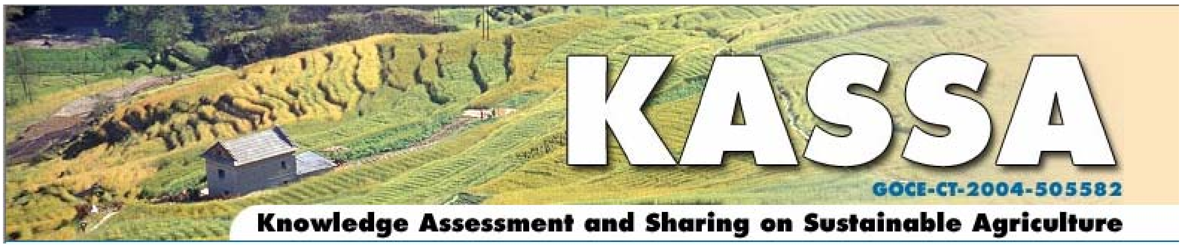

Asian platform comparative critical analysis. Learning from KASSA platforms' reports

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Asian platform summary describes carry home messages from the KASSA Platforms for Asian platform partners. The analysis is based on matching biophysical and socio-economic environments of technologies and their reported impacts by Latin American, European and Mediterranean platforms. Experiences and acquired knowledge from these platforms have been assimilated in Asian context to refine the existing technologies and to focus on alternative technologies and approaches that may be adapted to resolve complex natural resource management problems for location-specific, and regional situations.

Socio-economic and biophysical features in different regions of the KASSA Platform

The agricultural conditions in four platform countries represent a wide range of biophysical and socioeconomic situations where the evolution of concepts and practices of conservation agriculture have been studied and evaluated. Asian platform shares many characteristic features with other platforms. Climatic features of the Asian platform include monsoon type climate where nearly 80%of the rainfall is received in about three months period (July-September). Rainfall has high erosive capacity in sloping lands due to high runoff which not only lead to soil loss and decline in soil fertility but also result in prolonged periods of water scarcity putting serious constrain on crop choice in cropping patterns. Over a period of time, irrigation facilities have been created to overcome uncertainties associated with vagaries of monsoon rains yet nearly 60 percent of farming is practiced under rainfed conditions and only in 40 percent farmed lands, irrigation facilities are available. This is in contrast to conditions in countries of other platforms. In Latin America, for example Brazil, rainfall is uniformly distributed throughout the year in the subtropical areas. This makes it possible to grow 2 or even 3 crops per year depending upon the region. In humid *Cerrados* region, diversified CA systems were developed by farmers for the large-scale grain production and to replace the inefficient tillage–based sorghum monoculture system. CA system is practiced by small as well as large farmers. Driving forces included a combination of technical, agro-ecological, socio-economic and institutional factors. Initiatives of the farmers in no-till system were well supported by research. Institutional arrangements among various stakeholders (public/private research and extension institutions, agrochemicals companies, machinery manufacturers etc.) played a major role in development and promotion of CA. Similarly, adoption of new farming system with CA principles has also been a farmers-led process. Farmers who had access to large scale markets played a key role in the process. For example, farmer initiatives from eastern lowlands in humid tropical Bolivia in 1980's led to development of conservation agriculture without support from the research institutions. In later years, to improve profitability of the soybean-wheat rotation, CIMMYT helped develop a no-till system. In sharp contrast, in Bolivia, efforts of formal research institutions and a farmer-funded research foundation led to emergence of specialized CA networks. Here, machinery used by large farmers for practicing CA was a major constraint for small and medium scale farmers. CA principles were not adopted fully, no-tillage was stressed but use of cover crops and crop rotations is still incipient. This led to problem of soil compaction; soil crusting and increased incidence of diseases etc., maintenance of soil covers it self is a problem in humid tropics due to rapid rates of biomass degradation.

