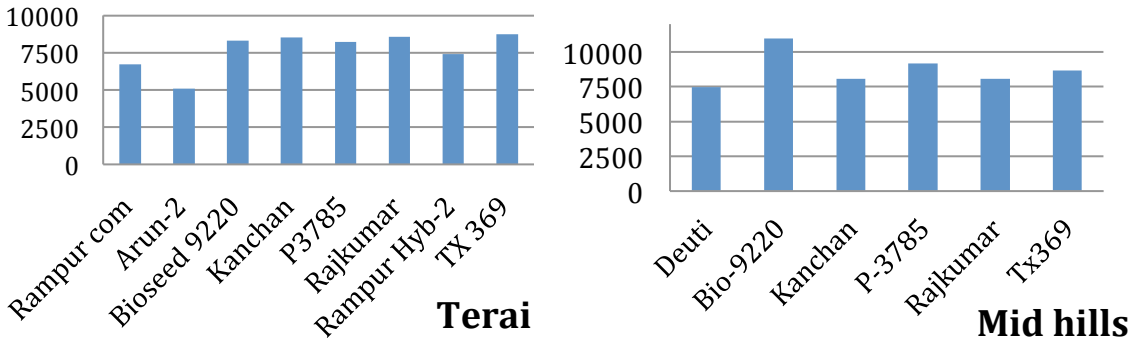
CSISA also introduced the group members to direct seeded rice (DSR) technologies, using both four-wheel tractor seed drills and Chinese two-wheel tractor seed drills. DSR, a technology that can provide significant cost savings to smallholder farmers, can be particularly attractive when labor availability is constrained as it eliminates the need for nursery bed preparation, puddling and transplanting of seedlings into the main field. DSR also reduces water requirements, while still providing similar grain yields achieved with transplanted puddled rice.

2 MAIZE

2.1 Maize hybrid identified for spring and summer seasons in Mid and Far West regions

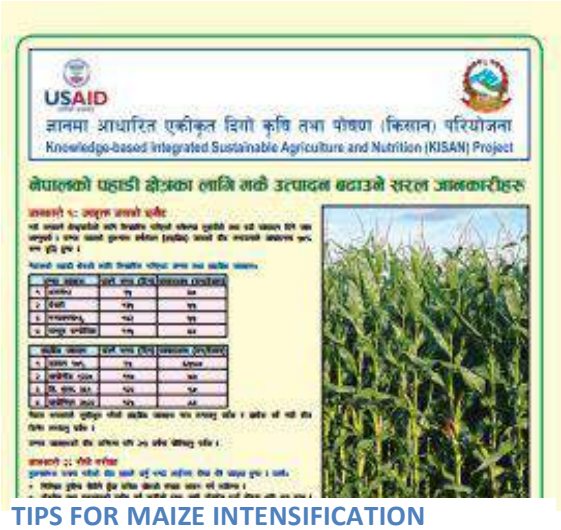
Testing and evaluation of registered commercial maize hybrids, hybrids developed by NARC, and improved OPVs for spring and Kharif season are key objectives for CSISA-NP. At present, all of the commercially available maize hybrids have been registered for use east of the Narayani River –i.e., the central and eastern regions of Nepal, outside of the FtF zone. As a consequence, seed dealers and distributors have been reluctant to stock and actively market maize hybrids in the Mid and Far West due to liability concerns.

In three years of collaborative research with farmers, national partners, and KISAN, CSISA has identified five well-performing hybrids that can be prioritized for registration in the FtF zone– namely Rajkumar, Nutan (Kanchan 101), Bio. 9220, Pioneer 3785 and TX 369. In all three years of evaluation, these hybrids significantly out-yielded the OPVs and other hybrids for spring (Terai) and summer (hill) seasons, suggesting broad adaptability.



GRAIN YIELD OF MAIZE (KG HA^{-1}) IN MID HILLS (KHARIF) AND TERAI (SPRING) SEASON

For the market development and commercialization of those hybrids in the FtF zone, CSISA-NP is coordinating with the national level variety release and registration committee that is composed of representatives from NARC and Seed Quality Control Center (SQCC). CSISA organized a one-day workshop on September 18, 2015 in Kathmandu to share research findings on hybrid performance. After reviewing three years' worth of CSISA data, the committee agreed to expand the geographic registration of the best performing hybrids to the Mid and Far West. With support from CSISA, NARC is developing a proposal for the Seed Quality Control Center for this purpose. Efforts are ongoing to complete this initiative, which promises to transform the market availability of hybrids in the FtF zone.



TIPS FOR MAIZE INTENSIFICATION IN THE HILLS

In consultation with KISAN and NARC, CSISA has also developed an easy-to-use guide to increasing productivity and profitability for Kharif maize for the mid hills. It has been distributed through KISAN's network and formed an integral part of their training programs.

2.2 Maize Crop Establishment

2.2.1 Strip tillage: A soil conservation technology for the hills

In sloping hills, soil tillage for seeding together with hoeing and earthing up (forming beds to reduce maize lodging and to control weeds), lead to large losses of topsoil through erosion. Reducing erosion is an important component of maintaining soil fertility in the hills. To reduce soil erosion and increase soil health, plowing and seed placement can be done in narrow 5–10 cm wide strips, a practice called strip tillage. As a complementary strategy, CSISA has introduced reel-type 'push' mowers that an efficiently suppress weeds and reduce drudgery without disturbing the soil when the crop is sown in lines.

In the summer season 2014 and 2015, CSISA evaluated the following treatments in different farmers' fields in the mid hills (i.e., Dadeldhura and Surkhet):

T1: Strip tillage (ST)+line seeding (LS)+ farmers method of weed management (HW)

T2: Strip tillage +line seeding + mower for weed management

T3: Full tillage + line seeding+ farmers method of weed management

T4: Full tillage+ line seeding + mower for weed management

T5: Full tillage + broadcast seeding + farmer's method of weed management

MOWING FOR WEED CONTROL AND STRIP TILLAGE WITH THE PUSH-ROW PLANTER

There was no difference in the grain yield of maize in any of the treatments, but under strip tillage cost saving for land preparation was \$60 ha^{-1} compared with the conventional tillage. Under strip tillage and with use of reel-mower, visual observation suggested a significant reduction in erosion along with reduction in labor requirement.

2.2.2 Mechanized solutions for seeding spring maize in the Terai

The manual seeding of maize in lines is tedious and requires a large amount of labor, which increases the total production cost. Due to the Agro-Machinery 'Jumpstarting Agro-Machinery Markets' (JAMM) initiative there are now many more options for mechanizing maize planting that bring greater degrees of precision to maize farming. CSISA has been demonstrating and evaluating different types of scale-appropriate machinery for seeding maize both in the hills and the Terai to evaluate the crop establishment and economic benefits of each machine, as compared to manual seeding. Below is a sample of existing and relatively new machinery that is being used in trials and in farmers' field demonstrations. Economic analysis of each machine is presented below.

Seeding costs related to all of the machinery used for seeding maize are lower compared to manual seeding. Among the machinery evaluated, seeding cost with the push-row planter were lowest (\$40/ha), followed by the jab planter (\$48/ha), followed by the 4WT multi crop planter (\$51/ha). These mechanized options reduce costs by more than 50% over manual seeding (\$98/ha). CSISA will

continue to evaluate these machines in collaboration with the government and private entrepreneurs to expand their use.

Note: Work on maize agronomy will continue through an investment by USAID Washington in CSISA-NP called Agronomy & Seed Systems Scaling.

