A REPORT ON FIELD RESULTS OF SCI IN CONSERVATION AGRICULTURE: FROM DANGS, GUJARAT, INDIA

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Conservation Agriculture has been widely adopted by farmers across the world as an alternative to conventional tillage-based agriculture. It represents smart agriculture which can lead to sustainability. The technique promises a win-win situation for farmers as it reduces their costs of production (without reducing their productivity), enhance soil health, safeguard the environment, and adapt the crops for climate change.

The energetic Dangs spearhead team of the Aga Khan Rural Support Programme-India has been doing remarkably well in extension of the System of Root Intensification for crops such as rice, chickpea, finger millet (ragi) and proso millet, reaching over 5,000 small and marginal aboriginal farmers.

The team after orientation given by Dr. Amir Kassam and some further training undertaken has started CA trials among farmers during the cropping season of Rabi 2015. A set of standard operating steps was initiated and followed with utmost care for the implementation of the Conservation Agriculture along with SCI principles in the testing sites.

Initially farmers were apprehensive about taking up CA in the test sites due to the strength of the tillage paradigm in their minds. But an exposure visit to Saguna Baug won their trust for the introduction and implementation of the CA in Dangs. Some tailoring was done with the Saguna Baug's no-till agriculture technique, which included no use of herbicides and the addition of mulch which went against their experience.

The AKRSP-I team is thankful for the introduction of an SCI dibbling frame which could be multiplied locally from a micro-enterprise nearby. A unique aspect of the intervention was that it also engaged System of Root Intensification methods along with CA for four different crops: chickpea, onion, okra, and French beans.

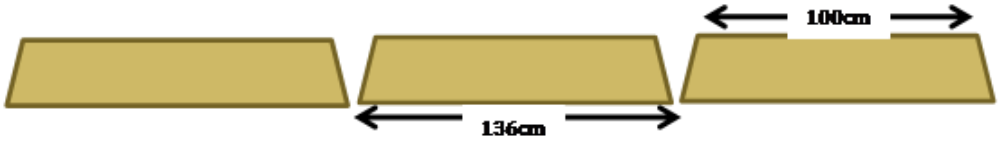
The standard operating steps which the team engaged for the method and test site adoption were:

Step 1: Test site selection and plot size

The land selected for a test site should be normal for cultivation and not prone to problems related to soil, water, etc. It should also be readily accessible to farmers and extension workers. The minimum size for a plot was set at 100 square meters (as land holdings are small in Dangs). Along with the selected site, a control plot of the same size also needs to be established to be able to compare results. Compacted soil layers and hard pan formed over time due to ploughing must be broken up by one-time sub-soiling or deep ripping.

Step 2: Formation of raised beds

One-time ploughing and fine soil preparation needs to be done to facilitate bed formation. Raised beds can be made with the help of a hand hoe or tractor mounted bed maker. The width of the raised bed should be 100 cm (keeping in mind the design of the iron frame dibbler), height depending on the soil type, while the length of the raised bed depends on the size of the land holding. Beds are separated by furrows that serve as water channels for irrigation and drainage. The bed should be made along the slope to prevent the probable damage to the beds and crops from heavy rains



DIMENSIONS OF RAISED BED

Step 3: Mulch cover

The raised beds are covered with mulch (biomass) available nearby while the furrows are not covered. Any type of biomass can be used as mulch cover such as straw, leaves (Gliricidia), grass (without roots), halms and stalks, and cover crops (e.g., sun hemp, sesbania, pigeon pea, beans etc.). Plants with matured weed seeds should be avoided.

Step 4: Making holes for seeds

An SCI metal frame can be used for making holes in geometric pattern with specified spacing, and seed should be sown as per the type of plant/crop cultivated; e.g. rice can be grown with 25x25 cm or okra with 50x50 cm spacing. Spacing is achieved with a pre-designed metal frame dibbler (see picture)

Step 5: Seed treatment

Seeds are dipped in brine solution (1 % salt in water), and light-weight seeds which float on the surface are removed. The remaining seeds are treated with *Jeev Amrut / Amrit Pani* solution.