Farmers in the Mediterranean region practice both an extensive rainfed and an intensive irrigated agriculture. Dryland farming systems are limited by weather, land topography, water availability, low soil fertility and soil erosion. Development of no-till agriculture has been very irregular in this region. A major factor inducing the change was the necessarily to increase soil organic matter to restore soil quality and productivity and reduce input costs. In development of CA technologies, machinery and herbicides molecules, private companies, played an important role. In countries of European platform, climatic conditions per se are not a major constraint in crop production. However, agronomic management constraint remains one of the main constraints explaining the low expansion of reduced tillage practices in northern Europe. Thus, environmental benefits of reduced tillage systems in response to the concerns for land and water quality and soil organic matter protection attracted the researchers to initiate studies on CA. On the other hand South Asian farmers are attracted towards CA as it benefit them through savings in fuel, labour, water and improve the productivity of externally added inputs. CA fulfilled the short term gains of producing more at less costs. CA also fulfills the longer term goals of enhancing the quality of resource base.

Approaches used for promoting the CA in between different KASSA-platforms

Conceptually, a consensus is emerging amongst platforms/countries that CA is a way to achieve high levels of productivity in a sustainable manner. There appears a good degree of agreement on the basic elements of CA-which are no-tillage, soil kept covered with crop residues and adoption of crop rotations, except that the Asian Platform partners are putting an additional thrust on controlled traffic to reduce soil compaction.. The CA practices are however, still evolving with agents for change and are at various stages of evolution in different platforms. Whereas, the concepts of CA are well entrenched in countries of other platform, the resource conserving technologies-an exponent of CA, which recently received lot of attention, are spreading at an accelerated pace through efforts RWC, and CG centers like CIMMYT, IRRI, ICRISAT, and CIP and beginning to make an impact in the Asian region.

Implementation of CA concepts and practices require different kind of planting /harvesting equipments, new sets of fine tuned agronomic (soil and water) and crop management practices. A significant characteristic feature worth exploring for the Asian platform is integration of crop-livestock interactions to capture ‘double productivity and profitability’ using high value crops such as maize, in places having large market access for produce.

Land tenure laws have implications for wide spread adoption of conservation agriculture, depending on the size of holdings (socio-economic environments), access to irrigation and markets and level of mechanization. Mechanization varies widely across the platform countries and in different regions within the country. In South Asia, mechanization is high in irrigated regions and low in rainfed areas. A completely new generation of drillers and planters specially designed to plant crops in no-till and surface residue conditions has been a key factor in promoting adoption of CA principles everywhere. Industry also invested heavily in these technologies based on the farmers' suggestions.

Transition to conservation agriculture: Suggestions for Asian conditions

Most studies across the platforms tend to show that the real benefits in terms of resource quality enhancement came about only when zero-tillage is practiced in conjunction with surface managed crop residues. In rice-wheat systems while zero-tillage is being adopted extensively due to benefits through reduced tillage, labour and fuel costs and enhanced production resulting from timely sowing of crops. Benefits in terms of resource quality improvement are likely to increase further if instead of partial retention of residues all the residues are retained on the soil surface. In rice-wheat cropping system rice is normally transplanted under puddled soil condition. The process of puddling leads to destruction of soil structure. Thus for implementing the concept of Conservation Agriculture and the elements that go with it, developing a 'double no-till' system for rice-wheat cropping system with contrasting edaphic requirements has been a major challenge for researchers and farmers. Other platforms have little experience with cropping systems having contrasting edaphic requirements. With support from RWC, farmers are experimenting In any case, there is sufficient evidence that zero-tillage and associated resource conservation technologies when combined with appropriate surface managed crop residues can provide favorable conditions for diversification of cropping systems and reversal of process causing soil degradation.

Benefits / Impact of Conservation Agriculture

Results of research summarized by different platforms permit to conclude that benefits from CA comes about in different ways. The nature of benefits will change over time. Benefits of CA accrue from cost reductions linked to savings in fuel, labour and machinery cost. Effects of CA on major gains in crop yields are expected to result from changes in soil physical, chemical and biological properties, which likely come about only with time. Near-term benefits from reduced costs in initial years usually enthuse farmers to adopt CA. However, near-term benefits have to be balanced against increased costs resulting from increased pesticide use experienced in other platform countries. Experience with no-till wheat in India, however, has shown reduced incidence of weed, *Phalaris minor*. There are not many studies which document that residue cover in unplowed fields leads to proliferation of pests and diseases compared to conventionally ploughed system. Residues of different crops which may serve as changing food substrate for the microbes likely also have a major effect on the ecological balance. Socio economic impact of CA appears not to have been studied/ documented well. Since change over from conventionally tilled agriculture to conservation agriculture is a major shift for South Asian farmers, researchers and extensionists, these nations will continue to need support from donor communities for capacity building and dissemination of knowledge for an accelerated adoption of CA. This is an important learning message that should prove helpful in formulating R&D strategies for this region.

