Conservation Agriculture Bulwarks Water Scarcity and Climate Change in India: A Review

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Abstract

At a global level, particularly India the agricultural sector has tremendous shift from "traditional animal-based farming of agriculture" to "chemical and mechanized based farming" led to multifold problems associated with the sustainability of natural resources. As a consequence, harms the environment and nutrient depletion in soils which adversely affects the soil quality and impairs the crop yield and poses a potential threat to sustainable agricultural production. In concomitant rise in the cost of production, and emission of Green House Gases (GHGs). This led to lower profit and making farming unattractive. Conservation agriculture (CA) is the potential approach in the management of the sustainable and resource-conserving agricultural system. The conservation agriculture embodied with three principles viz., minimum tillage, permanent soil covers and crop diversity. The CA has advantages in many aspects firstly reducing the cost of cultivation through saving the labor, farm power and proper utilization of available resources. At the global level, CA sequester carbon results in decreasing CO2 in the atmosphere which facilitates in mitigating the climate change. However, the area spread under conservation agriculture in India is less as compared to developed countries and it is about 3.5 million hectares especially in Indo - Gangetic regions for the rice-wheat system. The main reasons for this are the lack of skills and knowledge gap and preponderance of small and marginal farmers who cannot afford the suite of high-end machines. Hence, the effort may be a move–towards providing the suite of CA implements and machinery and technical service at the farmer's doorstep through Information and Communication Technologies (ICTs) tools and artificial intelligence and establishing the custom hiring centers. The capacity building and training, credit and technical support for the farmer's organization and land pooling may foster -conservation agriculture.

Key words: Conservation agriculture, Sustainable, Green house gases, minimum tillage

Introduction

India is the seventh-largest country with 329 million hectares of geographical area and 51 % of the agricultural land and with a population of 1210 million as per 2011 census. The pace of non-farm employment avenues is not consonance with population growth which forced them to live in the below poverty line. Furthermore, the rapid expansion of industrialization and urban growth in the name of economic growth which not only shrunken the land but also deteriorated quality and sustainable use of land. As result, the per capita availability of agricultural land in rural areas from 0.638 hectares during 1950-51 to 0.118 hectares during 2016 (World Bank, 2016). However, about 90 % of the agriculturally suitable area is under cultivation further no scope for horizontal expansion of agriculture.

In last decades the agricultural tremendous shift from "traditional animal-based farming of agriculture" to "chemical and mechanized based farming" as consequences of many problems associated with the sustainability of natural resources. The burning of crop residues and intensive applications of chemical fertilizers results into fertility fatigue and

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primary and secondary nutrient deficiency in many parts of the cropped area and severity could be observed in the canal command areas where intensive cultivation of rice and sugarcane is practised. Thus, achieving SDGs (sustainable development goals) of zero hunger is quite tough given that resource fatigue, depleting the groundwater, soil degradation and emission of GHGs. This led to lower profit and making farming unattractive.

Conservation agriculture is the potential approach in the management of the sustainable and resource-conserving agricultural system. Conservation agriculture (CA) is the potential approach in the management of the sustainable and resource-conserving agricultural system. The conservation agriculture embodied with three principles viz.,minimum tillage, permanent soil covers and crop diversity. The CA has multifold benefits firstly in reducing the cost of cultivation through saving the labor, farm power and utilizing available resources. Secondly, improved use resources efficiently which reduces the input usage led to a reduction in resources degradation and improves the soil nutrient exchange capacity. Thirdly, at the global level, CA sequester carbon results in decreasing CO2 in the atmosphere facilitates in mitigating the climate change.

The area spread under conservation agriculture in India is less as compared to developed countries is about 3.5 million hectares especially in Indo - Gangetic regions for the rice-wheat system. Conservation agriculture practices on an about 124.8 million hectares out of this, USA accounts of 26.50 M ha followed by Brazil (25.50 M ha), Argentina (25.65 M ha). However, this requires considerable farmer management skills and also private and public investment to foster its expansion.

Conservation agriculture and its implications on farmer's welfare

In India, CA practices in Indo - Gangetic regions for the rice-wheat system it covered an area of 3.5 million hectares (Joshi, 2012). Studies have shown that conservation agriculture technology has the potential to generate better net return in coupled with the reduction of cost of production. For instance, wheat farming in Haryana state which saves about 92 % of the fuel consumption and machine operations results in increasing net income about 18 % over conventional tillage as indicated in the table 1 implies that conservation agriculture achieves maximum net profit by conserving the resource concomitant with protecting the environment. Further, another study conducted in south Asia by taking the 67 crops used in this study by Kumara et al, 2020 and results implies that net returns under CA relative to conventional agriculture about 11.80 per cent and 31.50 per cent for wheat, legumes respectively. In rice-wheat cropping system have found that incremental benefit of 34 US dollars as against conventional agriculture mainly due to positive yield effect and cost-saving (figure 1). The marginal net returns under the CA mainly because of cost-saving and positive yield effects. It is evident from figure 2 that the productivity level significantly increased by 3.43 per cent,1.7 per cent and 4.43 per cent for wheat, maize and legumes.