Step 6: Sowing

Seeds are sown in according to the spacing made with the metal frame, at a depth depending on seed size. Small seeds such as rice and mung are placed in the upper soil layer at a depth of 1-3 cm, while bold seeds such as groundnut, maize and gram are sown at a depth of 5 cm. The seed holes are closed up by placing soil on the seeds to keep them out of reach from birds and rodents

Step 7: Management of pest and biodiversity

For pest management, border planting of pigeon pea (*tur dal*) can be done. Marigold as a trap crop can also be grown, *Amrit Pani* should be applied on a regular basis, i.e. at 10-day intervals, to help the keep pests at bay. Mixed cultivation of maize in between the rows of groundnut and gram should also be done in order to attract and retain helpful insects (natural enemies of pests) into the cropped plot. For the management of mice and crabs, Gliricidia plants can be grown nearby and their leaves can be placed all around the border of the cropped plot (as experienced at Saguna Baug).

Step 8: Weed management

Mulch will suppress weeds, while growing cover crops and keeping them as live mulch can also reduce or eliminate problems of weeds, at the same time enhancing soil health. Two to three hand weedings can be done as needed.

Step 9: Cover crop

Cultivation of a cover crop, e.g., through relay cropping, can be tested initially, and if successful it can be put into the package of practices after experience of one year. To do this, seeds of Sunhemp (*chann*) can be broadcasted on the standing crop of rice 10 to 15 days before harvesting. Once the rice crop is harvested, sun hemp seedlings will grow and cover the soil, thus reducing weed infestation for the subsequent crop. Before sowing of the next crop such as gram, the cover crop can be cut and its crop biomass spread on the broad bed. Later, crop seeds can be sown using the dibbler.

Important points which need to be checked for CA promotion with lead farmers

- ✓ The size of each test plot should be at least 100 square meters with proper measurement
- ✓ A control plot must be maintained where the farmer will practice his/her traditional methods of farming
- ✓ The two plots identified should be in an open location (not shaded by trees). The land used as a test site should not be a barren or degraded piece of land. Initially, one should not use waste/degraded land for testing site; otherwise this will give biased results to farmers.

- ✓ The direction of the bed should be along the slope in order to drain excess water from the field and avoid the mulch cover being washed away.
- ✓ Testing sites should be accessible to the farming community members, and a signboard should be installed on the test site mentioning the farmer's name and key details of the cropping system.
- ✓ Similar variety should be used for both plots (CA testing plot and control plot).
- ✓ An equal amount of inputs such as fertilizer/compost should be applied by the farmer in both test plots. The number of irrigation applications can vary, as per water requirements.
- ✓ There will not be any use of weeding implements in CA plots, while hand weeding can be done as per need, while in the traditional/control test site, weeding can be done as per need.
- ✓ Data should be collected from lead farmers on a fortnightly basis with relevant photos taken. For taking photos, one point should be kept fixed so that the photos can serve as a record and as visual evidence that can be used to promote CA involving a large numbers of farmers.

Combination of SCI+CA: The method adopted

The AKRSP-India team has been working for some years in promotion of System of Crop Intensification in crops- rice, finger millet, prosomillet, and chickpea. SCI has its core principles – wider spacing (with square geometry), transplanting young seedling, healthy soils (with enhanced soil aeration and organic matter) and management of weeds. The various principles are of primacy for the success of progressive productions and have demonstrated its success in not just rice but other crops too. Conservation Agriculture, a noteworthy technique, has been promoted under the auspices of FAO. Although the method has been extant across the world just like SCI, AKRSP-I India tried why not trial CA method with the well-established SCI in Dangs, Gujarat. The idea, from its conception to implementation with the farmers, went through the process of exposure, training, frequent hand holding and thus success was achieved. The extension team considers it to be a combination of two practices CA+SCI or one can say smarter SCI method. The team chose to trial this combination of both – CA and SCI, as we were infatuated by the SCI principles adopted earlier, square geometry spacing, nipping in some crops (chickpea, okra), use of lower seed rates and seed treatment. As we are aware about the socio-economic and environmental benefits of SCI, practicing it with CA will surely make the benefits for farmers and environment grow manifolds. The raised beds on which different crops were grown by farmers in different villages will be used for next season crops without tillage. The table below can be seen a check list of the method which was adopted by the farmers:

Particulars	Traditional	CA+SCI	Traditional	CA+SCI	Traditional	CA+SCI	Traditional	CA+SCI
Crop	Okra		Onion		French Bean		Chickpea	
Sowing on	Flat bed	Raised bed	Flat bed	Raised bed	Flat bed	Raised bed	Flat bed	Raised bed
Sowing method	Random point placement	Square geometry sowing	Random transplanting	Square geometry transplanting	Broadcasting	Square geometry sowing	Broadcasting	Square geometry sowing
Planting/Sowing space	60*5-15 cm	50*50 cm	15-20*7-12cm (no symmetry)	25*25cm	Broadcasting	25*25	Broadcasting	25*25
Seedling age	NA	NA	30 days	30 days	NA	NA	NA	NA
Seed treatment	Not done	Amrit Pani with 1 % solution	Not done	Seedling root treatment with 1% Amrit Pani	Pre-treated seeds	Pre-treated seeds	not done	Amrit Pani with 1 % solution
Mulching Material	NA	Dry leaves of local trees	NA	Rice Husk	NA	Rice Husk	NA	Rice straw
Nipping*	NA	30 days	NA	NA	NA	NA	Not done	25 and 45 DAS

**Nipping is topical bud removal of plants which facilitates profuse tillering in plants as done in chickpea and okra*

Results from the field as observed:

There were eight farmers who adopted CA testing plots for the Rabi 2015 season for four different crops: chickpea, onion, French bean, and okra. Out of eight farmers, five farmers had sown chickpea. For chickpea, French bean and onion, 25x25 cm spacing was kept while for okra it was 50x50 cm, thus making CA and SCI go hand in hand.

The area of test sites for control and CA+SCI was 100 square meter (0.03 acres) as landholdings are small in the region. All the conditions of the two testing sites, i.e., control/conventional and CA+SCI, were kept uniform except for the mulching added as a part of the CA methodology and equally-distant sowing. No special treatment was done in any of the two testing sites except for the addition of mulch and raised bed cultivation in CA+SCI.

Sowing was done on the raised bed with the help of an iron-frame dibbler, while in traditional cultivation, broadcasting was done for chickpea and French bean. For onion, transplanting was done in 25x25 cm while with traditional management, random placement was done. In the case of okra, 50x50 cm spacing was kept in CA while in the traditional sites; line-to-line spacing was kept at 50 cm, while no row-to-row spacing was maintained for uniformity.

Let's have a look on the results of different crops in different villages with control sites in adjoining plots.

TABLE 1: FIELD RESULTS OF GRAM IN DIFFERENT VILLAGES

Chick Pea

S. No.	Method	Name of farmer	Village	Variety	Seed rate, in kg	% difference in seed rates	Actual yield of 100 sq.m.	Representative yield (kg/acre)	% change in yield
1	CA+SCI	Sureshbhai Vanalbhai chidhri	Gaurya	GG 1	0.31	45.6	9.50	380.0	155.7
	Control			GG1	0.68	100.0	6.10	244.0	100.0
2	CA+SCI	Ramanbhai Somanbhai Gavint	Raochond	GG 1	0.25	66.7	5.80	232.0	184.1
	Control			GG1	0.38	100.0	3.15	126.0	100.0
3	CA+SCI	Khundubhai Chimanbhai	Ghodvahal	GG 3	0.30	85.7	10.32	412.8	113.4
	Control			GG 3	0.35	100.0	9.10	364.0	100.0
4	CA+SCI	Sureshbhai Jatarbhai Hiliyam	Jharan	GG 3	0.30	42.9	29.20	1168.0	133.9
	Control			GG 3	0.70	100.0	21.80	872.0	100.0
5	CA+SCI	Chagganbhai	Machaddi	GG 1	0.25	37.9	4.88	195.2	169.4
	Control			GG1	0.66	100.0	2.88	115.2	100.0

The test site results (Table 1) have shown that all the farmers who cultivated chickpea with CA+SCI methods could get higher yield. In each and every testing site, there was an appreciation in yield which went as high as 184 per cent as observed with Ramanbhai of Raochond village, while the minimum increment of the yield was 113 per cent, as seen with Khundubhai in village Godvahal. The average increase in yield was 51.3%.

Overall the adoption of the CA+SCI test sites gave a confidence to all the small farmers that the new methods can work well from the first year onwards. It was also seen that the seed rate of the CA+SCI testing sites was also less when compared to traditional site as the seeds were placed in the designated spacing. Farmers believe that there are still chances of reducing the seed rate with this method even more.