Decomposing residues in no-till systems trigger a series of processes which lead to enhanced biological activity, creating a gradient of carbon from the surface to deeper layers, accumulation of mobile nutrient elements in surface layers and changes in soil properties. The nature and magnitude of these processes will depend on agro-climatic situations and cropping and cultural practices. These changes have a profound influence on the management needs, options and overall role in ecological functions. In Asia, with monsoonal climate, farmers generally incorporate the residues into soils for their fast decomposition. Retention of residues on the surface, require a new set of practices for crop establishment, fertilizer use, water and weed management. European and Latin American platforms report a number of long-term studies aimed at undertaking the dynamic of changes following adoption of CA practices. Such understanding is continuously helping in improving strategies necessary for achieving sustainability goals. South Asian countries should also establish some long-term sites for studying the consequences of no-till agriculture. Compared to soils in Latin Americas and European platform countries, organic matter content of soils in Asian platform countries is very low. Understanding the dynamics of changes following CA will be extremely important under a range of situations in both irrigated and rainfed situations for protecting soil organic matter against microbial decomposition.

The primary aim of management strategies in CA systems in many countries of European platform, particularly Western Europe, is to minimize the environmental impact of using pesticides and or other pollutants (e.g. heavy metals and fertilizers, organic pollutants originating from agricultural use of fertilizers sludge, and composts), and reduce leaching losses of nitrates. Other issues, that have drawn increasing attention relates to building up carbon stocks, quality of soil organic matter, bio-diversity changes etc. Development of indices that integrate major physical, chemical, and biological properties to measure and monitor soil quality changes as sustainability indicators is emerging a key researchable issue. These aspects will be increasing research focus in Asian Platform countries.

Major constraints of CA and learning messages from other platforms

In the context of Asian platform countries it would appear that while environmental problems associated with high productivity regions have been increasingly highlighted, effective strategies are constrained by water shortages and thus appear to be not in place to devise ways to minimize their impact. Some studies show that nitrates leaching to ground water during the monsoon season can prevented by growing a catch crop before rice season However, water shortage for summers have restricted the use of such practices on large scale. Only few attempts have been made to understand the practices that minimize adverse efforts. Results of research presented in European platform countries clearly bring out that conservation agriculture offer opportunities through reduction in use of external inputs and minimizing adverse effects.

'Soil nutrition principle' is an approach, which has evolved over a period in Argentina looks beyond the concerns for crop fertilization. It provides a more systematic approach that considers the interactions among soil chemistry, soil biology, soil organic matter and structural properties, nutrient cycling etc, rather than putting just the addition of nutrients to a given crop. This has been the result of some long-term studies carried out on no-till.

So there is a need for good research on the effect of tillage on changes in soil profile. This aspect in Asian platform need to be strengthened. Similarly as indicated earlier one of the driving forces for evolution of CA in many of the Mediterranean platform countries has been the necessity of controlling erosion by rainfall – runoff and wind. Crop residues left on soil surface are an effective way to reduce erosion and several studies have elaborated on processes that contribute to reduced erosion. These include reduced impact of raindrops on soil surface, reduced velocity of runoff and greater opportunity time for infiltration. Other studies bring out the role of decomposing residues in promoting aggregation and stability of aggregates of surface few mm of soil, contributing to enhance infiltration capacity and reduced crusting and proneness to erosion by water and wind. Soil degradation resulting from erosion by water and wind are wide spread and serious problem in both irrigated and rainfed regions in countries of Asian platform. In the Indo-Gangetic plains, soils are deep and erosion process being insidious this aspect has not received the desired attention. High intensity monsoon rains concentrated in a span of about 100 days cause heavy soil losses with adverse effects both on on-site and off-sites. In the rainfed ecologies, controls of runoff and soil erosion are most critical in enhancing and stabilizing yield in many risk prone regions where the poorest live. There is urgent need to evaluate and promote elements of CA approach in addressing resource degradation and livelihood issues for vast majority of people who have been bypassed by 'Green Revolution' technology.

