CONSERVATION AGRICULTURE PRACTICES TO MEET CHALLENGES OF GLOBAL WARMING

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INTRODUCTION

The total land area of India is 329.8 m/ha and out of this about 180-190 m. ha area (gross) is cultivated. India occupies 2.45 % of the worlds land area, 4 % water resources but supports 16.2 % of the world's human population and 15 % of the livestock. About 61 % of the land area is under agriculture. It is endowed with varied climate biodiversity and ecological regions. The food production is falling/stagnating and it is a matter of concern. One reason for this falling/stagnating low food production is due to climate change which needs immediate attention.

Rice–Wheat is an important crop rotation and covers an area of 72 m.ha. The total area under no-tillage/zero tillage in the world is 90 m. ha and in India it is about 3.43 m.ha. Due to increase demand for food production the farmers have started growing more than one crop a year resulting in land degradation, unsound agricultural practices and increase in use of different inputs such as seed, fertiliser, chemicals and agricultural machinery. All these require excessive use of energy thus contributing to the global warming. This has also resulted in increased use of fuel for doing various farm operations thus resulting in greater CO_2 emissions. India consumption of petroleum products is about 155.8 Million Metric Tonnes.(MMT) out of which 127.83 MMT was imported at a total cost of Rs. 2603 billion Rupees. The fuel prices had shot up to US$ 140 a barrel. In India efforts are on to promote biofuels and other non-edible oils for running engines. The Govt. of India has fixed gargets for blending of diesel and petrol with biofuels by 5%, 10% and 20% by 2012, 2017, beyond 2020, respectively to substitute fossil fuels, reduce import cost bill and reduce CO_2 emissions. The CO_2, emissions are 1.2 t per capita and energy use is about 510 kg of oil equivalent per capita.

Conservation Agriculture(CA)technologies have the potential to contribute to increased productivity in a sustainable way. The term CA refers to a set of agricultural practices and is based on three fundamental principles namely, following no-tillage, permanent soil cover and diversified crop rotations. The paper deals with Conservation Agriculture, its effect on climate change, its impact on agriculture, zero-tillage, carbon credits, programmes launched by Govt. of India to reduce Global warming and list the viewpoints of different individuals on carbon trading in agriculture and suggest measures to mitigate climate change.

KYOTO PROTOCOL AND CDM

Kyoto Protocol was adopted in the third conference of the parties of the UNFCCC (COP3) in Kyoto, Japan on, 11th December 1997. 197 countries signed the document first. India became a signatory in 2003. Kyoto Protocol of 1997 contrives and suggested reduction of emission of greenhouse houses into the atmosphere and fixed individual quotas for each of the ISO member countries. Said quota mandates the tolerable. The developed countries are supposed to reduce their carbon emissions to the tune of 20% by 2012. The Kyota Protocol is designed to cut greenhouse gas emissions by making the polluter start paying for **climate change.**

Kyoto Protocol includes three flexibility mechanism for reduction of GHGs,

a) The Kyoto protocol's clean development mechanism (CDM) allows developed countries to gain emissions credits for financing environmentally friendly projects based in developing countries.
b) A country can also earn emissions credits something called joint implementations, which allows a country to benefit by carrying out something like a reforestation project in other industrialised country or "economy in transition"
c) The third mechanism is carbon trading. It allows countries to buy emission credits from countries that do not need them to stay below their emission quotas.

The Clean Development Mechanism (CDM) is one of the three flexible mechanisms established under the Kyoto protocol. It allows developed countries to invest indirectly in GHG emission reduction projects in developing countries, by buying tradable Certified Emission Reduction (CERs). Since developing nations generate lower gas emissions and also need to develop hence, an acceptable rating system need to be formulated. The carbon credit was introduced in the mainstream to precisely to address this disparity. Four of the 25 EU states – the Czech Republic, Greece, Italy and Poland have not joined the system at all, and the UK is resquabbling with European Commission over its emission allowance under the scheme. No country wants to put its business a disadvantage so all played safe, erring on the side of generosity when setting emission quotas for industry. Carbon Credits are tradable permit bonds set with a signed monitory value that have been devised to implement a global cut back on gas emissions. Each carbon credit gives the owner the right to emit one ton of greenhouse gas into the atmosphere. If an individual or a company exceeds the set credit quota, the purchase of additional bonds equivalent to the exceeded value becomes a form of penalty. Those companies which have gone below emission levels can be paid for the effort. Each country that has signed on to Kyoto has its own target for slashing CO_2 emission. Countries that cut their emission of greenhouse gases get credits for their efforts: one credit for each ton of reduced CO_2 emissions. Under the Kyoto protocol, companies that would fail to meet the quota or carbon caps are required to undertake greenhouse reduction projects in other countries where costs are deemed much lower in order to compensate for the excess generated in their locality. This also helps in developing country to get new technology.

