**Course Name:** Conservation Agriculture based Sustainable Intensification

**Week 01-Lecture-1:** CASI and its components

**Course Instructor:** Dr. Mahesh K. Gathala, Sr. Systems Agronomist, CIMMYT, Bangladesh

Hello friends.

The topic that we are discussing today is on Conservation Agriculture based Sustainable Intensification or Conservation Agriculture. 'But before we get into the details, I want to take you back hundred years ago to understand its origin.

During 1930 in the United States of America, it was strongly felt that when farmers plow their field massive amount of dust particles were carried out into their cities through dust cyclone/hurricanes which made the lives in the cities extremely discomforting. To resolve this problem, many researches and discussions were carried out. As a result, a conclusion was made that a new farming system without tillage was necessary.

Therefore, CA started in 1930 and it didn't gain popularity till 1950. Between 1930 to 1950, when CA was applied as a piloted research, it garnered many positive results which quickly lead farmers to adopt CA practices. But from 1950 to 1990, there was very little rise- CA was practiced in only 2-million-hectare land. From 1990 to 2015, CA was practices in almost 180-million-hectare land with 10-million hectare annually around the world. The places where CA is practiced the most is Brazil, next is America followed by Australia. In India, we practice CA at 3-million-hectare land in different form.

Now I am going to focus on what is CA.

CA mainly has three principles:

1. Minimum soil disturbance (not more than 30% of soil disturbance)
2. Soil coverage with organic biomass (to mulch soil with the residue of harvest)
3. Crop diversification (to sow different crops using different methods at different times on a rotation in a one-year crop cycle on same piece of land which is also called a crop cycle)

The successful adoption of CA that we mentioned earlier has been in the rainfed areas or the areas where they only harvest one crop in a year. But in South Asia we have a complex farming system because our agriculture is linked with animal farming and fisheries; and also, we follow 2-4 crops in a cycle that include cereals and vegetables and that keeps on changing according to farmers' demand and requirements. So, it is very complicated to apply all three principles of Conservation Agriculture in South Asian region.

For which we go beyond Conservation Agriculture and discuss about Conservation Agriculture based Sustainable Intensification.

Now I want to address some problems in Indian agriculture. To find the source of problems that we are currently facing in Indian agriculture we must go back in time. In 1960 when Green

Revolution started, we were successful in increasing productivity which came with a price. We unleashed a lot of problems which can be arranged in two categories: man-made and nature.

Under man-made problems comes monocropping system in which only one type of crop is sown continuously. Second problem is to adopt new crops and cropping system in new location where not fitted with available resources. The third one is residue burning which is becoming a great problem these days. Fourth one is intensive tillage which is to plow field repeatedly that results in deterioration of the nutrition of soil. And flood irrigation is yet another big problem. So, we have created many more problems.

Another category of problems- natural problems include climate change issues (like flood, cyclones, other variations in climate), abiotic stresses that we are facing these days like drought, flood, salinity, acidity etc. along with biotic stresses like new diseases. And it can get really complicated if we put them together. The impact they have is very devastating- the water level is decreasing; soil health is deteriorating; global warming is increasing; and our produce is getting low.

Now the challenge we face is we need to increase our productivity, sustain it and protect it from climatic stress.

So, what are the solutions to the problems I mentioned earlier? There are many solutions but the best one is the Conservation Agriculture based Sustainable Intensification.

Conservation Agriculture based Sustainable Intensification is broader than Conservation Agriculture and goes beyond. Conservation Agriculture only deals with tillage, residue and crop diversification but the components of Conservation Agriculture based Sustainable Intensification includes Conservation Agriculture practices along with efficient use of external inputs and natural resources. It is economic and viable to farmers, and appropriate to our farming system that addresses our livestock, fish and soil.

This will make our farming system more resilient, save energy for our future generation, create cleaner environment, and bring biodiversity back in our soil and thus in our ecosystem. In addition, it brings more income to the farmers, improve nation's economic condition, improve our livelihood, increase our food security and we get better nutrition.