One of the constraints frequently cited in adoption of mulch based systems is the availability of crop residues as they are consumed by livestock. These are the issues, which will call for working hand in hand with the farmers for generating residues without additional need for irrigation water, learning and educating them in developing and promoting CA systems under a range of agro-climatic / farming situations. Consortium partners are promoting a 'co-culture' practice wherein rice and Sesbania are grown simultaneously before knocking down the green manure crop after 30-35 days of sowing.

Resource conserving technologies, an exponent of conservation agriculture, perform best when fields are precisely leveled and there is an effective control on application of irrigation water. Thus, it will be important that production-protection agriculture is given the much needed policy support to save on external inputs and enhance the quality of natural resource base. Diversification at times is taken as substituting a cereal crop with another cereal or legume crop. Such a diversification strategy is very restrictive for capturing the 'double productivity and profitability gains'. Experiences in other platforms suggest that diversification through crop-livestock interactions provide such opportunities, for example, one from the high-value cereal grain product and the other from using the green maize stalks as high-value feed for dairy production. When crop- livestock interactions are integrated in pursuing CA, it is probably the best form of CA.

Mediterranean and European regions also provide their vast experience with respect to organic farming. In India, over the past few years interest in *Organic Farming* has been expanding and several governmental / Public agencies are getting actively involved in promoting the programmes by assisting in development of national standards, accreditation criteria and procedures, inspection and certification criteria and procedures etc.,. In these efforts active involvement and collaboration is being sought from such agencies as International Federation for Organic Agriculture Movement (I FOAM). It is apparent organic farming movement is entirely market driven and is in response to concerns of health and quality consciousness arising from widely perceived adverse effect of chemicals which have come to be used in conventional agriculture. Although the area under organic farming is rather minuscule, but promoting it on more vigorous scale can damage the fragile balance of national food security in South Asia.

❖ *Socio-economic and policy conditions necessary for adoption by farmers*

Conservation Agriculture has emerged as a major strategy to achieve goals of sustainable agriculture. No-tillage when combined with surface managed crop residues sets in motion processes whereby slow decomposition of residues results in soil structural improvement and increased recycling and availability of plant nutrients.

- It is well understood from the learning of other platform reports that the concept of CA in India has not yet established its roots and is just beginning to make its mark. Thus, adaptive strategies for CA system will be highly site specific yet learning across the sites will be a powerful way in understanding why certain technologies or practices are effective in a set of situation and not effective in another set. This learning process will greatly accelerate building a knowledge base for sustainable resource management.
- Driving forces for shift to CA varied and depend upon specific socio-economic conditions among the various platforms. Under Indian conditions, in the past major driving force has been increasing productivity with little concern for resource quality and its improvement as a continuous process. However, there is increasing awareness that sustainability is under threat due to continuing resource degradation.
- In South Asia, a well articulated policy goal for livelihood security and rural development must now replace the myopic 'food security' policy based on cereal production. Policy framework for promotion of CA will require radical changes and these will have to be identified and promoted in holistic manner. A factor price support followed by mandatory procurement for the crops alternative to rice, that do not overexploit natural resources, thereby enabling policy mechanism and environment for other alternative crops. Emphasis should be on selecting and developing short duration varieties instead of long duration for saving various inputs like, water, electricity, fertilizers etc..
- A reversal in policy making and decision making in agriculture with involvement of farmers with other stakeholders at different levels. Policy regimes need to emphasize resource conservation and co-evolve with it. For example, learning messages on Resource conserving technologies from Rice-Wheat Consortium should be internalized more and more into national programs.
- Sharing of information amongst farmers, scientists and other stakeholders would be critical, in advancing the spread and continued upgradation of CA systems. Therefore, geo-referenced databases will be critical for extending the principles of CA.