Some concerns have been raised against carbon trading. It is felt that one cannot trade in something unless one owns it. When governments and companies "trade" in carbon, they establish defacto property rights over the atmosphere; a commonly held global commons. The carbon trading would allow the rich nations to pollute the atmosphere and putting cap on developing countries to reduce their carbon emissions and use of low energy technology. Some researchers are of the view that "Hot Air" trading is an accounting fraud. For example, Russia's economic collapse since 1990 has reduced its emissions by 30%. Russia is intending to sell this incidental windfall as international carbon-credits-potentially swapping the market. Thus there are strong incentives for cheating and creating bogus credits that do not represent any real reduction in emission. The countries should join hand in undertaking joint projects to reduce CO_2 emissions and develop new and efficient technologies for use in urban as well as rural areas. We need to evolve varieties and genomes which will be able to bear the rise in temperature, drought, floods etc. The organic farming needs to be promoted instead of use of chemicals as fertiliser factories have been found to be the main contributor to global warming and burning of straw needs to be curbed

Burning of fossil fuels that release heat trapping gases are responsible for global warming that may disrupt water and food supplies with even more droughts, floods and heat waves. CO_2 levels are at about 300 ppm. Global warming has resulted in change in climate all over the world and concern is felt due to melting of the Glaciers. It is estimated that globally, 30 % of the Earth's species could disappear, if temperature rise by 4.5° F(2.2° C) and upto 70 % , if the temperature rise by 6.3° F(3° C). The hardest hit will be plants and animals in cooler climate or at higher elevations and those with limited ranges or tolerance for temperature change. Global carbon emission is about 8 billion tonne per year and by 2057 it is expected to be 16 bt/year.

It is difficult to track emission values and difficult to know if a particular company exceeded its quota or achieved reduced emissions. In Agriculture it is much more difficult to keep such record and also to fix emission reduction quota. However, for industries a system known as the CO_2 calculator has been formulated to estimate the gas emitted in the atmosphere. The combustion of fossil fuels borne out of the use of vehicles powered by gasoline and the production run of gas, oil and coal fired power plants, tops the list of atmosphere pollutants. The major pollutant industries are cement, steel, textile, air conditioners, refrigerators and fertilizer.

India has already initiated integration of CDM in National Policy by establishing an Inter Ministerial Committee on Climate change. A National CDM Authority has been constituted by legislation passed by Cabinet Committee. The 42 SD (Sustainable Development) criteria set by GOI are also approved by Inter Ministerial Committee and all projects have to comply to their criteria to get host country's approval. The SD criteria for CDM projects are zonal, economic, environmental and technological well being.

India established CDM authority in December 2003 and 1st project on CDM was registered in March 2005 and on October 2005, first project received CER's. Out of 818 CDM project sanctioned, 283 (35%) are located in India, 123 project (15%) in China, 3% in Chile, 12% in Mexico, 13% in Brazil and 22% (other).

CLIMATE CHANGE

India, a large developing country (1.4 billion by 2040), is likely to be impacted more due to climate change. The rural climatic sensitive sectors are agriculture, forests, fisheries etc. Hence, climate change is a very critical issue for India more than other countries and needs due attention. Due to climate change there will be impact on agriculture sector with reduce food production, effect on water resources due to change in stream flow, increase drought incidence and retreat of glaciers and untimely rains. There will be effect on forest ecosystems, such as loss of biodiversity, change in forest types and shift in forest boundaries. Climate change will affect coastal zones and there will be increase in sea levels and increase in cyclones and hurricanes. There will be impact on health and diseases. There is need to address to climate change through mitigation and all activities be aimed at reducing Green Houses Gases (GHG) or carbon intensity of goods & services, reducing CHG emissions(GHGs) and increase removal of CO_2 from the atmosphere.