As mentioned earlier, there has been positive results from Conservation Agriculture based Sustainable Intensification. In past 20 years from our own farm-trials, we have found:

- 5%- 10% increase in production from crop diversification
- 8%- 17% of irrigation water saved
- 26%- 42% labor saved
- 46%- 62% fuel consumption/ energy saved
- 16%- 56% increase in farmers' income
- 11%- 16% reduction in $CO_2$ emission

Dear friends, today we talked briefly on Conservation Agriculture based Sustainable Intensification. We will tell you more on related aspects in upcoming course. Thank you very much.

**Course Name:** Conservation Agriculture based Sustainable Intensification

**Week 01-Lecture-2:** Zero Tillage Technology

**Course Instructor:** Dr. Mahesh K. Gathala, Sr. Systems Agronomist, CIMMYT, Bangladesh

As we discussed yesterday on Conservation Agriculture based Sustainable Intensification, it has three principles and one of them is minimum tillage. What is a definition of minimum tillage? Soil surface should not be disturbed more than 30%. Under 30% of soil disturbance depends upon crop to crop, planting to planting, location and environment. Under minimum tillage, there are two categories: one is zero till or no till which includes surface seeding and other is reduced till which includes strip tillage.

We need to remember that reduced till does not mean reducing the times you till or decrease the number of tillage passes**.** It is more related with less than 30% of soil disturbance. This is the only qualifying criteria under reduced tillage or else it will be regarded as full tillage because these days there are such implements that does everything in one pass, disturbing equal amount of soil as in 10-15 times tillage or more, like rotavator. So, we are not encouraging its use.

Why do we need zero tillage technology in India? Our Rice-Wheat system is applied around 10-million-hectare land in India. But our rice planting is mainly dependent on rain and later wheat is sown. Since we largely depend on rain, the rice plantation usually gets delayed and again, farmers who sow long-duration rice variety further delay the process. After harvesting rice, wheat needs to be sown and normally it takes 20-25 days for land preparation. Zero till technology was therefore introduces to shorten this period.

Another reason is: because of maximum tillage, farmers' expenses are increasing. Also, since we are carrying out the same Rice- Wheat system, ***Phalaris minor*** in wheat has become a big problem. To get rid of these problems, zero tillage technology was introduced.

Due to this zero-tillage technology, as soon as rice harvests, on the same day we remove the residue and directly sow the wheat. This process saves at least 15-20 days of land preparation and thus, shortens the duration which also increases 15- 20% wheat yield. So, this is the main reason behind the initiation of zero-tillage technology.

With time many improvements have been made to this technology, like happy seeder, zero tillage seed drill, zero-tillage multi-crop planters, strip tillage machine, two-wheel tractor operated zero tillage and strip tillage machines etc. Depending on the location and the type of power required, the zero-tillage technology has been improvised accordingly. So, this is the reason why we need zero-tillage technology.

Now what are the benefits of zero-tillage technology? The first benefit is previously farmers had to till 10-15 times but now the same work is done in one operation. Another benefit is it shortens the planting duration by 15-20 days. Third benefit is it saves minimum 70% of time that farmers used to invest from land preparation till seeding. Thus, saving 70%- 80% of time. It also saves 35l- 45l of diesel per hectare of land. Based on crop system, it reduces 35-40 labor per hectare of land.

It reduces cost of production by INR 6000- INR 10,000 per hectare of land. A farmer can save from INR 4000- INR 5000 per hectare till seeding. It is found that 5%- 10% of irrigation water is saved. Also, the weed problem which was a huge issue in wheat was significantly reduced due to zero-tillage technology. There is a reduction in herbicide consumption as well. It is also found that there is 5%- 10% increase in production. So, farmers net income has increased by 20%- 40%. Farmers' water productivity which is also referred as per drop- more crop has increased by 10%- 15%.