- ***Proposals for appropriate local and regional policy and Gaps to be filled***

- CA practices e.g. no-tillage and surface maintained crop residues results in resource improvement gradually and benefits came about only with time. It is important that evaluation of CA takes into account its impact on the environment, and improvement in the quality of natural resources.
- Promoting CA will call for moving away from the conventional compartmentalized and hierarchical arrangement of research that generated and perfected technologies, extension that delivers it and farmers who adopt it. All the stakeholders involved would need to be brought together on a common platform to conceive end-to-end strategies. Roles of research, extension, farmers and other stakeholders should be institutionalized in a way that strengthens these partnerships.
- As CA systems are much more complex managing the systems efficiently will require understanding of basic processes and component interactions which determine the whole performance of the system. Understanding system interactions and developing management strategies will call for team work using an innovation system framework. This will also call for new ways of managing and funding research.
- Institutional mechanisms are required to ensure that ***Conservation agriculture/ RCTs is seen as an important component of the national / regional strategy for food security, poverty alleviation, health for all, rural development, enhancing productivity, improve environmental quality and preserve natural resources.***
- There is a need for policy analyses to understand how conservation technologies integrate with other technologies, policy instruments and institutional arrangement that promote or deter conservation agriculture. It is therefore a challenge both for the scientific community and the farmers to overcome the past mindset and explore the opportunities that CA offers for sustained agriculture. CA is now considered a route to sustainable agriculture. Spread of CA, therefore will call for a greatly strengthened research and linked development efforts.

New ways of during research in Resource Conserving Agriculture:

Traditionally agricultural research was conducted in the national agricultural research system mainly as on-station trials. This system has long time lag in development of information and its subsequent use and uptake by the farming communities.

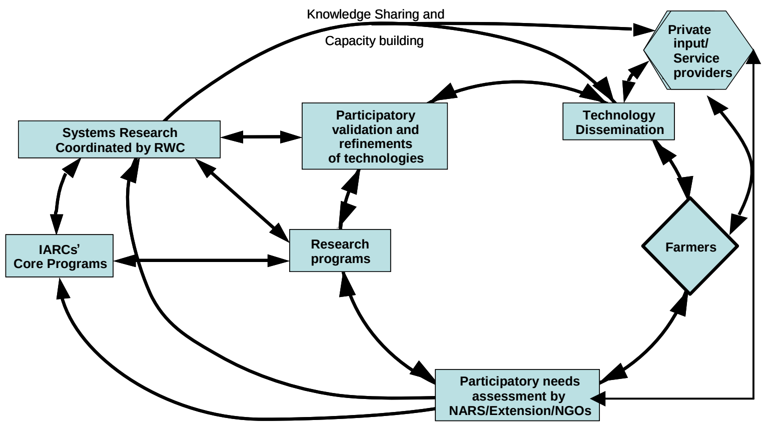

Fig. 1.Impact pathways of CA in South Asia. (Source: Seth et al.2004. RWC Review Panel Recommendations, RWC, New Delhi, India).

In RAC, many of the agronomic and crop management practices are crops followed depend on the way crops are established. Therefore, in RCA, tillage and crop establishment is at the center stage of all of our activities and hence requires a paradigm shift in the way research is planned, organized and implemented. RCA is more about farmer led research in participation. The schematic diagram shown in figure (1) depicts the way research is planned, organized and implemented in Rice-Wheat Consortium in South Asia. It has been our experience in the RWC that involvement of the key stakeholders from private sectors, particularly the machinery manufacturers and input suppliers other service providers is very important in spread of the RCA. These institutions are usually not interested in research and development (R&D) as such but when sensitized are willing to modify and redesign their prototype to meet specific needs appropriate to different environments.

An important finding in Asia Platform partners was the 'divisibility' in application and utility of CA (no-tillage, surface seeding and raised-bed technologies) promoted by the Consortium partners (NARS, IRRI and CIMMYT, ICRISAT) in the Indo-Gangetic plains.

It was observed that farmers need researcher's help in generating options (agronomic and crop management practices) that can easily fit into their socio- economic endowments rather than a tight package of agronomic and crop management practices of CA. For instance weed can managed in different ways before after seeding crops. Similarly savings in irrigation water can be effected in several ways (e.g. change of crops; change crop geometry, mulching, irrigation methods and schedules and land leveling etc.). Some these pactices can be add on type to keep accumulating the benefits of each practice (eg. Precision land leveling, direct seeding and no-till ZT, with surface mulching, real time N management through use of LCC).