A National Action Plan on Climate change just been released by Prime Minister of India, mandates setting up of energy benchmarks for each sector and allows trade in energy saving certificates. This is expected to kick start a domestic trade in energy just as the world trade in carbon emission certificates. It is proposed to save 10,000 MW by the end of 2012 through energy efficiency measures. The key demands of the India's National Action Plan as climate change are 1) Solar energy boost (1000 MW) solar power by 12th Plan) 2) Steel, power and textile industries to trade in energy efficiency targets 3) Minimum target of 5% renewable energy for power grids to procure 4) Nuclear power plant on climate mitigation package 5) Critical data to be digitized: sharing and access made easier 6) recycling from automobiles at the end of their life and 7) 5000 MW thermal plants to be closed by 11th Plan. Additional 10,000 MW to be shut or overhauled by 12th Plan.

The ICAR has also launched a Network Project on "Climate Change" involving 15 research institutes and State Agricultural Universities for conducting critical research on crops, livestock and fisheries. ICAR has also entered into agreement with the International Centre for Research on Agro-forestry (ICRAF) for collaborative research on farm forestry aimed specifically at dealing with climate change.

4.0 **CONSERVATION AGRICULTURE (CA) TECHNOLOGIES TO MITIGATE EFFECT OF CLIMATE CHANGE**

CA involves practices such as minimum or zero mechanical disturbance, crop residues retention, permanent organic soil cover, diversified crop rotations, precise placement of agro chemicals, in field traffic control and application of animal manure and crop residues. The benefits of CA are lower farm traffic, reduction in use of mechanical power, labour inputs thus resulting in timely field operations, lower risk of crop failure and ultimately resulting in higher yields, lower costs and reduction in environmental pollution. The latter relates to reduce use of fossil fuels with associate reduction in CO_2 emissions, improved soil carbon levels, reduction in use of fertiliser and chemicals and thus resulting in carbon sequestration.

Research is being carried out on CA in India by Indian Council of Agricultural Research(ICAR), State Agricultural Universities(SAUs) and CIMMYT's Rice-wheat consortium. A good number of machines such as no-till drill, strip till drill, raised bed planter, laser land leveller, straw cutter cum incorporator, straw baler, farm residue collector, straw combine have been developed and are being propagated. In rice also to reduce water requirement direct seeding of rice on raised beds and System of Rice Intensification (SRI) method of paddy cultivation is being experimented. To produce 1 kg of rice about 3000-5000 lit. of water is required. To apply water irrigation pumps are used and they are operated by diesel engines which emit CO_2.

Photosynthesis is a process through which plants absorb CO_2 from the atmosphere and release oxygen molecules in the atmosphere and store carbon in their tissues, especially roots. After plant dies, the carbon molecules remain in the soil unless disturbed by tillage or any other operation which allows carbon atoms to combine with oxygen and escape into the atmosphere as CO_2. The amount of carbon sequestered by plants is almost equal to the amount lost in the atmosphere. Following no-tillage results in higher levels of carbon stored in soils.

4.1 No-tillage

An effort to promote zero tillage in India was started in 80's. The technology was promoted by Imperial chemical Industries Limited of U.K. to promote their chemical "Gramoxone" to control weeds(*philaris minor*) in zero tilled wheat. One of the basic requirements of zero tillage is that the weeds must be controlled. Late sowing of wheat is a major problem in paddy-wheat cultivated areas, which results into decreased yield @ 1-1.5 % per day when planted after November. This happens due to late harvesting of paddy especially long duration basmati rice. Sowing of wheat with traditional method requires 7-8 days in field preparation that also delays sowing of wheat resulting in decrease in yield. Hence, for timely sowing of wheat, a conventional zero-till drill was developed by Shukla, Tandon & Verma (1981) at Punjab Agricultural University, Ludhiana. It consisted of conventional tractor drawn seed cum fertilizer drill with disc coulters attached in front of the fixed type furrow openers. It was used for sowing wheat in fields where paddy had been sown earlier. The performance of the zero till drill was found to be satisfactory and comparable yields were obtained under conventional tillage (Table 1). From the table above it can be seen that the germination count and yield was higher in case of no-till planted fields as compared to conventionally sown fields.

Table 1. Comparative performance of No-Tillage and conventional Tillage Systems for Growing wheat after paddy.