Now you may be curious to know if this zero-tillage technology can be used in all crops, cropping systems and location. Yes, it can be used everywhere. We have studied that it is suitable for all cropping systems like Rice- Wheat, Rice- Maize, Maize- Wheat, Rice- Pulses, Cereal- Pulses etc. The only thing that we need to keep in mind is that the seeding mechanism should be fitted according to the crop for which we need to modify the machine as per the requirement. Otherwise, this technology can be used for every crop. Besides, this technology can be used in other crops as well like cereals, legumes, oil seeds, even tuber crops and vegetables.

However, to maintain this technology is not possible for some crop rotation or crops, like tuber crop and potatoes and root vegetable crops like radish, carrot etc. This technology can be used for seeding but to harvest these crops one must disturb the soil. This is the only limitation otherwise there is no problem in seeding using this technology. Apart from this, this technology is very location specific. This technology requires proper adjustments according to location, crop, soil type and environment.

Thank you.

**Course Name:** Conservation Agriculture based Sustainable Intensification

**Week 01-Lecture-3: Crop Residue Retention**

**Course Instructor:** Dr. Mahesh K. Gathala, Sr. Systems Agronomist, CIMMYT, Bangladesh

We are discussing about another component of CASI which is residue retention. What is residue retention? Before getting into the topic, we must understand how crop biomass can be managed? There are different methods like crop residue which is left in the field; crop removal which is taken out of the field; third one is crop incorporation which is mixed with the soil in the same field; and the fourth one is crop burning in which farmers usually burn the residue in the field which causes environmental pollution. Among all these methods, the most beneficial one is crop retention.

We can also opt for crop incorporation, but this method consumes a lot of energy and the field needs to be tilled several times. This is a very difficult, time consuming and expensive process for farmers. Now what is crop retention? When we harvest crop, generally Combiner is used. These days SMS (Straw Manager System) is attached to the Combines which helps in equal distribution and forms a mulch in the field. We do not disturb that mulch rather continue seeding in to the mulch. This retention of the mulch is called crop retention.

As mentioned, there are different methods of residue retention and we need to understand its importance. If we take 1 ton of residue, we can find 5.5 kg of nitrogen, 25 kg of potassium, 2.5 kg of Phosphorus, 1.2 kg of Sulphur, 70%- 80% of micronutrients that can absorb and around 400 kg of carbon. When we burn the residue, the nutrients are lost and so, the soil is deteriorated. And if we incorporate it, usually nitrogen and carbon get mineralized and decomposed during the process and the nutrients are lost in form of gases. So, in retaining the residue we get maximum benefit from all the plant nutrients.

Now we deal with comparative advantages of crop residue retention. The first advantage is it increases the organic carbon of soil and catalyzes the secretion of carbon. The second benefit is it improves soil fertility and releases nutrients. It also improves structure of soil and helps in soil aggregation. Besides, permeability of soil or infiltration- an ability to absorb water, increases. This consequently increases the recharge and improves water-holding capability.

It’s been found that if we mulch, the moisture in soil is conserved and soil temperature remains balanced. In extreme cold, mulch keeps the temperature of soil from dropping. And in extreme heat, it keeps the temperature of soil cooler by 3- 4 degrees. Overall, it moderates soil temperature and balances by 5-6 degrees due to which microbial properties increases.

If we mulch the entire season, the conservation of soil moisture remains highest throughout. We have measured it as you can see clearly in the graph, where there is residue, there is less soil tension and vice versa.

With residue retention, the relation between soil, plant and water also improves. This also boosts up plants’ physiological activities like increase in photosynthesis, balance in canopy temperature, better respiration etc. So overall, plants get healthier. Mulching also controls decomposition and mineralization of nutrients in the soil. The nutrients are released gradually throughout the season which helps plants to prosper across the season.

One of the benefits that we are losing in conventional agriculture is soil biodiversity. When we mulch, organic matter is decomposing in the soil due to which soil bacterial, fungal, actinomycetes and overall the population of micro- fauna and macro-fauna, overall soil microbial properties improve. This will improve soil health and hence, rises soil quality index. The overall improvement in soil brought by residue retention improves soil’s health which will result in healthier plants, healthier produce and nutritious diet. These are the benefits of residue retention which plays very important role in making soil healthy.