NATIONAL AGRO MULTI-CROP PLANTER USED FOR SEEDING THREE ROWS OF MAIZE IN ZERO-TILLED SOIL

NATIONAL AGRO MULTI-CROP PLANTER USED FOR SEEDING TWO ROWS OF MAIZE IN A TILLED FIELD

4WT-DRAWN NATIONAL AGRO BED PLANTER, SEEDING MAIZE ON TWO BEDS

CHINESE 7-HORSEPOWER MINI-TILLER DRAWN FOUR-ROW PLANTER SEEDING MAIZE IN TWO ROWS

CHINESE PUSH ROW PLANTERS CAN BE USEDIN TILLED AND STRIP-TILLED SOIL

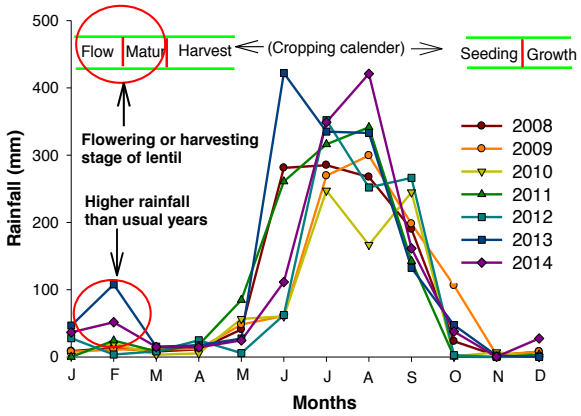
CHINESE JAB PLANTERS CAN BE USED IN TILLED AND STRIP-TILLED SOIL

CHINESE POWERED SINGLE AND DOUBLE ROW DEDICATED MAIZE PLANTERS AND WEEDER AND FERTILIZER SIDE DRESSING

CSISA IS WORKING ON THE DEVELOPMENT OF LOCAL SERVICE PROVIDERS AND LOCAL MARKETS TO COMMERCIALIZE MECHANIZED MAIZE PLANTING TECHNOLOGIES

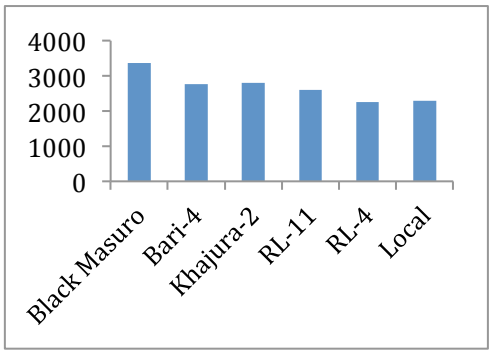
3 LENTIL

The western Terai is the most important area for lentil production in Nepal. In the last three years lentil production in the Terai has been severely affected by recurrent winter rains (see figure). The water logging and disease pressure associated with wet conditions that persist after rains, especially in the heavier textured soils of the Terai, has had a negative impact on farmers' yields and CSISA experiments. 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 soils that facilitate drainage.



3.1 Lentil varietal evaluations

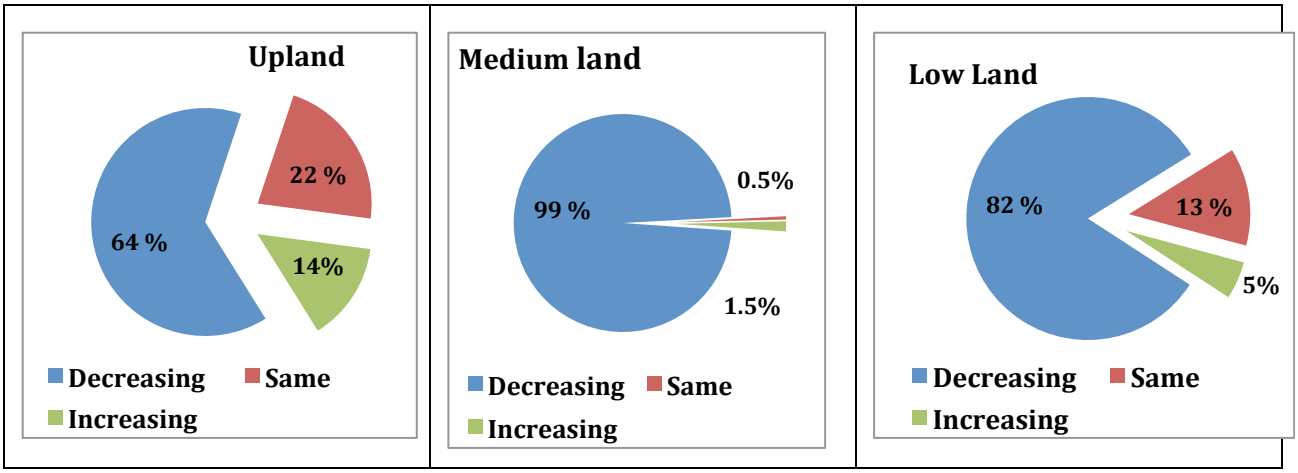
In 2014–15 in collaboration with the National Grain Legume Program (NGLP–NARC), CSISA evaluated six different released and pipeline varieties: Black Masuro, Bari-4, Khajura-2, RL-4, RL-11, both in the Terai and the hills. In all locations, Black Masuro was the highest yielder compared to other varieties and it was preferred by the farmers during a variety-ranking exercise. Disease infestation was also lower in Black Masuro compared to other varieties. **Similar to a year earlier, yields were severely affected in all four Terai districts due to 3–4 sizeable winter rains, which negatively affected the lentil production; average productivity in the Terai trials was less than 500 kg ha^{-1}** due to the water logging and disease pressures associated with the wet conditions that persist after rains on the heavier textured soils in the Terai. On the other hand, the same winter rains were beneficial in Dadeldhura (mid-hills) where most varieties produced more than 2.3 t ha^{-1} as shown in the figure on the right. In Dadeldhura, yield advantage with Black Masuro (3.2 t ha^{-1}) was about 1 t ha^{-1} higher than the local variety (2.3 t ha^{-1}).

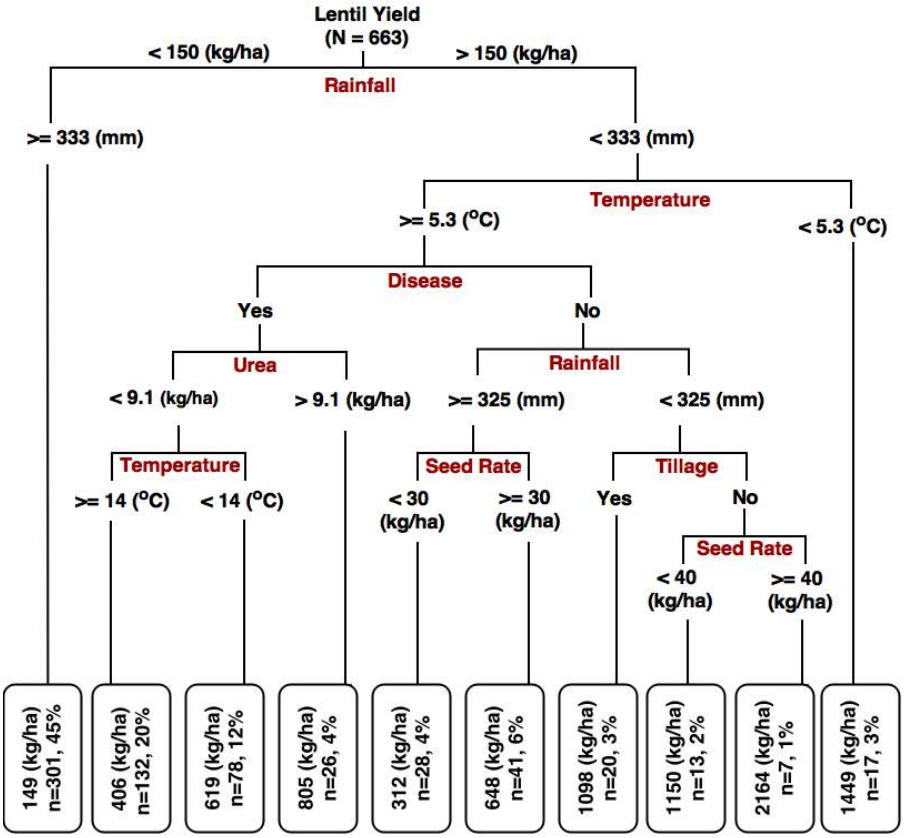


LENTIL YIELD IN DADELDHURA, 2014/15

During the last three years of CSISA's lentil evaluations in different locations, the limits of existing germplasm to confer resilience to winter rains and disease outbreaks have become evident.