Scale neutrality of the RCA

In South Asia, we have observed that RAC technologies are scale neutral. It implies that RCA can be practiced on all types of farms (small, medium and large sized farms). It may be mentioned that medium / large farmers who have greater capacity to absorb the risk of practicing RCA are often first to experiment with RCA. But soon the landless/ lease farm holders and small farmers. In the drought year 2004, many farmers who were unable to manage traditional wet rice were either forced by drought to reduce rice area or had to change-over to more water-wise technologies such as direct dry seeding of rice (DSR) in shallow depth and use of post-sowing, pre-emergence herbicide molecules combined with residue retention of previous mungbean or wheat crop or go in for 'brown manuring' with *Sesbania*. These strategies helped farmers to grow rice without yield penalty, save irrigation water and earn additional US$100-150 per hectare through reduced costs in cultivation of rice. DSR can be followed both by small and large farmers just as combine harvesting of rice and wheat crops.

KASSA Platforms characteristic features and Commonalities of CA Experiences across platforms

Characteristics	Mediterranean Platform	Asian Platform	Latin America	Europe
1. Climate	Mediterranean	Tropical & subtropical	Tropical & subtropical	Temperate
2. Rainfall	• Annual average 250–700 mm (Autumn/early winter and Spring) drought is endemic	• Annual average 400–2800 mm Monsoonal (June–Sept), drought in other periods	• Annual average 1200-2000 mm well distributed and drought like condition in some countries.	• Generally well distributed, not a constraint,
3. Main Resource base problems- Cropping systems impacts on soil properties	• Soil erosion, over-grazing, declining of soil fertility. High doses of chemical fertilizers. • Rainfed: Stubble burning and overgrazing, low OM, deterioration of initial soil properties, soil compaction, desertification. • Irrigated: excessive chemical application, high nitrate and pesticide lixiviation, contamination of underground water, pollution. • More weed and pest population	• High erosivity in sloping lands, Decline Water tables and SOM, draught, • Rainfed: stubble burning and overgrazing, low OM, deterioration of initial soil properties, soil compaction, and desertification (bare lands and hills). • Irrigated: excessive chemical application, high nitrate and pesticide lixiviation, contamination of under ground water, pollution.	• Soil loss through high erosion, mechanical-measures not effective; avoid the growing of annual crop. • Water problems in some countries. • Main constraints for small-scale farmers are: difficulties in weed control (choice of herbicide and spraying technology), increase in the incidence of pests and higher use of pesticides	• High erosivity • Pollutions due to excessive reliance on herbicides/ pesticides, • Soil compaction. • In wetter regimes, some areas may have constraints, accumulation of mobile nutrients (NPK) in top layer of soils, Soil humidity and temperature are major problems ,
4. Animal husbandry	• Livestock, Sheep and goats grazing, feeding and bedding but the conflicts between feeding animals and mulching.	• Livestock (Buffaloes and cows). • Goats are traditional but rapid development of goat production has started very recently. However, as goats are poly-eaters, they may be damageous for crop cultivation. So, we have to take this into account in decision making.	• The main problem is shortages of feed and also a clear conflict between the need of mulching materials and animal feed.	• Animal grazing areas is very large segment of UK farming.
5.Land preparation	• In European Mediterranean countries (EMC): Partial mechanization and still animal drawn implements • Minimum tillage with small hoe cultivators is	• IGP: Tractors, animal traction • VN: Small hand run tractors, animal traction and hand mechanical tools like hoes, spades,	• Mechanization of large farms. • Small/ family farms are still not fully mechanized	• In European countries: tractors are totally used for tillage.