**Course Name:** Conservation Agriculture based Sustainable Intensification

**Week 01-Lecture-4: Crop Diversification and Intensification**

**Course Instructor:** Dr. Mahesh K. Gathala, Sr. Systems Agronomist, CIMMYT, Bangladesh

Now we will talk about the third principle of CASI i.e. Crop Diversification and Intensification. So what is Crop Diversification and Intensification? The way we know this is, crop diversification is to alternatively sow different crops in a sequence in the same piece of land in the same year to next year. And crop intensification is that instead of doing one crop, we do two crops and instead of two crops we do three crops in a sequence in same year. These depend mainly on 4 or 5 things. The first is that if our cropping system is less profitable and unsustainable then we can turn it to more efficient, profitable and sustainable. This is the first principal - Less profitable to high profitable with more sustainability.

Now, we look at the second principle. If our cropping system is very water loving i.e. requires a lot of water, then we can replace it with a less water loving crop within the same system i.e. one that requires less water and optimizes it. We call it the "more water loving to efficient water loving cropping system". We look at the third principle. In some cropping systems, we keep repeating the same crop and extract more and more yield and biomass. This causes high nutrient uptake. So instead of practicing a high nutrient uptake, if we move towards optimum and efficient nutrient uptake cropping system then we can increase our sustainability.

The last one is that if we keep repeating the same type of crop then it increases the biotic stresses like diseases, insects and these carry forward. So to break this, we move towards a less biotic stresses with changing cropping system. This is our biotic stresses based cropping system and crop diversification. So these were the principles of Crop diversification. Now we look at the advantages of cropping systems. What are the benefits and advantages of it?

The first benefit is how we can increase the income of small and medium scale farmers.

If we do crop diversification and adopt a more cost effective or less requirement crop, then the income of farmers can increase The second point is that if we keep repeating the same crop like in Punjab and Haryana, rice and wheat are very popular. This has an effect on the prices and the government is unable to buy and the prices fall. Instead of just doing rice and wheat, if we diversify into legumes and oil seeds, then the prices of agriculture commodities will be

maintained and they won't fluctuate. The third point is that some cropping systems are very sensitive to the climate. If we adopt the one crop cycle, then it is more prone to climatic shocks. If we diversify the cropping system, then the cropping system becomes more resilient to climatic shocks. Like if our one crop gets damaged, then we can profit from the next crop. We also have a mixed crop where if one crop fails, the other is saved. If we add a third crop then farmers can benefit from at least two crops in case, if one gets damaged. So due to crop diversification, the climatic resilience increases.

Now the biggest benefit is that if we just grow rice then we would only eat rice and the same is true for wheat. But, if we grow different crops in our farm then at least our diet will be balanced and our nutrient intake will be better. If we grow different crops like rice, legumes, oil seeds or vegetables and adopt them in our food then we fulfill a balanced diet and food security requirement.

Besides this, our livestock is also dependent on our cropping system. Not just livestock but also our fisheries and dairy is also dependent on our cropping system. All these things are dependent on the cropping system. If we keep growing the same crop like rice or wheat or any other crop, then we won't find nutritious fodder for our livestock. If we grow different types of crops, then the quality of fodder for our livestock will improve and this can increase our livestock production.

We know the most important subject is natural resources. We have seen how in Punjab, Haryana, the whole of Northwest India and in southern states like Maharashtra, there is a problem of groundwater depletion and one of the reasons for it is our cropping cycle. Like in Punjab and Haryana because of rice and wheat cultivation, our groundwater table is falling down more and more. One day it will finish. Keeping this in mind, if we can adopt an efficient cropping system where we replace rice in the rice-wheat cropping system with maize, sorghum, legumes, oils or soybean then we can save the water table and also increase the farm income. So we can save a very important natural resource and at the same time also improve our air quality. With single cropping cycle, we are using more and more fertilizers and pesticides because the biological

stresses are increasing. This contaminates the groundwater and also pollutes our air quality. With diversification, we can improve on these things.