Recently, CSISA conducted a household survey of lentil productivity trends in 663 farm households in its working districts. The results suggest that higher rainfall is the major predictor of lower lentil yield. About 85% of the farms obtained a lentil yield lower than 300 kg ha^{-1} in 2015, out of which more than 50% harvested less than 150 kg ha^{-1} in 2014-15. In line with our on experiment results, farmers with fields that are mid and low-lying points of the landscape (i.e. more poorly drained) had much lower yields compared to farmers with better drained fields in upland positions, suggesting that lentil intensification efforts in the Terai should focus on upland fields. Survey data also suggests that surface seeding (relayed with rice) and increased seed rate for uniform plant population can be beneficial for lentil production under unfavorable weather condition.





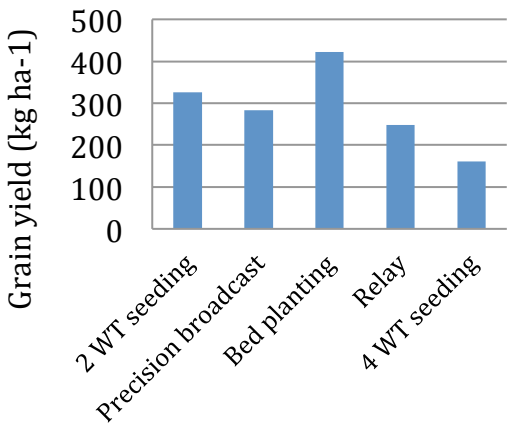
LENTIL YIELD AND ITS PREDICTORS IN STUDY AREAS

3.2 Lentil crop establishment methods

Farmers in the Terai commonly practice two planting methods for lentil: relay seeding into standing rice or broadcast seeding on tilled soil after the rice harvest. Under current farmers' practice, the lentil plant stand is not uniform and consequently weeds are a severe problem. Line seeding using tractor-operated seed drill machines or the use of the Earthway seed and fertilizer spreader for uniform seed broadcasting can be good alternatives for obtaining a uniform plant stand.

In 2014–15, CSISA conducted on-farm evaluations of the following crop establishment methods in different farmers' fields in Banke, Bardiya, Kailali and Kanchanpur districts:

1. Broadcast seeded using spreader + Power tiller Operated drill single pass
2. Strip tillage with 2 wheel tractor (2WT) drill
3. Bed planting using bed planter
4. Relay seeding with standing rice
5. Zero tillage (ZT) flat using 4WT drill
6. Conventional Tillage (CT) seeding with seed drill



Crop establishment and the initial crop growth were good under all establishment methods in all locations, but due to 3–4 sizeable winter rains, lentil production was severely affected in all treatments and yield was significantly reduced (to less than 500 kg ha^{-1}). Compared to other treatments, bed-planted lentil produced better yields (around 200 kg ha^{-1} yield gain). Due to disease and rain coinciding with flowering, even the bed-planted lentil did not yield as expected as shown in the figure to the right.

WELL-ESTABLISHED LENTILS ON BEDS IN FARMERS' FIELDS ON THE LEFT, AND THE SAME BEDS AFTER RAINS IN KAILALI DISTRICT

Note: Work on lentil agronomy will continue through an investment by USAID Washington in CSISA-NP called Agronomy & Seed Systems Scaling.

In Focus: *Improved Lentil Cultivation Boosts Rural livelihoods in Mid-hills*

Sabitri Ayer with her stored lentil seed

Sabitri Ayer attended a training conducted by CSISA on improved lentil cultivation practices and fertilizer management. 'We were reluctant to use fertilizers in our fields but CSISA's intervention on the appropriate use of nutrient management for lentil, wheat and maize changed our perception,' said farmer Sabitri Ayer.

The training further stressed the importance of using better lentil varieties and of seed replacement. She added, 'The improvement in the yield of our crops by using fertilizers is very evident and encouraging.'

CSISA works in some of the most remote villages of far west Nepal. One such village is Littrigaun, a hilly village in Dadeldhura district characterized by caste segregation, marginal lands, labor out-migration, soil erosion and low agricultural yields. Since 2012, CSISA has been working with farmers in the village to improve productivity, promote food security and increase their incomes. Intensified lentil cultivation is becoming popular among farmers.

Last year, farmer Sabitri Ayer grew lentil on 0.05 hectare and achieved a yield of 45 kilograms. She used 10 kilograms for household consumption and saved another 10 kilograms by mixing it with wood ash in a plastic jar sealed with mud at the top. She sold the remaining 25 kilograms in the market at the rate of US$ 1.5 per kilogram, which was enough for her son, Binod, to re-stock a small grocery shop.

The few farmers in the village who grew lentil, in a limited area, were yet to reap much. Owing to a belief that fertilizers can destroy soil, they only used farmyard manure and plant litter to enrich their soil. Low nutrient levels — particularly for nitrogen —led to consistently low crop productivity. Moreover, the farmers grew traditional local varieties.

CSISA also conducted varietal demonstrations in the village and Khajura-2, a lentil variety recommended by the National Grain Legume Program, was distributed to some of the farmers. The crop performed well and famers even saved the seed for next year. Moreover, the demonstration brought about a significant change in the perception of farmers regarding lentil production.

"We used to practice intercropping of barley and a local variety of lentil before the introduction of Khajura-2. But seeing the increased production of lentil, nowadays we prefer only cultivating Khajura-2,"said farmer Durga Ayer. She added, "Lentil has good market value and customers even find their way to our doorsteps to buy lentil."

In 2014, approximately 20 farmers began growing lentil. This year, Sabitri says, she will increase the area under lentil cultivation to boost her livelihood further.

USAID Washington has provided $3 million over four years (2014–18) to CIMMYT/CSISA-Nepal for work on wheat, lentil and mung bean agronomy, as well as efficient fertilizer use and seed systems scaling. Accomplishments to date are covered below.

MUNG BEAN

4. Mung bean initiative

With the aim of increasing the area of mung bean cultivated in Nepal, CSISA has interacted with national partners in the public and private sectors to take stock of the current production and marketing systems. Findings show that large quantities of mung bean are imported from India, as domestic production cannot meet the growing demand. For instance, Nepal imported 251 MTs of mung bean grain from India during the period from January 2013 to February 2015 via Raxaul boarder, worth of US$160,452 (NRs. 16,045,200). Traders estimate that the aforementioned import data does not reflect the actual mung bean import in Nepal from foreign countries as importing pulses from India is banned.

In collaboration with NGLP and the World Vegetable Centre, CSISA had conducted on-farm evaluations of four different varieties (released and pipeline) namely Bari mung, Hum -16, Pratiksha and Kalyan, in different farmers' fields in the mid and far western Terai**. The crops performed well in all farmers' fields and the average seed yield was ~ 850 kg ha^{-1}. Being a short-duration crop, it can fit as a spring crop immediately after harvest of the winter crop, occupying land that used to be fallow. Therefore, farmers can generate an additional profit of $250 per hectare growing this crop.**

5 WHEAT

5.1 Systems approaches for sustainable yield intensification and minimizing terminal heat stress in wheat adopted at scale

5.1.1 Exploring best-bet agronomy for wheat

5.1.1.1 Opportunities of zero tillage wheat in mid and far western Terai

Under a warming climate, wheat yields can be severely affected by terminal heat stress during the reproductive growth phase when seeding is delayed. Research shows that any delaying in wheat seeding after the end of November results in a 1–1.5% loss in yield per day of delay. Advancement in seeding helps to minimize the effects of terminal heat stress. Zero tillage (drilling seed and fertilizer in untilled soil using a 2WT/4WT seed drill) of wheat allows for early seeding (10-15 days) as it avoids the land preparation before seeding. Zero tillage seeding significantly reduces production costs without compromising yield. No-till uses a seed and fertilizer drill and thus improves germination and plant stand over traditional

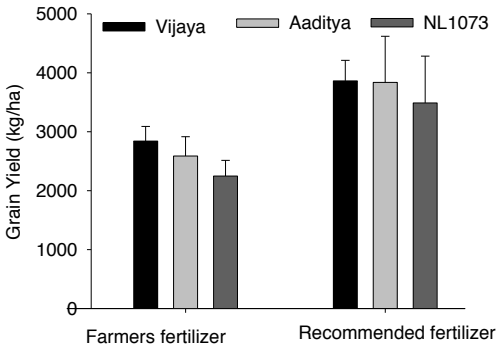
ZERO TILLAGE WHEAT SEEDING AND CROP PERFORMANCE

broadcasting systems and improves fertilizer efficiency through better placement.