Table 1. Cost and returns of wheat cultivation in Haryana, India (per ha)

Particulars	Conventional Tillage	Conservation Tillage	% of Change
Machine operation (hours)	12.00	1.00	-91.67
Machine hours	12.60	1.60	-87.30
Fuel consumption (litres/ha)	80.00	6.00	-92.50

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Production cost (000'Rs)	27.86	26.02	-6.60
Net income (000'Rs)	14.55	17.23	18.42

Source : Food and Agriculture Organization,2018

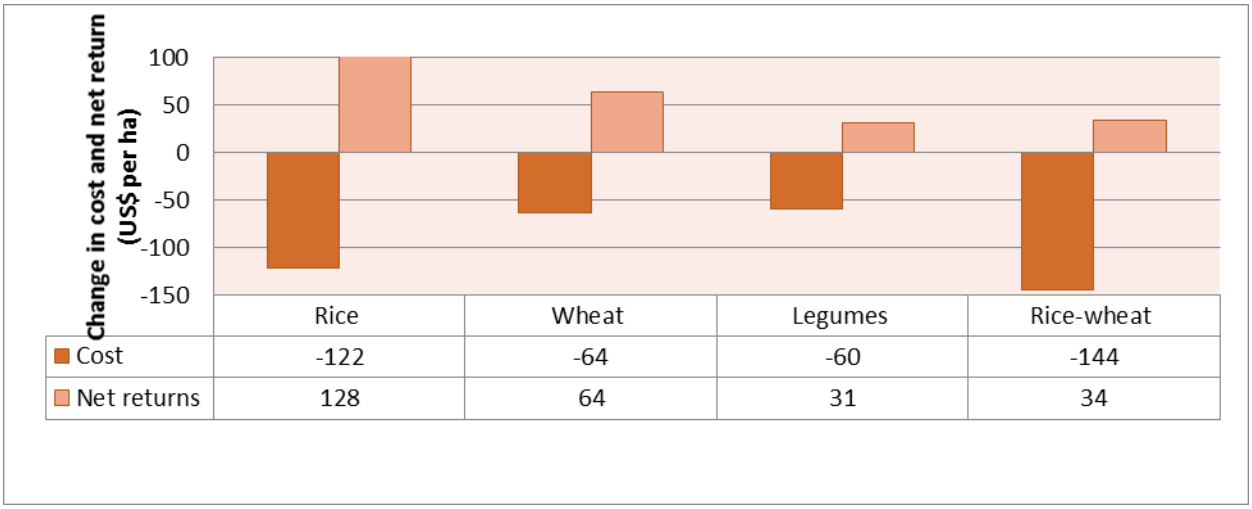

Fig 1. The cost and net returns of conservation agriculture (CA) over the conventional Agriculture

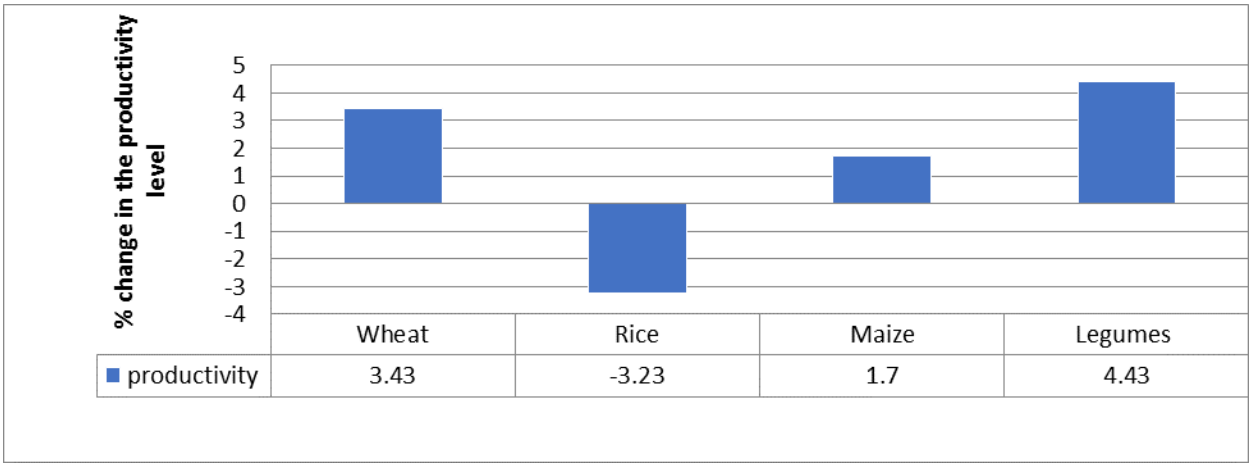

Fig 2. The percent change in the productivity level of CA over Conventional agriculture

Nexus between the conservation and climate change

The conservation agriculture embodied with three principles is minimum soil disturbance, diversified farming system and permanent soil cover enables in mitigating the climate change through sustainable land management. The three principles and its inherent process are depicted in figure 3. The

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conventional tillage is a serious impacts on the climate change through the emission of GHGs from soil to the atmosphere (Lal 2008), for instance one such study by Kumar et al., 2020 findings reveals that significant reduction greenhouses gases (CO2, CH4) by 4.28 and 25.67 respectively. It can be noted from Fig.4 under aerobic condition theemission of (Nitrous oxide) N2O–N was lesser in CA (1.78%) practices whilst under anaerobic soil conditions (12.15%) because of intervention in the conservation agriculture.