If we do crop diversification in a proper way, then our environment pollution especially air quality like residual burning can improve. Instead of rice, if we bring in another crop then we don't have to burn the crop residue and we can use the residue for other things. Like legume crop does not have a big biomass and it decomposes quickly in case we want to keep it in the farm. Also, if we add a third crop in the rice-wheat cropping cycle like Moongbean, then the deterioration of soil is restored as it is a legume crop and there is nitrogen fixation and its residual increases soil quality and structure.

Now, our use of farm or external inputslike fertilizer, seeds, pesticides and agro chemicals would decrease if we adopt proper and optimum cropping cycle of crop diversification. For example, if we grow legumes or oilseeds after rice then its consumption will decrease as some crops have Allelopathic effects as they break the cycle of diseases and insects and are able to control pests. This is why we see some weeds that are particularly associated with specific cropping systems. Like in the rice-wheat system, we have *Phalaris minor* and particularly in rice, we have *Echinochlovaspp.*. If we keep following the same system, then the seed bank of these weeds keep increasing in the soil and the problem increases. But if we replace rice-wheat with rice legume or oil seed or vegetable, then we can exhaust the weed seed bank and subsequently can control the weed population. This is true for diseases as well. The carry forward diseases which have its **inoculum and spores** stayed in the soil, we can break its cycle. So we can control the disease, weed and pest population and benefit from it.

Lastly, we can increase the community of food. Like if we keep growing rice after rice, we are increasing our problems but if we diversify our crop then there would be no storage problem and we would also get better quality food and we will have food security. So these are the benefits of Crop diversification and we should adopt it and these are very useful.

Now, we look at the linkage of Crop diversification with CASI (Conservation Agriculture Systems Innovation Center). Crop diversification is an integral part and principle of CASI. If we

add all the three aspects of CASI like Zero Tillage technology, residue and crop diversification then the overall holistic benefits we derive out of this will have a large scale impact on soil, environment, system, crop productivity and natural resources and farmers will benefit immensely. So we looked at the three principles and its different components.

The end

**Course Name:** Conservation Agriculture based Sustainable Intensification

**Week 01-Lecture-5:** Practical Issues in Promotion of CASI

**Course Instructor:** Dr. Ram Datt, Assistant Professor-cum-Jr. Scientist (Extension Education), BAU, Sabour

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Hello Friends! During this week, you got to know about Conservation Agriculture based Sustainable Intensification, Crop Diversification, Crop Residue Retention and Zero Tillage Technology. Since 2014, we are promoting conservation agriculture under SRFSI project in India, Nepal and Bangladesh. We faced a number of challenges during the promotion of conservation agriculture. Today, I will discuss aboutthe key challenges we have faced during the promotion of conservation agriculture and how can we deal with them? Friends, when we talk about challenges, according to me an individual (farmer) is more important than a technology. Especially, perception and mood of a farmer is very important for technology adoption. A farmer who is sowing wheat and maize after a number of ploughing since their ancestors and suddenly, you reach there and suggest them to sow without ploughing obviously, it is quite difficult. If we talk about paddy, a farmerdoespuddling and after that they do transplanting. But,you say NO you have to go for mechanical sowing. This happens to be quite challenging. Second important thing is group dynamics. Farmer is not alone, (s)he has his family &neighbourhood and (s)he lives in a village. People who are associated with him also sometimes create hindrance in adoption process. We have an example, in2014 when we were promoting CASI,A lady farmer was ready to adopt CASI technology but her husband stopped in doing so andploughed farm during night. Therefore, group dynamics is very important. Third important thing in adoption is small land holding. More than 90 per cent farmers of EGP are belonging to small and marginal category. They do not want to take risk. If you would say by spending one rupee you can earn 2 rupee, in such circumstances predicting the situation of loss aversion they do not wish to do so.Next issue is fragmented land, farmers are having small plots thereforeit is difficult to use machines. This also causes difficulty for service providers. Next important issue is gender inequalities, especially in EGP male migration rate is quite high and women are managing farms. Although women do farming but farm related decisions are takenonly after consulting their husbands. You can convince women through farm demonstration but it is quite difficult to convince their

husbands without technology demonstration. It furthercreates hindrance in the adoption process of a technology.