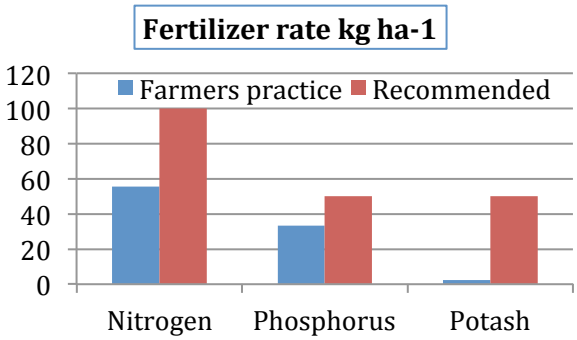
Building on CIMMYT's earlier work on technology verification and out-scaling through service providers in South Asia, CSISA-NP demonstrated and evaluated zero tillage wheat for the first time in the FtF zone using both two-wheel tractor and four-wheel tractor seed drills in joint demonstrations with KISAN, comparing ZT with the conventional method in farmer's fields. Uniform germination and vigor plant growth of ZT wheat were observed by farmers. **In almost all sites, zero till seeded wheat out-yielded the conventionally seeded wheat. During the farmers' field day zero till wheat was the major attraction for the farmers and government personnel.** Due to crop establishment cost savings (ca. 2,500 NPR per hectare), there is already huge demand for ZT wheat for the coming season. CSISA-NP plans to expand access to this technology through service provision and market development for machinery (see next section).

5.2.1 Fertilizer management: Entry points for wheat intensification in the Terai

Fertilizer management (appropriate rate, time and method of application) is a major component of increasing production of cereal crops in Nepal. CSISA-NP conducted on-farm evaluations of different improved wheat varieties (Vijaya, Aaditya and NL1073) under two different fertility levels, i.e., existing farmers' level (65:35:9 NPK kg ha^{-1}) and the recommended level (100:50:50 kg NPK per ha) in four farmers' fields in Kailali and Kanchanpur districts in the 2014/15 wheat season. Preliminary results show that on average, **with an additional investment of $60 per hectare in fertilizer, farmers can increase grain yields by more than 1 t ha^{-1}, increasing profitability by $140 from one hectare of land**.



Similarly, during the 2014–15 wheat season, CSISA-NP conducted a household survey on wheat cultivation practices in the FtF districts of the Terai, covering 400 households. Results indicate that farmers under-fertilized their wheat fields relative to the government recommendation (almost half the recommended dose) with average productivity of ~ 2 t ha^{-1}, which is below the national average (2.5 t ha^{-1}). This shows that there is huge potential to increase wheat yields through appropriate fertilizer management in the mid and far western Terai. In collaboration with scientists from the National Wheat Research Program (NWRP–NARC), CSISA is preparing a simple guide for intensified wheat production which offers updated recommendations on crop management and fertility practices that boost yields while enhancing profitability.



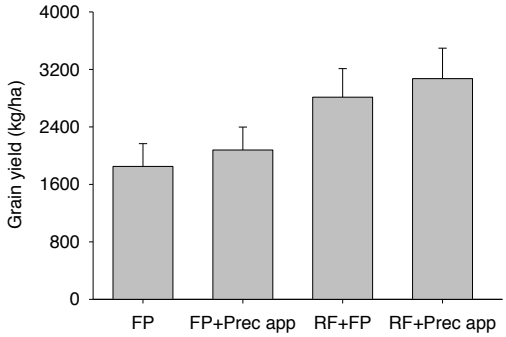
5.2.1.1 Precision application technologies for increasing the efficiency of fertilizer

In Nepal, fertilizer application rates are far below the national recommendation, yet application technologies for fertilizer are imprecise and commonly result in significant reductions in crop yield compared to what can be obtained through better management. CSISA has been testing and evaluating the Earthway spreader for precision broadcasting of seed and

FERTILIZER APPLICATION WITH PRECISION BROADCASTING

fertilizer for two years in different Terai districts. During wheat season 2014/15, CSISA conducted on-farm evaluations of the following treatments:

T1: Recommended dose using precision spreader
T2: Recommended dose broadcasted manually
T3: Farmers dose using precision spreader
T4 : Farmers dose of fertilizer broadcasted manually



Evaluation results from the 2014–15 wheat season show that **the use of a precision spreader for urea topdressing in wheat improves yield by 9% under the farmers' fertilizer level and by 12% under the recommended level of N application, compared with the farmers' application method.** Labor costs for application are also saved.

Realizing the importance of precision broadcasting of seed and fertilizer, CSISA-NP has provided training to farmers, government personnel and agro-vet to deploy the spreader through service providers. CSISA has also produced a user-friendly guide for using the Earthway spreader, which covers handling guidelines for both seed (wheat, lentil) and fertilizer (DAP and urea) broadcasting (see photo to the left). This has been distributed to farmers, agro-vets, KISAN, and DADOs who are responsible for deploying this machine.

5.3.1Entry points for wheat intensification in the mid hills

5.3.1.1 Varietal replacement

Mr. Yam Prasad Chalise was one of the farmers involved in CSISA's on-farm varietal evaluations of wheat in 2014–15 in the hills of Surkhet. In his field, variety WK 1204 was seeded on 550 m^2 of land and was compared with the local variety under the same management practices. From this field, Mr. Chalise was able to produce 200 kg of WK1204 seed, a yield three times higher than the local variety. He wants to seed WK 1204 on his whole field in the coming season. Similarly, his neighbor who has seen the field requested seed of this variety.

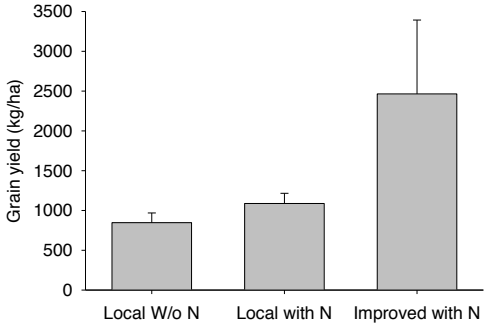
Seed replacement rates for wheat are very low in the hills, and are considered one of the major factors responsible for low yields. To evaluate the performance of different improved varieties (Danfe, Dhaulagiri, WK1204), CSISA conducted on-farm evaluations of new varieties under improved management practices (60:30:30 NPK kg ha^{-1}), comparing them with local varieties grown with the same management. Farmers preferred Danfe and WK1204 because of their bold grains and dense spikes. **All improved varieties produced 40-60% higher yield as compared to the local variety.** Farmers in the region were highly impressed with yield performance of the improved varieties and showed interest to grow them in the upcoming season**. All farmers who have been involved in the on-farm evaluations saved seed for the next season. Also, neighboring farmers expressed willingness to grow these varieties and demanded seed for the upcoming season.**

CSISA is working in collaboration with DADO, KISAN, Seed Company and Agro-vets to introduce improved varieties in the hills.

5.3.1.2 Nitrogen management

Wheat productivity in the Mid and Far-West hills is well below the national average, and few development efforts have sought to assess the prospects for intensification through improved management. Along with the absence of irrigation, cultivation of local varieties and the extremely limited use of fertilizer are the major factors responsible for low yields in these rainfed production systems.

With the objective to better characterize the scope for wheat intensification in rainfed ecologies of the mid hills, CSISA-NP has superimposed N fertilizer through topdressing immediately after rainfall (during vegetative growth) for both local and improved varieties to document the yield benefits of the fertilizer topdressing under current farmers' practice. With the application of 20 kg N/ha, yield increased 25% for the local variety (1.7 t ha^{-1} from 0.85 t ha^{-1}), while three times higher yields were observed when nitrogen application was paired with an improved variety adapted for the hills (2.5 t ha^{-1} – see inset).