	now more common than 40 years ago. • Development and adoption of no-tillage has been irregular; Knowledge of these technologies has not reached all places, but in some places, no-tillage accounts for 80%.	etc. • Hand work always takes long time, so reduction of labor on land preparation and weeding will save a lot of time for farmers, and they can open new income generation activities.		
6. Development of CA	• EMC: since the 1960s, more rapid than North African MC. • Winter cereals in rotation with legumes, sunflower, canola; Use of cover crops in perennial crops (Olives, nuts, and grapes) is increasing. Inter-cropping maize with alfalfa, etc. • Research to promote CA development started in North African Mediterranean countries in 1980	• CA does exist for long time in some forms in sub-humid and humid rainfed systems and was interrupted by GR. • Research to promote CA development started again with irrigated RW systems in IGP. • On slopping lands CA (mulching, reduced tillage) has been adopted at small farms.	• CA is practiced from small-scale to large-scale farmers. • Area under CA was 55.6% in the subtropical region and 44.4% in the tropical region during 2000-01. • Cultivation of grain crops may include rotation with onion, tomatoes and tobacco.	• CA development in Europe, particularly no-tillage, is progressing with low pace with revision of whole range of agronomic practices. • CA adoption leads to the necessity to revise the whole management process.

Some commonalities of CA experiences across different Platforms

Topic	Description
Crop yield	+ / ~ except in some initial years at some specific locations
Product quality	improves the quality +
Emergence and crop establishment	Positive or negative response is site and crop specific. But, in general, does not affect final yield
Water use efficiency	Positive response under dry conditions, and similar in favorable conditions
Nutrient use efficiency	There are evidences in possibility to increase or improve the efficiency
Crop residue management effects	Positive in all situations but difficulties in establishment of crops, Residues retained on the surface act as good herbicides for effective weed management. Use of herbicides to control weeds in initial few years is a necessity.
Pest and disease management	Some negative incidences of particular pests and diseases in favorable humid areas, *Yes, but we are more focusing on adverse dry conditions. Effects of cover crops having different constitution – to serving as food substrate not clearly understood.*

Crop nutrition and crop fertilization	Fertilization application practices to increase productivity and response, required to be fine tuned under CA with residues
Adapted genetic resources	Very limited data *(crops with elongated coleoptiles length and more vigorous genetic materials in early growth stages will be better adapted). Interaction effects of GxTxE yet to harnessed.*
Fallow management	Chemical weed control may be necessary for optimum performance of crops after Fallow under CA.
Cost of cultivation	Generally less than conventional, but with higher yields, in some situations there is a risk in initial stages of practicing CA if technology is not appropriate.
Soil biology	Perceptible increase in soil biological activity, how it affects various soil processes over time is not fully understood. Stress factor on biotic activity may be used as criteria to evaluate resource base/soil quality.
Erosion by wind and water	Reduction of water and wind erosion.
Soil quality	Concept of soil quality is only beginning to emerge across platform.

Learning messages and technologies

Generalized Messages
• Make CA a farmer-led program for accelerated adoption of CA • CA requires multidisciplinary approaches to resolution of complex NRM problems. • In context of CA, new approaches to crop improvement, establishment and management are required for different cropping systems for a range of situations. • New generation of farm machinery able to seed in loose residues required for small, marginal and large farm holdings • CA requires adjustments in the traditional agronomic and crop management practices. • Issues of environment, soil erosion and land and water quality have to re-emphasized. • Integrate Crop and livestock sectors for resolution of the conflicts for straws for soil cover and fodders. • CA requires a paradigm shifts from till to no-till agriculture and hence would need support for training and research from donors and policy makers.
Technologies/ Practices that can be adopted / upscaled
• Residue retention is an integral part of CA. Free wheeling leads to soil compaction so controlled traffic be promoted. • In sloping lands with less than 15^o slope, CA can obviate the need for terrace farming. ‘Up and down’

cultivation can be practiced.

- Raised bed system promotes crop diversification and biodiversity.
- Intercropping with live mulches or brown manuring can bridge the missing link of in situ production of the mulches for promoting CA in cropping systems even in those having contrasting edaphic requirements in flat, and or gently sloping lands.
- Unpuddled transplanting of rice/ maize in no-till situations on flats / raised beds
- Parachute transplanting of rice nurseries in puddled / un puddled no-till situations
- Controlled traffic in no-till in due course changes over to wider raised beds and can help reduce erosion and guided runoff of rainwater to promote up-down cultivation.
- Co-culturing of green manure crops, provide the much needed surface covers during monsoon season and help manage natural weed suppression .