Field No.	Plot No.	Treatment	Moisture Content of soil in percentage	Average germination count/m	Wheat Yield (Quintal/ha)
I	1.	No-till	12.00	41.50	31.61
	2	1 discking + 2 cultivator +1 planking	12.50	39.00	30.12
II	3	No-till	14.00	43.10	34.58
III	4.	1 discking + 2 cultivator +1 planking	14.00	41.30	34.58

The reversible furrow openers provided behind disc coulters of the no-till drill resulted in formation of clods and did not allow the seed to emerge above the surface. Hence, these reversible shovel furrow openers were replaced by boot type furrow openers and had coulters fixed in front of the furrow openers for opening the slit in the soil to enable the seed and fertilizer to be placed in the soil. The modified drill was used for sowing wheat in fields where paddy had been grown earlier and in fallow land. From the study conducted, it can be seen that there was not much difference in yield between zero till drilled fields and fields where one disking was done (Table 2). The fallow–wheat rotation gave lowest yield. In the zero till drilled plots the incidence of weeds was less, mostly broad leaf weeds were observed and there was no incidence of philaris minor a weed which is difficult to control.

Table 2. Comparisons of zero tillage and reduced tillage for sowing wheat after paddy and in fallow field

Treatments	Av germination count per meter length/No. of	Average grain to straw ratio	Yield, Q/ha	Type of weeds

	tillers /plant			
1.No tillage (paddy-wheat)	43.00/3.144	1:1.35	34.90	Lamb's quarter/Chenopodium album,Mexican prickly poppy (*Argemone mexicane*)
2.One discking (Paddy-wheat)	57.00/2.34	1:1.95	41.16	Lamb's quarter/Chenopodium album, Cynodondactylon
3.No-tillage(Fallow-wheat)	54.00/2.56	1:0.77	21.32	*Canobis sativa*, Chanopodium album

Source: Tandon & Powar (1985)

A Rice-Wheat Consortium for Indo-Gangetic plain by CIMMYT, a CGIAR eco-regional initiative involving several CG Centers and National Agriculture Research System of India, Pakistan, Bangladesh and Nepal was formulated to promote resource conserving technologies such as, laser land leveller, zero-tillage, furrow irrigated bed planting system (FIRBS), surface seeding, nutrient and water management, residue management, alternative to rice-wheat cropping system in relation to CA technologies. Zero-tilled drills, strip till drills, roto till drill were used for direct drilling of wheat after paddy and their performance was compared with conventional tillage(Table 3). In these drills, the furrow openers were replaced by inverted "T- type" furrow openers. In No-till plots, fuel consumption was found to be 11.30 l/ha as compared to 34.62 l/ha by conventional method resulting in fuel saving of 24 l/ha. There was 67 % saving in fuel due to no-tillage as compared to conventional method(Table3).

Table 3. Comparison of different tillage equipment used for sowing wheat after paddy

Particular	No-tillage seeding	Strip tillage seeding	Seeding with roto –till-drill	Conventional tillage (3 passes + levelling)
Time required(h/ha)	3.23 (70.15)	4.17(61.46)	3.45(68.1)	10.82
Fuel used (l/ha)	11.30(67.36)	17.80(49.45)	13.80(60.14)	34.62
Operational energy (MJ/ha)	648.96(67.16)	1001.76(49.31)	783.60(60.34)	1976.11
Cost of operation Rs/ha	639.54(66.39)	979.95(48.50)	807.30(57.58)	1903.04

- Figures in brackets show % of saving over conventional practice. Source: S. K. Rautray(2003)

In another study conducted by Rautray(2003), conservation tillage as compared to conventional practice (Table 4) showed higher performance in terms of increased benefit cost ratio (2.47-2.17) and lower operational energy (5.1-26.1%). The reduced tillage system reduced the cost of cultivation due to reduction in energy requirement and yield returns were similar to the conventional practice as can be seen from Table 4. In zero tillage the specific energy was found to be the least (1.93 MJ/kg) as compared to other three treatments and operational energy was found to be the least as compared to other three treatments.

Table 4. Comparative performance of zero till drill, strip till drill, rota till drill and conventional tillage

Sr.No.	Particulars*	Zero tilled drilled wheat	Strip till drilled wheat	Rota till drilled wheat	Conventional tillage seedling
1	Grain yield (t/ha)	3.71	3.66	3.70	3.80
2	Cost of Production – (Rs./ha)	9746	10328	11064	11825
3	Benefit cost Ratio	2.47	2.30	2.17	2.09
4	Operational energy (MJ/ha)	7176	8604	9216	9708
5	Specific Operational energy (MJ/kg)	1.93	2.35	2.49	2.55
6	Specific Cost of Production (Rs. /kg)	2.63	2.82	2.99	3.11

Source: S. K. Rautray (2003) Sale price of wheat Rs.6.50/ kg.