WHEAT YIELD AFFECTED BY VARIETY AND N FERTILIZER

6 SEED SYSTEMS

6.1 Robust seed systems that ensure timely access to elite cultivars and hybrids

6.1.1 Business development initiatives

6.1.1.1 Business mentoring for local seed enterprises

CSISA assessed 10 cereal seed enterprises with reference to their organizational development, research & development capacity, seed production, processing & value addition and marketing through a semi-structured questionnaire and a SWOT analysis. Results show that the seed transaction volume of these enterprises is far below the national requirements. The growth of the enterprises is mainly constrained by the limited availability of source seed, poor seed storage and processing facilities, a lack of trained human resources, and limited financial capital. Seed enterprises argue that improper seed subsidy schemes and unpredictable/erratic weather patterns (e.g. heavy rainfall during crop harvest) impose constraints on their growth. To address these internal and external challenges, CSISA is facilitating these enterprises to develop company-specific business plans, as well as to network and foster collaboration with Indian seed companies. Drawing on the lessons of the assessment, a paper entitled 'Current status, challenges and opportunities for the growth of seed enterprises' has been prepared. To facilitate the distribution of registered hybrid maize in the market, CSISA also organized interaction meetings so that hybrid maize value chain actors can understand the constraints to, and opportunities for, hybrid maize promotion. CSISA is supporting NARC and Nepalese and Indian seed companies in the design of a protocol for the testing of new hybrid maize varieties.

6.1.2 Seed Entrepreneurs Association of Nepal (SEAN) resets its strategy

SEAN was formed in 1981 to support the collective interests of seed entrepreneurs in Nepal. With a changing membership, dynamic policy environment, and evolution of the internal market development for seed, SEAN member began perceiving the need to re-assess their mandate and vision of success as an organization. To assist in this process, CSISA facilitated a workshop to critically

review SEAN's organizational strategy. Participants included 17 of SEAN's board members with facilitation provided by Ms. Rupinder Kaur (organizational change expert), Mr. Gurbinder Gill (seed business expert), and Dr. Narayan Khanal (value chain expert). At this workshop, participants formalized SEAN's core values and mission. Based on individual voting and group discussions, the participants selected four words to represent their values as an organization: respect, which indicates that the members should value others' ideas; innovation, implying that seed companies should create a learning environment; commitment; honesty ('RICH').

The group developed a vision statement, imagining what they want SEAN to be after 10 years. They also decided that SEAN's core mission would be to improve the business growth environment for the seed industry, to build the capacity of stakeholders and to expand their national and international networks. To contribute to the abovementioned goals, SEAN's members developed goals, including increasing the association's membership to 1,000, delivering 20 trainings (12 awareness-raising and 8 technical) to their members, and organizing one national-level policy workshop with 50 participants from government and line agencies. At the last session of the workshop, Dr. Vijaya Sardana, a guest speaker, shared his lessons from managing over a dozen associations in India. He highlighted that associations should keep out of politics, which minimizes internal conflict among the members. Also, the association should facilitate knowledge sharing and be seen as a knowledge center, which would help the association to be recognized at national and international levels. He also shared some tips for drawing the attention of policy makers on the issues raised by the association, such as linking associations' strategy with governments' missions/programs and making short, but focused, presentations.

Currently CSISA is helping SEAN's member enterprises develop their business plans as well as strengthen their technical capacity through training. To further strengthen both technical and business mentoring advise, CSISA has linked Nepali seed enterprises with established companies in India. These relationships will deepen in the coming months with India companies hosting interns from Nepal.

6.1.3 Improving the availability of registered maize hybrids

CSISA team members visited and interacted with hybrid maize seed traders across the Central, Western, Mid West and Far West development regions to understand the current situation of hybrid maize distribution, production area, cropping patterns and seasons for maize production. It was found that about 2,500 t of hybrid maize seed is imported into Nepal through Birgunj, and >60% of this import is through informal channels. Farmers grow hybrid maize both in winter (November planting) and spring (February planting) in the central Terai, but spring season planting is not common in the western zones. There is limited distribution of hybrid maize seed in hilly areas, and the insufficient availability of short-duration and white-grain hybrid varieties in the market are major constraints to its distribution. To facilitate the promotion of registered hybrid maize varieties, a traders' meeting was organized in Chitwan on April 16, 2015, convening eight hybrid maize seed dealers and distributors. At that meeting, CSISA presented the findings of agronomic and varietal trials carried out by CIMMYT through different projects, and shared lessons on how Indian seed companies addressed constraints associated with trading registered hybrids in Nepal.

Also importantly, there is a lack of registered hybrid maize varieties recommended for western regions, and very few for the hills. Traders feel quite hesitant to promote non-registered hybrids. To address the hybrid maize registration issue, CSISA is coordinating with NARC and Seed Quality Control Center (SQCC) to expand the registration of commercial maize hybrids into the FtF zone (see section 2.1)

CSISA is also exploring opportunities to forge partnerships among NARC, local seed companies, Indian seed companies and CIMMYT for the testing of promising hybrid maize materials across the maize production domains.

6.2 Stakeholder summit for developing roadmaps towards strengthened seed systems in Nepal

In 2014, CSISA approached the Ministry of Agricultural Development (MoAD) and several development partners about the utility of holding a national 'seed summit' with the goal of identifying near and medium-range opportunities for coordination and investment that could improve the functioning of seed systems in Nepal. With MoAD leadership, the National Seed Summit was held on September 14-15, 2015 with technical and financial assistance from different organizations including CSISA-NP. Over 100 participants representing several governmental (MoAD, Ministry of Finance, Nepal Agriculture Research Center etc.), nongovernmental, international and donor agencies (USAID, DFID, IFPRI, IRRI, CIMMYT etc.), seed entrepreneurs and farmers participated. The main purpose of the summit was to formulate and sanction a common strategy and guidelines for the development of Nepal's seed sector. As a chief guest of the program, Hon. Deputy Prime Minister Mr. Bam Dev Gautam emphasized the role of seed in modern agriculture. Similarly, Dr. Beth Dunford, Mission Director, USAID Nepal, acknowledged that the summit would be helpful in designing an action plan as per the strategies contained in the Seed Vision (2013–25) and Nepal's Agriculture Development Strategy 2014. Papers were presented covering seed policy, quality control mechanisms, and experiences and lessons from seed sector development in Nepal and abroad. Each presentation was followed by a panel discussion and open discussion. Importantly, seed entrepreneurs raised concerns about their inability to access quality source seed, credit, erratic subsidy scheme, and stringent regulatory mechanisms.

Facilitated by Dr. H.K. Upadhyaya, seed expert and CIMMYT consultant, participants identified the major barriers in the seed value chain and agreed on the major action plans. These action plans were categorized into four groups: (1) genetic resource management; (2) variety development, multiplication and maintenance; (3) seed quality assurance and marketing; and (4) private sector development. The first group's action points were: facilitating the implementation of the Plant Variety Act and identifying benefit-sharing mechanisms. The second group's priorities were: increasing research budgets, manpower and facilities in seed related programs/projects; accelerated hybrid research programs; the introduction of royalty payments to breeders; simplifying variety registration processes; creating a separate Genetic Resource Maintenance Cell within NARC; decentralizing source seed production; subsidizing seed production for new varieties; in remote areas, training seed producer groups and cooperatives on quality seed production; and introducing seed crop insurance. In the third group, the following action points were identified: training and licensing private crop inspectors; conducting point-of-sale inspection of seeds; implementing seed zones; developing community seed processing and storage facilities; increasing quality awareness; enforcing the Contract Farming Act; and projecting seed demand. The summit has also recommended that NARC establish a private sector coordination cell, which would allow the private sector to access NARC's breeding lines and manpower, provide fiscal incentives for private investment in R&D facilities, and establish a seed industry innovation lab. Speaking at the closing session of the summit Mr. Uttam Kumar Bhattarai, Secretary, MoAD said the Nepalese government would integrate the action plans into new policies and ongoing project activities.

6.2.1 Demonstrating elite cultivars of wheat and pulses for seed companies

Seed enterprises in Nepal do not engage in R&D; rather they multiply source seed (foundation and breeder) provided by NARC and sell in the market in the form of truthful labeled seed. For sustainable growth of their business, seed enterprises need to proactively engage with 'demand' side customers, including farmers and dealers, to better understand their needs and preferences. From CSISA-supported business mentoring and exposure visit to India, Nepali seed enterprises have realized the value of product demonstrations for creating demand. In response to the seed enterprises' request, CSISA has helped organize 120 integrated crop management (ICM)

demonstrations for new wheat and lentil varieties in coordination with Unique Seed and Global Agri-tech across the FtF zone.