Another important factor is technological issue which affects the adoption process. Here, agronomical issues are quite important. In 2014, when we started promoting conservation agriculture of Maizeat that time there was an establishment problem in maize crop. Then, we saw farmers were sowing seed mixed with fertilizers through machine. Maize seed is very sensitive to fertilizers and which resulted in poor germination. You have to be very careful. If, machine is simply calibrated to 2 cm then fertilizers will be dropped first and then seeds. Definitely, germination of maize crop will be good. Second issue is, if you are using combine harvester, then there will be a heavy straw load in the field. Under this situation Zero Tillage machine will not be suitable, so you have to use happy seeder. If you will not be careful then there will be a poor germination. Moisture level is another critical point for germination. If you will be careful about proper moisture level and improper depth of sowing will also lead to poor germination. Especially in DSR, weed management is very critical; there is a chance of crop failure if you will not manage weeds. In addition, quality input is another critical factor for success not only in CASI but also for conventional farming.

Third important factor for CASI is weak value chain. Small farmers cannot purchase their own machines,they depend on other service providers. Mostly service providers use to sow their own fields first then they prefer large farmers over small or marginal land holders.Timely access to machines is an issue for small and marginal farmers. Lack of trained driver is another limiting factor for promotion of CASI. Custom hiring centre (CHC) and Service providers are having sufficient trained drivers to handle CASI machines or not, it is also a matter of consideration. There are some critical issues with CASI machines like operation, calibration and maintenance so we need trained drivers to deal with mechanical issues. Unavailability of parts of machineries and maintenance workshop is another importantneed for CASI. In India, CASI machines are being purchased from Punjab state, if any part of the machine got damaged then again we have to purchase it from Punjab. There is no local workshop for the same.

Apart from all these, lack of right information at the right time and lack of awareness are limiting factors due to which promotion of CASI has not reached to the highest level. However, there is another important cause which has affected the promotion of CASI,that is relative advantage.

Main focus of farmers aregetting high yield out of any technology. In this particular technology, the cost of cultivation definitely goes down, but the yield gain does not necessaryto go high, it increases by 5-10 percent only. In this technology it is not assured that the production will be drastically increased. Therefore, this becomes a matter of concern. Let's look at its two dimensions; one is farmers' felt need, when farmers feel the need of adopting a technology just after coming to know about it, that is yield. However, CASI has other benefits, in order to bring this technology in practice we need to work on farmers' behaviour change. Like, this technique is time saving, it saves water, energy. It is environment friendly. How can you make the farmers understand all these facts in an easy way through communication is the biggest challenge.Other than this, we will also have to look at our policy issues. Government gives 50-75 per cent subsidy on purchase of many types of machinery. Most of the times, farmers do not tend to avail subsidy benefits. So we also need to improve our system in such a way that those farmers who are willing to purchase machinery could do so easily. We also need to provide proper training to the extension professionals who are working for promotion of CASI. This is very important. If they will not be properly trained how they can guide the farmers. We need to work on our complete value chain from buying machine to sowing to harvesting and packaging practice, government will also have to take initiative for the same.

Apart from this, as I have previously said women do not have their farms registered on their names. This causes trouble in getting credits from banks. Hence, credit access is also an important dimension of agriculture and sometimes it creates hindrance in adoption of CASI.

So, you will have to consider all these facts. Friends, we talked about the challenges and one more thing I must say, if you tell anyone about this technology, they will not believe you. To convince farmers more and more field demonstration is required. You will have to plan as many field days as you can, call as many farmers as you can and then demonstrate this technology. Only when they will see it, they will believe it. Secondly, to encourage the adoption of CASI you will also be required to ensure the availability of trained drivers and access to machines. Thank You .