Jat (2008) conducted studies on permanent raised beds and no-tillage was followed both for sowing wheat as well as rice. No-tillage was compared with raised bed system. The results of double no–till study in rice-wheat cropping system indicated that the crop yield was comparable under flat bed and raised bed sown wheat and paddy and was equal to yield obtained by conventional method. However, the maximum water productivity (kg per cu.m. of water) was recorded under permanent raised bed (1.59) followed by no-tillage (1.37) and conventional till flat bed sown crops (1.19). Improvement in soil physical properties was recorded in Permanent Beds (PB) and No-till (NT) compared to Conventional Tillage (CT). The net profit was maximum with NT (316 US$/ha) followed by PB(308 US$/ha) and least profitability was obtained under CT (240 US$/ha).

The experience of zero tillage /direct drilling showed that there are many benefits in keeping the soil undistributed for long periods as nature intended. It was found that due to zero tillage, the soil drainage improves with draught cracks - worm channels - old root systems and soil pores all linking together to help to remove rain water quickly and therefore avoiding the sponge effect created by normal cultivation. Researchers have observed that worm population are higher and that root system are stronger and deeper in direct drilling system. Soil structure is also improved with the organic matter being retained near the surface. This helps to improve and build up a natural surface tilth which requires little preparation for cereal sowing in addition the crumb stability or soil strength is increased. Though the effect of direct drilling (no-tillage) has been found to be advantageous in terms of increase trafficability, decrease soil compaction in long run, reduced soil erosion due to wind and water, decreased water evaporation and increased availability of water in the soil, decrease lodge condition of the crop, reduced investment in machinery due to reduced energy requirement and improved timely planting and harvesting. However, to realise the full advantage of zero-tillage and to sequester carbon, retention of crop residue especially with controlled traffic measures may further be beneficial due to reduce soil compaction and increased water infiltration and reduced soil evaporation due to residue mulch and provide more water for plant growth. Crop residues may be effective to some extent in suppressing weed growth thus reducing use of herbicides. In depth long term studies on no-tillage be conducted to see the effect on soil compaction, carbon sequestration, soil erosion, temperature of soil due to soil mulch cover, water infiltration etc and their effect on reduction in global warming.

4.2 Long term studies on build of organic carbon due to different tillage treatments.

A long term tillage studies were conducted at Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad (India) for eight years. The organic C (g/kg) was determined at 5 to 20 cm depth by following conventional and minimum tillage. The organic C was found to more in minimum tilled fields as compared to conventional fields (Table 5.):

Table 5: Organic C in conventional & minimum given in filled fields.

Tillage Treatments	**Organic C (g/kg)**	
	0-5 cm	**5-20 cm**
Conventional	5.42	5.26
Minimum	6.16	6.00

It is estimated that global conversion of all crop lands to conservation tillage (CT) can sequester 25 Gt C over 5 years. Chicago Climate Exchange (CCX) payments based on the assumption that CT sequesters 0.3 t C/ha/yr. It has been found that crop rotation under CA practices lead to sequestering of 0.01-0.03 Pg C/year in the maize/ soybean growing regions of the US. Similar studies need to be carried out in all countries following CA. Crop rotations, especially legume-based ones, are generally regarded as extremely valuable for maintaining soil fertility and have a very good potential for sequestering in dryland systems and needs to be promoted.

4.3. Conservation Practices in Paddy

Paddy is sown in puddled soil and requires large amount of water and irrigation is to be given every alternate days under upland cultivation. Efforts were made to overcome ill-effects of puddling on soil structure in rice-culture, reducing drudgery of rice planting without yield penalty and developing **double no-till system** to grow rice, wheat and other crops. Hence, surface seeding, pre-germinated paddy seeding, direct paddy seeding and SRI method of paddy sowing are being promoted. In different states of India (Punjab, Haryana, U.P. & Uttranchal) rice was directly seeded on the side of raised beds without puddling. The rice transplanted on raised beds yielded 10-15% more grain and saved 14% irrigation water as compared to conventionally tilled puddle transplanted rice. Direct seeded rice saved more than Rs.6000/ha as compared with traditional rice culture. In some cases there was also 30-40% saving in water due to application of water in the furrows of the raised bed. The raised bed are kept wet but no standing water is needed. Thus, this results in reduction of number of hours of use of water pumps for lifting water for applying to the field. This ultimately results in reduction of CO_2 emission by the engines used for running the pumps.