Similarly, CSISA visited mung bean producers, traders and processors to understand the size of the mung bean market, as well as the challenges and opportunities associated with this crop. CSISA is linking mung bean processors and seed companies with The World Vegetable Center (AVRDC) to bring advanced genetics, including yellow-mosaic resistance, to the Nepal seed market.

7 MECHANIZATION

For mechanization technologies to successfully spread and have a beneficial impact in South Asia, three enabling conditions need to be present: 1) widespread awareness among farmers (demand 'pull'); 2) strong supply chains for machinery, spares, and repairs; and 3) and a robust network of service providers to ensure broad access to capital-intensive technologies through custom hiring.

In the last year, CSISA has been very active in awareness-raising and demand generation for scale-appropriate agricultural technologies through demonstrations, farmer field days, and agricultural fairs. On the supply side, CSISA has focused on strengthening importers and their dealer networks as well as training service providers with public, private, and development partners like KISAN. CSISA will continue to leverage these partnerships to achieve scale. Encouragingly, many of the private sector companies that we work with have started to sponsor their own farmer field days based on new agro-machinery technologies, several of which were introduced to the Nepal market by CSISA.

7.1 Operational land consolidation with laser leveling

An additional example of CSISA's responsiveness to farmers' constraints has been a scoping study related to the impact of laser land leveling (LLL) on the potential for operational land consolidation. Many farmers in the mid and far-western Terai split their relatively large plots into multiple small plots by constructing temporary bunds, which are knocked down and reformed each season. The primary reason for making temporary bunds is to facilitate the uniform distribution of irrigation and rainwater across these undulating larger plots. When water is unequally distributed, crops often suffer from too much or too little water and yields decline. Making bunds and then knocking them down every season in order to address the water problem is also labor-intensive and costly, and area taken up by the bunds cannot be cultivated and results in economic losses. Bunds are also an impediment to the adoption and use of large and small agricultural machinery such as harvesters.

FARMER MAKING BUNDS TO SPLIT THEIR PLOTS IN BARDIYA

Laser land leveling is performed by a four-wheel tractor (4WT)-drawn laser-guided land leveling attachment. The leveling of the field not only improves water distribution but also increases the plot size by reducing bund area. Land previously covered by bunds can be used for crop production and the costs incurred in making bunds each season, as well as doing traditional land leveling, are saved. Independent of area increase, an average yield increase of 8–10% in rice and wheat yields have been recorded after using LLL in CSISA sites in the central Terai and in experiments in India. These studies also suggest that using LLL can save irrigation water by almost 15–20%. CSISA has introduced laser leveling technology into the FtF zone to conduct performance assessments and simultaneously build awareness. In a complementary study, CSISA has conducted a survey of 400 households in Banke, Bardiya, Kailali and Kanchanpur districts to characterize the existing cropping systems, the presence and costs of bunds, and the potential for 'operational land consolidation' through LLL. CSISA is working with LL manufacturers to stimulate market development for this technology in the FtF zone.

7.2 Service provider trainings

With technical and business development advice, CSISA's service provider trainings focus on farmers who own a 2-wheel or 4-wheel tractor, or who are likely to purchase one in the near term. Usually an experienced 'lead' service provider is invited to these trainings to act as a trainer and a role model. More in-depth trainings are conducted for

established SPs who already own a machinery attachment for their tractor such as a reaper or zero-till seed drill. Training efforts are essential in the FtF zone, because service provision beyond tillage is extremely rare.

Two service provider trainings were held in March 2015 at each of the ARTCs near Nepalganj and Dhanghadi. The two-day program in Nepalgunj held on 18–19 March had 20 participants and covered a wide range of topics including improved agronomy for spring maize, including conservation agriculture, and introduced service providers to over ten different machines including two wheel tractor seed drills and their use and calibration.

The second two-day training was held at Authariya Bazaar near Dhangadhi on 28–29 March 2015 with approximately 40 potential service providers. This training focused on familiarizing the SPs with a wide variety of machines and agronomic practices, but also covered mechanized wheat harvesting including the self-propelled reaper, 2WT reaper attachment, and motorized scythe blade or brush cutter for harvesting wheat. The photo to the left shows a woman who was an outside observer to the training trying her hand with the powered brush cutter for harvesting wheat.

7.3 Field demonstrations

CSISA field staffs invest significant time on demonstrations in farmers' fields, which includes not only experiments and trials, but also targeted assistance on how to use new machines to plant or harvest. There are also activities where we simply want to test new machinery (new to us and new to farmers) and to solicit farmer feedback (see box below).

7.4 Agricultural fairs and field days

District Agriculture Development Office, Dadeldhura, organized an Agricultural Fair on 14–15 January 2015 in Dadeldhura on the occasion of *Maghe Sankranti* this year. CSISA managed an exhibition stall displaying various small machines appropriate for Nepal's hill agriculture such as mini-tillers, jab planters, seed drills, self-propelled reapers, paddle rice threshers and electric powered and manual maize shellers. Approximately 5,000 people attended the fair.

CSISA STALL IN DADELDHURA FAIR

7.5 Agro-machinery market development

In the Western development region (Chitwan, Nawalparasi, Rupandehi, etc), CSISA previously worked in an environment where there were established and mature agro-machinery markets and

relatively high awareness for some of the targeted machinery like 4WT and 2WT seed drills, 2WT reapers and even LLLs. In the Mid- and Far West regions, though, where there are only 4WT dealers, machinery markets are less well established and, in general, farmers' awareness of agro-machinery is considerably lower.

CSISA's core strategy for market development is to strengthen custom-hire agricultural services. CSISA and its partners envision that service providers will provide most of the access to agricultural machinery for smallholder farmers. Yet, multiple diverse interventions must be made to strengthen markets such that thousands of service providers are sustainably providing services to tens of thousands of farmer clients. Linkages must be strengthened – from the training of SPs and rural mechanics to the backstopping of importers and their local sales agents and dealers, who are the central support structure for successful service providers. CSISA has been very active in the last six months backstopping the private sector and helping to increase supply of targeted machinery.

7.5.1 The new NAMEA

Nepal Agricultural Machinery Entrepreneurs Association (NAMEA) became an officially registered professional organization in mid-December 2014. With market intelligence including information on new products from CSISA, and its GoN partners, NAMEA members have begun to sponsor their own marketing and training activities for increasing machinery sales via farmer field days as well as sponsoring national and regional agro-machinery fairs. Additional recent support to NAMEA by CSISA has been travel assistance for two of its members to the Patna Agro Trade Fair in February 2015. To obtain the travel support the members had to report back to the larger group about what they found interesting at the fair. One remarked that the fair had only traditional agro machinery and tools and that he was considering how he could break into the Bihar market with new machinery.

Additionally, the Nepal Agricultural Machinery Entrepreneurs Association (NAMEA) continues to go from strength to strength and has even hired a secretary in June who has been busy with membership dues collection drive since late summer. With the help and continued backstopping from CSISA and its partners in the Agricultural Engineering Division (NARC) and Agri Engineering Directorate (DOA), NAMEA has established new and independent linkages to two international centers. In August, two executive committee members participated in UN's Center for Sustainable Mechanization (UN CSAM) meeting on 4th -10thAugust 2015 of the Regional Council of Agricultural Machinery Associations in Asia and the Pacific (ReCAMA) in Beijing, China. By doing so, they are now the official member of this council representing Nepal. While in China, they participated in a training and study tour organized by China Agricultural Machinery Sciences and made new trade linkages by visiting area factories. The week-long event was organized by UN CSAM in collaboration with the Centre of International Cooperation Service of the Chinese Ministry of Agriculture and China Agricultural Machinery Distribution Association (see http://un-csam.org/news_detail.asp?id=467). On their return, the two, Krishna Sharma and Mahindra Kandel reported back to the larger group on what they had seen and learned.
Another linkage was created when NAMEA was invited by IFPRI as advisory members in their USAID funded Policy Reform Initiative Project For Agricultural Development And Food Security In Nepal project and have sent representatives to a recent program review and planning workshop.