TABLE 2: FIELD RESULTS OF ONION CROP IN AMSARPADA

S. No.	Method	Name of farmer	Village	Variety	Actual yield of 100 sq. m.	Representative yield (kg/acre)	% change in yield
1	CA+SCI	Ramanbhai Ganaptbhai Chidhri	Amsarpada	Traditional	164.7	6588	108.7
	Control			Traditional	151.5	6060	100.0

The field results for the onion crop were encouraging too as the measured yield for CA+SCI testing site was higher when compared to traditional methods. Apart from the good yield of the crop, this farmer was able to apply one less flood irrigation with the CA+SCI crop. The farmer also observed that the color of the onions was redder and they were larger in size when compared to the traditional practice.

TABLE 3: FIELD RESULTS OF OKRA IN HOLIPADA

				Okra					
S. No.	Method	Name of farmer	Village	Variety	Seed rate, in kg	% difference in seed rates	Actual yield of 100 sq. m.	Representative yield (kg/acre	% change in yield
1	CA+SCI	Ishwarbhai Babubhai Patel	Holipada	Samrat	0.50	71.4	139.9	5595.2	122.7
	Control			Samrat	0.70	100.0	114.0	4560.0	100.0

Just like with the other crops, the okra seed rate for the CA+SCI test site was less compared to the traditional plots, and at the same time yield was better than from traditional cultivation. The farmer could get an extra 95 kilogram of okra from his field (see table 3), and being a premium-priced crop, he was much satisfied by the method.

TABLE 4: FIELD RESULTS OF FRENCH BEAN

French Bean

S. No.	Method	Name of farmer	Village	Variety	Seed rate, in kg	% difference in seed rates	Actual yield of 100 sq.m.	Representative yield (kg/acre	% change in yield
1	CA	Vithallbhai Sitarambhai Gangoda	Gundiya	Falguni	0.30	56.6	45	1800.0	64.3
	Control			Falguni	0.53	100.0	70	2800.0	100.0

This test site gave very different results from those for other crops. A mistake which the team realized too late was that the raised bed was formed against the slope, and a heavy off-season downpour washed away the bed along with the main crop. The crop sown on the flat control plot survived, due to drainage in the field. The CA+SCI test site partially failed due to the technical faults from the team. So this is a lesson worth taking for all others who wish to promote this method on undulating land. The raised bed must be prepared in alignment with the slope, and proper drainage of any excess water should be assured in the field. Although the yield which came from the CA+SCI testing plot was less, this was from just half of the land (50 of the 100 square meters). The seed rate in the intervention was almost half that of traditional cultivation. So the potential productivity of the new methods was clearly demonstrated. Thus the farmer came to trust them and will be adopting the CA+SCI in the upcoming season, as he said with fervor.

Observations:

Yield: In all of the cases (except for French bean as a special case), the production of the test sites was seen to be higher. This is one driving force for farmers to overcome their apprehensions about adoption of new methods.

Seed rate: SCI combined with CA led to lower seed rates, although there is still scope to reduce the seed rate further and to standardize optimum rates for a particular crop and variety. This will happen over a period of time, through co-learning with the farmer.

Phenotypic observations: The crops themselves were fairly superior when compared to the traditionally-grown crops as reported by the farmers and as observed by me and the field team. There was profuse tillering in the chickpea and okra, while onions had better bulb formation.

Weeds: There was reduced need for efforts by farmers to manage weeds due to the well-covered soil with mulch.

Labor: There had to be an initial greater investment of labor in the adoption of Conservation Agriculture as it was necessary to break up the pan with a ripper/sub-soiler and for formation of raised beds and for mulching in the initial years, until the system itself generates sufficient mulch or organic matter. The farmers recognized that there is a higher need for labor (although on a one-time basis) for making beds and mulching, but this can be compensated by no-till practice. It is being planned to reduce labor by the introduction of a bullock-driven bed-maker made by a local fabricator and from introducing seed-sowing implements.

Challenges faced while adoption:

When someone starts to work in a new direction or with a new paradigm, there are many challenges faced, beginning with acceptance of the new ideas by farmers. We also faced some, but exposure and frequent training of the farmers, with use of proper extension materials got the farmers to accept and adopt testing sites. Although we could find encouraging results in the CA+SCI plots, but there were a few challenges which when rectified will make the adoption of the CA-based system by the farmers more convenient. The challenges included the following:

1. **Direction of beds:**

   Dangs is a region with uneven topography. Considering the topography is very important for determining the direction of beds. One of the farmers, without understanding the slope and runoff pattern, made the raised bed pointed down rather than running along the slope,. This led to soil runoff and to water build-up in the bed leading to washing out and rotting of French bean crop. This became learning for the team that all beds need to be made along with the slope without fail, in order to prevent such damage. The challenge was overcome by the team asking farmers to intercrop chickpea in gaps thus formed in the testing site. Farmers still have confidence that the technique will work for any crop as there is no need for tillage in the field.