4.4 Conservation of water due to laser land leveling

Animal and tractor drawn levelers are used for leveling the land. Laser land leveler has been recently introduced and levels the fields in both, x & y direction very precisely and accurately. Precision land leveling helps in uniform application of water; better crop stands and improves input use efficiency. Laser assisted precision land leveling saves irrigation water, nutrient and agro chemicals. It also enhances environmental quality and crop yields. The total water use in wheat and rice in laser leveled field was reduced to 50% and 32%, respectively. In raise bed planted wheat about 26% water can be saved through laser land leveling. In a study conducted in Punjab, using laser land leveling on 60 ha, resulted in 24% saving in time and 11% increase in yield as compared to conventional method of leveling of yields (Table 6.). Saving in irrigation application time is directly related to saving in electricity, diesel and most importantly saving in ground water.

Table 6: Yield and irrigation water saving for laser leveled and traditionally leveled plots for rice crop under replicated experiments at Punjab Agricultural University, Ludhiana

Sr.No.	Yield (t/ha)		% Increase in yield	% saving in irrigation time/water
	Laser Leveled	Conventional	% Increase in yield	% saving in irrigation time/water
Site No. 1	8.78	7.73	13.60	26.15
Site No. 2	8.30	7.53	10.30	-
Site No. 3	7.60	7.00	8.57	25.00
Average	8.22	7.42	10.82	25.57

Source: Sidhu et.al (2007)

It is estimated that extension of laser assisted precision land leveling system to just two million hectare of area under rice wheat system would save 1.5 million hectare meter of irrigation water and save diesel upto 200 million litres (equivalent to US $ 1400 million) and improve crop yields amounting to US $ 1500 million in three years and reduce GHG emissions equivalent to 500 million kg. It will also increase cultivated area by 3 to 6% due to reduction of bunds and water channels in the field. In laser leveled fields, the performance of different crop establishment option such as zero tillage raised bed planting and surface seeding are known to improve significantly.

4.5 Residue management and reduction of environmental pollution through CA practices

In most of the South Asian countries the paddy straw is burnt before sowing wheat. This contributes to soil degradation through loss of organic matter, soil erosion and also causes environmental pollution. Hence, efforts were made to develop machines to cut, spread and incorporate the paddy straw in the field to help in sowing wheat after harvesting paddy to avoid burning of the straw. The straw cutter cum incorporator developed cuts the straw in the field and mixes it with the soil thus adding organic matter and improving soil health**.** A Happy Combo Seeder in collaboration with Australia has been developed for direct seeding of wheat in fields where paddy had been grown earlier. This machine cuts the paddy stubbles left in the field after combining and throws it at the rear of the machine. Straw balers have been developed and are being used for cutting the straw and making bales which can be then fed to the animals. This also helps in avoidance of burning of straw in the fields thus reducing CO_2 emissions.

In wheat fields to recover the wheat straw from the combine harvested fields, a straw combine (reaper) has been developed. It cuts the standing stubbles from the ground level and makes bhusa and which is then blown to a trolley attached to it. It helps in recovery of 1000 kg of straw/ha and about 40-50 kg of grain/ha. This also avoids burning of straw and reduces pollution. Crop residue management by use of straw cutter cum spreader, straw baler and straw combine helps to avoid burning of the crop thus reducing atmospheric pollution, also enriches soil and provides farmer additional income.

Hence, it can be seen from above that conservation agriculture studies carried out by the different Institutes of the Indian Council of Agricultural Research and the State Agricultural Universities that no-tillage and direct seeding results in saving in time, fuel and labour requirement. Conservation Agriculture does not as per definition include the water and chemical management, which is one of the most important components needing attention of the scientist world over.

Different cropping systems yield different amount of soil carbon. Tillage results in large decline in solid carbon due to significant flush of CO_2 . Tillage perturbs the soil system and causes a shift in the gaseous equilibrium by releasing CO_2 that enhances oxidation of soil C and organic matter loss. Agriculture plays an important role in mitigating the greenhouse gas emission. Conservation Agriculture and residue management can contribute to mitigation of climate change by appropriate land with best management practices to increase crop production.