7.5.2 Jumpstarting agro machinery markets in Mid and Far West development regions

During September and October 2014, CSISA placed orders for nearly $100,000 USD to 'jumpstart' the sales of select scale appropriate agricultural machinery for the Mid and Far West markets. The objectives of this investment are to:

- establish new sales agents and dealers in the Mid and Far West;
- increase the physical stock of new equipment in the showrooms of new and established businesses
- assist importers and dealers organize their own field days and demonstrations

CSISA has placed much of this large stock of agricultural machinery on a 'consignment sales' basis in the hands of select agro-machinery dealers and agro-vets of the Mid and Far West Development Regions. For example, Habi Auto placed 10 of the 20 zero till seed drills imported from National Agro in India to Habi's existing agents in Nepalgunj and new dealers in Gulariya, Bardiya and

Photograph on left shows three fertilizer cum seed spreaders for sale at an agro vet store in Kajura Bazaar in Banke District. On the right is a new agro machinery dealer in Munalbasti that was established after getting business advice from CSISA. Among his own stock of 2WTs and mini-tillers is a walk-behind reaper on consignment sale from CSISA NP.

Dhangadhi in Kailali District. Another example would be the 20 two-wheel tractor reapers ordered from two NAMEA importers (SK Traders and Kubir and Sons), which were placed with SK Traders and Kubir and Sons' new agents in the Mid and Far West (see section below). Through this free 'stocking' of machinery and the urging of CSISA, the imp orters and dealers are expanding their own businesses and product base as well as engaging in field demonstrations of the targeted machines like reapers.

By working through the private sector, CSISA is ensuring that sustainable market systems are strengthened at the same time that technology demand is being built.

7.5.3 The last mile: Strengthening local agro-machinery agents, dealers and agro-vets

The local district and regional based machinery agents, dealers and agro-vets represent perhaps the most vital link and are 'the last mile' in reaching target farmers and lead service providers with the new technologies. Programs like the machinery agents' meeting last December 21, 2014 held in Dhangadi included 30 participants from various agencies and projects, as well as nine different local and regional agents to attend a meeting to discuss the creation of a professional association similar to the national-level Nepal Agro Machinery Entrepreneurs' Association. Again, this is done so that CSISA can develop and strengthen the local and regional agro-machinery dealers, including their (1) technical capacity and knowledge of new products; (2) business linkages; (3) business acumen. The results are accelerating the growth of the supply side, which in turn boosts the spread and use of targeted technologies in the Mid and Far West. As an example of the capacity building provided, Mr. Shiva Bhandari, Chief Customs Officer, Dhangadhi, explained the most important tariffs and other charges applied to various types of agricultural machinery.

We envision that the Far West group and a yet-to-be-formed Mid West group to become self-sustaining professional organizations by the end of the project.

7.5.4 Leading with research: International Conference on Ag Residue Burning

CIMMYT participated in the Conference on Open Burning of Agricultural Residues in the Himalayan Region in Kathmandu, 20-21 February 2015 at ICIMOD (http://www.icimod.org/?q=17365). CSISA Agricultural Economist Gokul Paudel presented the paper, Conservation Agriculture: a resilient way to eliminate trade-offs in combine harvester use and residue burning in rice-wheat systems of Nepal. The report, which was based on last season's fieldwork on combine harvester use in Nepal by CIMMYT Agricultural Engineering Intern Subash Adhikari, has generated so much interest that the conference organizers, International Cyrosphere Climate Initiative (ICCI), has requested CIMMYT to consider submitting a project proposal to them for promotion of strategies and technologies to reduce the crop residue burning in Nepal. CSISA and its national partner NARC has generated evidence on many proven and even new potential solutions (e.g., new small-scale residue straw management equipment for Nepal like straw bailers, rakes, etc.) for managing residues from combines that will reduce greenhouse gas emissions and improve air quality.

Note: Work on scale-appropriate agricultural mechanization will continue through an investment by USAID India in CSISA-NP called Mechanization and Irrigation, described below.

In Person: *Early Adopter Leads the Way for Entire Village*

OmkarChaudhary in his rice field

Farmer Omkar Chaudhary hails from the village of Mainapokhar in Bardiya district, which lies in the mid-western region of Nepal. He owns 3.7 hectares of farmland, a landholding relatively larger than what most own in the region. Consequently, the shortage of labor during peak periods is a serious challenge for Chaudhary and he must rely instead on family members to help with farm activities. This has made him eager and willing to test modern agricultural technologies.

In 2012, CSISA facilitated an exposure visit for farmers from mid and far-western Nepal, including Chaudhary, to demonstrate the successful implementation of new technologies and practices such as the laser land leveler (LLL) and zero tillage (ZT) in India. Laser leveling helps farmers level the surface of their fields, which can result in water savings of up to 25-30 percent during cultivation. Following his visit, Chaudhary was quick to adopt and use LLL on his field.

The following year, when CSISA approached farmers in his Mainapokhar village to cultivate a demonstration plot for direct seeded rice (DSR), Chaudhary was the first to come forward. Under DSR, farmers can save on water and labor costs as it does not require them to prepare a nursery or manually transplant the seedlings.Even though there are no significant yield advantages over conventionally transplanted rice (TPR), direct seeding provides farmers the opportunity for early sowing of their winter crop by at least 15 days. Chaudhary, who has since adopted the practice himself, estimates that he can save a total of US$ 132 per hectare using DSR as compared to TPR.

Early adopters like Chaudhary are helping CSISA create and spread awareness about the benefits of these technologies across the country. His willingness to adopt new technologies himself is a strong influence on farmers in the village and district. A CSISA study on the effect social networks play on the demand for agricultural technologies finds that having a benefiting adopter in one's network increased demand by over 50 percent. Seeing Chaudhary's reduced cultivation costs from DSR, for example, farmers from the village were quick to employ DSR themselves. Currently more than 11 hectares of farmland in the village is under DSR cultivation.

Chaudhary said, "CSISA has provided us the opportunity to observe and evaluate different new and innovative technologies that are beneficial for farmers." This year, when CSISA introduced farmers in the village to ZT wheat using both two-wheel and four-wheel tractors, Chaudhary, once again, was among the first to express a willingness to try them.

A $1 million investment over two years (2015-2017) by USAID India allows CSISA-Nepal to continue practical research into appropriate-scale agricultural machinery and irrigation technology in Nepal, and to contribute to the scaling of agricultural mechanization in CSISA's working domains. Activities to date are described below.

8.1 Achieving scale: Reapers explode onto the market

CSISA has spent considerable time and effort over the last two years in the Mid and Far-West regions demonstrating reapers for two-wheel tractors (2WT) and training service providers (SPs) on how to use them. Until recently, though, we had not been getting much traction in generating sales for reapers or for reaper services. The scenario began to change In September 2014, with a critical mass of would-be service providers understanding the technology and a sufficient number of farmers interested in overcoming labor bottlenecks and drudgery at harvest time. CSISA took advantage of the increase in interest and through a new activity we called, 'Jump-starting Agro-Machinery Markets', CSISA placed 20 new reapers in local markets in the Mid and Far West regions this last February and March just prior to wheat harvest season. This initial influx of machines generated interest among farmers and spurred dealers to import and stock more, which resulted in sales of over 100 2WT reaper/harvesters in this last wheat harvest season (March–April 2015).

The sale of approximately 100 two-wheel tractor reapers this wheat-harvesting season (March–April) was in some ways unexpected by CSISA, DOA and private importers. For the last two years an array of demonstrations and trainings for 2WT reaper attachments, self-propelled reapers, and now mini tiller reaper attachments have been conducted by CSISA, NARC's Agri Engineering Division, DOA's Engineering Directorate and, just as importantly, various private sector importers like SK Traders, BTL Traders and Kubir and Sons. Yet, sales lagged such that only a few were sold in those two years. Last September–October when CSISA gave an initial order of twenty reapers for its Jumpstarting Agro Machinery Markets program, the team was hopeful that they might sell 5–10 of these reapers in the coming wheat season. In December CSISA learned that Kubir and Sons and BTL somehow had an instinctual good feeling about the future of reapers in the west, and that they ordered an additional 25–50 pcs each to sell in the west.