2. **Availability of mulch**

   Two farmers faced the problem for the availability of good-quality mulch for covering their fields. There is still need of promoting growing of more Gliricidia shrubs nearby. This will not only fulfill the need for mulch, but will also help to keep rodents away from the field.

3. **Tedious bed making process/standardization of beds:**

   Making raised beds, although a one-time investment for the farmers as there will then be no need for tillage with CA, is a tedious task for farmers. Two farmers made their raised beds with the help of a bed-maker behind a tractor, while for the other test sites beds were made with the help of hand ploughs. As the area of two testing sites was just 200 sq. m., scaling up to larger areas will be a time-consuming activity. As Dangs is an undulating region, the demand for tractor-driven bed makers could be far flung. So our organization is looking for innovation in the making of a bullock-driven, light bed-maker.

4. **Infestation of rodents in mulch (rats and squirrels)**

We are well aware that pests are among biggest challenges in agriculture, coming in the form of insects, weeds, and certain types of animals. We could see that rats and squirrel ate seeds of gram planted in the field. Farmers suggested that poor plant growth was the result of pest attack in the field. It becomes imperative that farmers adopt Gliricidia which can act as a repellent for mice as seen in Saguna Baug. It also a good-quality green manure which when added to the beds will lead to an increase in soil nitrogen.

Way Ahead: The testing sites will be maintained, and rice will be cultivated on them with direct seeding method and no tillage on the same beds where the crops were taken. The real challenge lies ahead to manage the rice crop with heavy rain and weed infestation, but we are hopeful to standardize the practice and to operate without use of herbicides. The team is also innovating for integration of drip irrigation with the combination of CA+SCI with 5 farmers in rice cultivation.

PICTURES FROM THE FARMERS' FIELDS

SURESH BHAI, VILLAGE GAURYA -- CROP: GRAM

SURESH BHAI, HIS WIFE AND DIBBLING FRAME (LEFT), AND WELL-MUCLHED GERMINATED CA+SCI PLOT (RIGHT)

TRADITIONAL (TOP) VS CA+SRI (BOTTOM) CHICKPEA

KHUNDU BHAI, GHODVAHAL VILAGE -- CHICKPEA: CROP

CA+SCI PLOT IN CHICKPEA (LEFT), TILLERING (RIGHT)

TRADITIONAL (LEFT) VS CA+SCI (RIGHT)

SURESH BHAI, JHARAN VILLAGE -- CHICKPEA: CROP

CA+SRI CHICKPEA-SOWN BEDS (LEFT), FULLY-GROWN CHICKPEA (RIGHT)

FIELD DAY ORGANISED ON THE RESULTS

ISHWARBHAI, VILLAGE HOLIPADA -- CROP: OKRA

OKRA UNDER CA+SRI COMBINATION; RAISED-BED VS. TRADITIONAL OKRA (LEFT), CLOSE VIEW OF MULCH (RIGHT)

ISHWARBHAI WITH HIS WIFE (FROM RIGHT) ON GREEN RIBBON-MARKED CA+SRI PLOT

RAMANBHAI, VILLAGE AMSARPADA -- CROP: ONION

FIGURE 2: ONION TRANSPLANTED ON RAISED BED WITH MULCH AT 25X25CM SPACING (LEFT), FIELD DAY (RIGHT), GREEN RIBBON PLOTS ARE CA TEST SITES, WHILE RED ONES ARE TRADITIONAL

FIGURE 1 CA+SRI (LEFT) VS TRADITIONAL (RIGHT)

CHAGGANBHAI, VILLAGE: MACCHADI -- CROP: CHICKPEA

MULCHING ON RAISED BED (LEFT), CHAGGAN BHAI WITH GERMINATED CHICKPEA (RIGHT)

FIELD DAY ON THE CA+SCI RESULTS

LAST BUT NOT LEAST! THIS NEW PLOT (BOTTOM) IS THE ADOPTION SITE WHICH A FARMER MADE ON HIS OWN WITHOUT SUPPORT FROM THE PROGRAM, PUTTING MULCH ON THE ENTIRE AREA, ADJOINING THE TESTING SITE (TOP), VILLAGE GHODVAHAL