5.0 METHODS FOR MEASUREMENT OF CO_2 EMISSIONS AND CARBON CREDITS.

Soil contains both (weathered rock particles and minerals) and inorganic (plants, animals, insects and microbes) components. Soil carbon content can be either expressed as either a concentration (%) or a stock (t/ha). To convert one unit of measurement to other, depth of measurement and bulk density values needs to be known. Soil bulk density is the dry weight of one cu. m. of soil and is expressed as gm/cm^3. Soils having low bulk density are well structured have more room for air and water and have more pore space and provide better conditions for soil life and nutrient cycling. Bulk density and C content increases with soil depth. For every tonne of carbon lost from soil adds 3.67 tonne of CO_2 gas to the atmosphere. Conversely, every 1 t/ha increase in soil organic carbon represents 3.67 tonnes of CO_2 sequestered from the atmosphere and removed from GHG equation.

The CO_2 emitted from the fuel can also be used to calculate the CO_2 sequestered. As per conversion factor of 2.6 kg/l of diesel (Grace et al 2003) (Gupta 2007) and an estimate of 24 lit/ha of diesel saving as per Table 3 given under Sr. No. 4.1, the estimated annual savings due to following zero-tillage, saving in CO_2 emission are 62 kg/ha. Hence, adoption of zero tillage in 90 m. ha in the world works out to be 5.58 million tons of CO_2equivalent and would save 2160 million liters of diesel. Similarly for India where about 3.43 million ha area is under no-tillage estimated annual no-tillage (NT) savings in CO_2 emission would be 0.21 million tons of CO_2 emission. So saving in diesel is about 82.32 million litres. Taking diesel price as Rs. 35/lit, it works out to be Rs. 2881.2 million(US$ 61.30 million)annually.

Other greenhouse gas emission, including methane and nitrous oxides, have an even greater effect on global warming. Grace.et.al (2003) have highlighted that no-tillage with residue retention and with 50% of the recommended NPK application, would effectively have the total carbon equivalent emissions to 14 t CO_2 /ha/yr compared to high input conventionally tilled cropping system with residue burning and organic amendments due to improved nutrient use and environmental efficiency. The burning of crop residues is not considered as a CO_2 source to the atmosphere by the Intergovernmental Panel on Climate Change (IPCC), as on annual basis there will be no change in the C stock. Zero-tillage also reduces CO_2 emissions by slowing oxidation of the carbon stock due to reduced soil disturbance.

Zero-tillage farming on 0.25 m ha in IGP reportedly saved 75 million $m.^3$ water in 2002-03 (Malik et al 2004). Hence, 3.43 million ha of wheat under no-tillage would save an estimated 1029 million m^3 of water every year. It would also reduce hours of operating the pumps thus reducing emission of CO_2 from engines used for operating the pumps. Hence, we need to develop methods to determine the reduction in CO_2 emissions by the pumps and make improvements in the engines used for running these pumps. As many farmers are going for zero-tillage for both kharif and rabi crops hence, these shall be substantial reduction in CO_2 emission which would help India to claim more compensation and increased carbon credits.

CONCLUSION

To mitigate the affect of climate change, all the countries need to conserve energy and reduce emissions of CO_2, CH_4 and N_2O. Systematic long term studies need to be carried to analyse technical options for mitigating GHG and other harmful emissions from use of tractors, combines and diesel engines which are used on the form for doing various farm operations. There is also need to identify and rank the barriers to the introduction of selected technical option such as zero-tillage, reduced tillage, laser land levelling, solar energy, bio-fuels to mitigate environmental emissions. We also need to develop varieties which are drought and flood tolerant. The pollution in the urban areas are bound to increase thus effecting climate. The emission levels can be reduced by certain technical options such as, use of alternate fuels eg. use of dual fuel (LPG & gasoline); more efficient tractors & diesel engines; and methanol or ethanol run tractors and diesel engines. A mega project in this respect be launched to meet the challenges of global warming. The concept of Conservation Agriculture as has evolved under varying situations, calls for integrated and participatory approach by involving plant breeders, agronomists, soil scientists, environmentalists and engineers to solve emerging problems and suggest efficient method of cultivation of crops and their efficient management to mitigate the effect of climate change.

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