When the CSISA orders began to arrive in January–February 2015, CSISA insisted that the importers come with their machines to the west and place the CSISA-purchased machinery with their agents. On one visit to the Far West, Scott Justice reported that he saw two CSISA reapers in a new shop just to the west of Artariya Bazaar on the East West Highway. When chatting with the store owner he found that the owner had no idea that the machinery belonged to CSISA and insisted it was the importer's machine: which is just what a mechanization promotion project like CSISA should be doing – enabling, but staying out of the way and letting business flourish. That is just what happened. It appears that along with sales of 25 reapers from BTL traders (mostly in eastern Kailali), 10 reapers from SK Traders, 18 reapers from CSISA's Jumpstart Program (in Banke, Bardiya, Kanchanpur and Kailali) and more than 50 reapers from Kubir and Sons (mostly in the Far West) nearly 100 machines were sold in the 2014-15 Rabi season, whereas essentially zero had been sold in the previous year.

Sensing the opportunity SK Traders, Kubir & Sons, SKT, and BTL Traders have said they have ordered many more reapers – over 100 reapers each – in anticipation of even higher demand in the coming rice season. The current fuel shortages and border blockade will have some as yet unknown affect on sales this rice harvest season.

8.2 Negotiations for site selection of ag mechanization R&D and training centers

With NARC Engineering Division and the DoA's Engineering Directorate, site selection and design planning has been accelerated for establishing co-located facilities for machinery design and testing as well as a skills development training center for mechanics and service providers. Administrative delays in project approval through the Ministry of Agricultural Development (MoAD) following the earthquakes in April and May pushed back the timeline for build-out by approximately 6 months.

8.3 2nd National Agro-Machinery Fair

Negotiations have been initiated with the Engineering Directorate and the Nepal Agricultural Machinery and Entrepreneur's Association for CSISA to be the main sponsor of the 2nd National Agro machinery Fair. The government has provided the preliminary consent that the fair could be held in the Feed the Future zone in the Mid-West in February of 2016.

8.4 Walk-behind maize planters

As mentioned above, due to the apparent success of new models of single- and double-row gasoline engine powered 'dedicated' maize planters in China, one model was imported and is being evaluated in Littrigaon village near Daldeldhura under reduced till and zero till conditions. The interesting thing about these particular machines is that, while they resemble a mini-tiller, they: 1) have either a single and heavy lugged metal drive wheel or a single track-type caterpillar ground drive system that gives this small-horsepower machinery additional pulling power to do conservation agriculture seeding (one row) in lighter soils; 2) can inter-cultivate and band "N" in one pass after the emergence of maize.

An example of the track type or caterpillar type ground drive systems that gives more "draft" or pulling power than conventional tire type mini tillers.

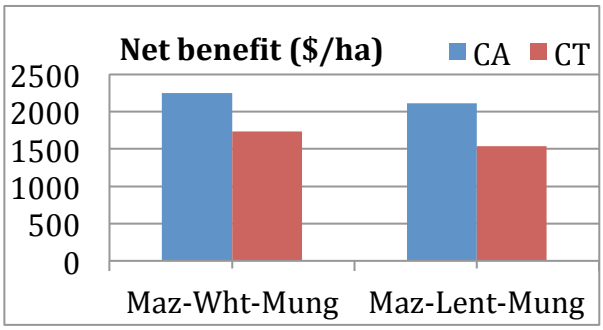
If results of the trial this summer are successful, CSISA will import various other models and advise NAMEA members to consider importing and marketing them in Nepal.

9.1 Capacity building

9.1.1Leading with research: PhD Research Support

CSISA provides technical and financial support for seven PhD candidates who are staff members at eitherDOA or NARC to build capacity while broadening and strengthening CSISA's field research.

One of our students, Mr. HariPrasai (PhD scholar from NARC) conducts research entitled Evaluation of Conservation Agriculture Technology in Maize-based Cropping Systems for Far Western Hills. His research seeks to evaluate the performance of different crops and profitability of two maize-based cropping systems, i.e., Maize-Wheat-Mung and Maize-Lentil-Mung, under conservation and conventional agriculture systems in the Far West hills. The experiment was conducted in RARS, Dotisince 2014. The treatments evaluated were: 1) Tillage systems: two tillage based systems, i.e., conservation agriculture and conventional agriculture based management system; and 2) cropping systems: two, Maize-Wheat-Mung and Maize, Lentil-Mung.The preliminary research data shows that, conservation agriculture based management system is more profitable than the conventional system under both Maize-Wheat-Mung (29 % more profitable) and Maize-Lentil-Mung (37 % more profitable) systems. Among the grown crops the large difference on conservation and conventional systems was found for maize where yield performance of both hybrid and OPV was approximately 1 t ha^{-1} higher with conservation agriculture-based management.



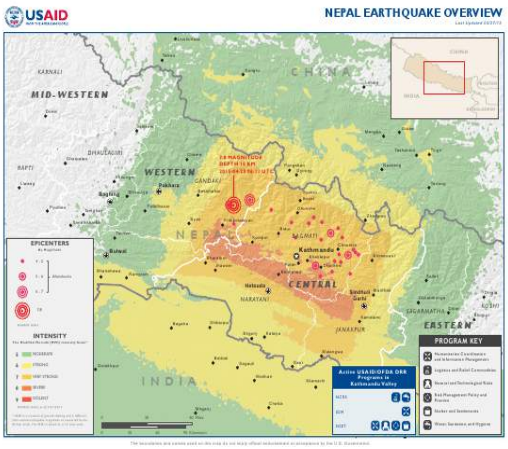
9.1.2 Leading with research: International Year of Soils 2015

As a part of the celebration of International Year of Soils 2015 with the theme "Healthy soils for a healthy life", CSISA collaborated with NARC's Soil Science Division to organize a National Soil Fertility Research Workshop on March 24–25, 2015 in Kathmandu.

The main goal of the workshop was to provide a common platform for sharing knowledge and expertise on all aspects of soil science-related research in Nepal and to compile allsoil science-related research information and data available in the country. More than 120 scientists and technical experts participated in this workshop. CSISA-NP provided both technical as well as financial support for this workshop.

PARTICIPANTS OF SOIL FERTILITY RESEARCH WORKSHOP, MARCH 24-25, 2015, NARC,

In Focus: *Challenges Faced During the Reporting Period*



Map illustrating quake severity of the quakes in central Nepal

Along with what seems like the regular vagaries of weather that CSISA's farmers face, the country this year faced much more severe challenges. The 7.8 earthquake that struck Nepal on 25 April 2015, followed by a 7.3 earthquake on 12 May and many additional aftershocks, had huge negative impacts on the country and its agriculture and food security. It is estimated that about 8 million people have been affected by the earthquakes, with smallholders in hilly regions being most hard-hit. There were over 8,800 killed and 25,000 people injured. This tragedy has of course affected all development projects. While no major injuries or deaths occurred to CSISA staff, two lost their homes in the earthquake affected region. Yet, as the earthquake was confined to the central Nepal field operations were only lightly affected in the Mid and Far West target regions. Understandably, the Government of Nepal and MoAD have prioritize earthquake recovery over other pending matters, resulting in administrative delays for CSISA and other projects in the FfF zone.

CSISA field staff report that more than the earthquake, the violence and strikes in Mid and Far West Terai region that started in mid -July 2015 as a result of the contested constitution-making process have greatly reduced their ability to manage day-to-day activities. In addition, the import of critical inputs from India has been severely curtailed, compromising the team's ability to fully implement precision nutrient management trials. Since September, agitating Terai groups with allies in India have effectively closed the border, resulting in severe fuel shortages across the country that are undermining farmers' ability to harvest rice and establish winter crops – in many areas there simply is no fuel to be had at any price.

On the climate front, winter rains have been both heavier and more frequent in the last five years, benefiting lentil production in the hills but severely damaging production in the Terai. CSISA continues to research the best ways to reduce risk and build resilience to climate extremes.