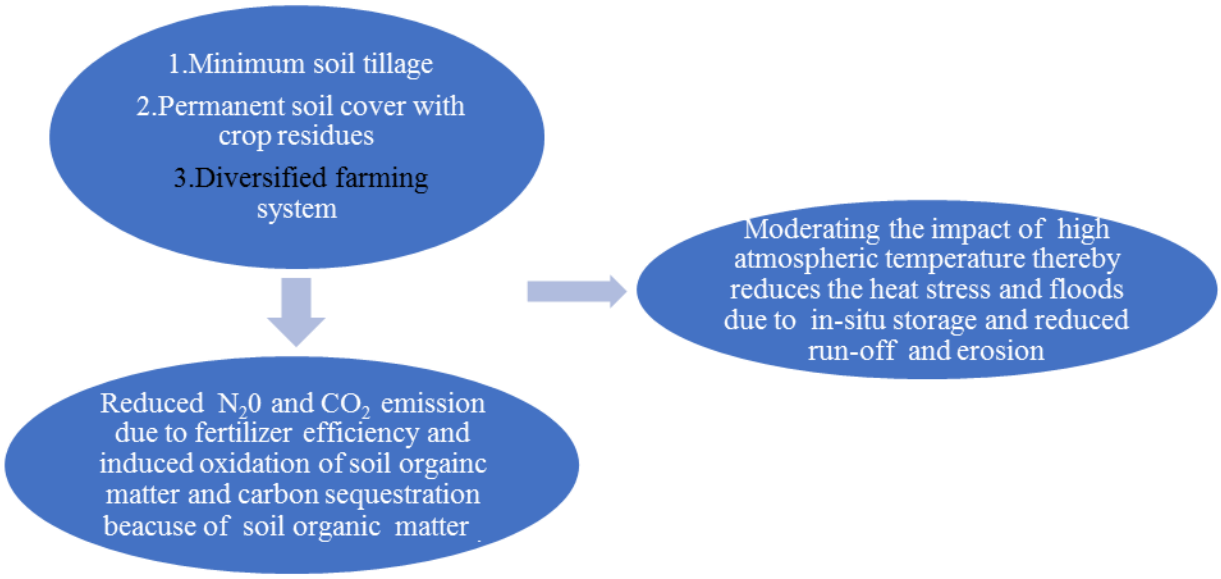

Fig 3. Nexus between conservation agriculture and mitigating the climates change

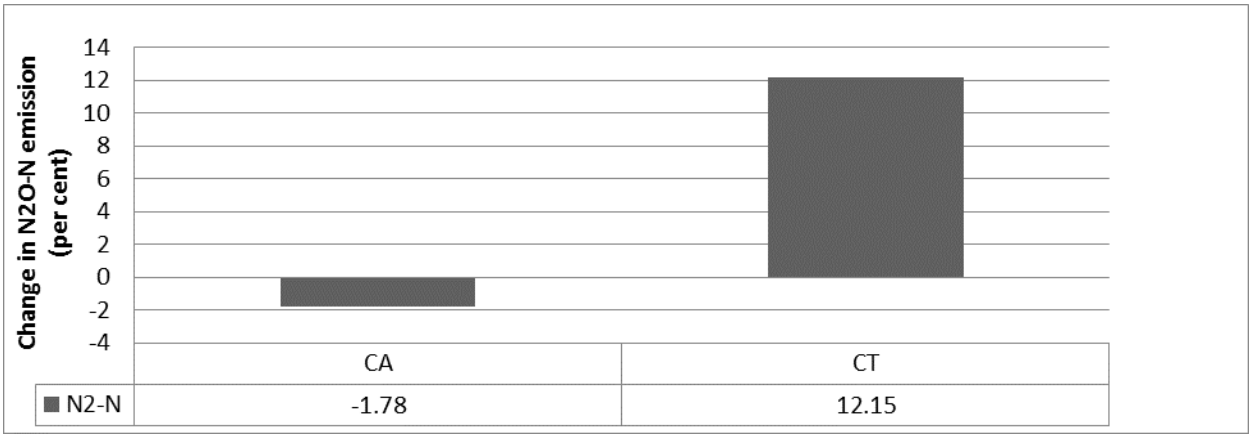

Fig 4. The change in N_2O-N emission in CA over the conventional tillage

Challenges in fostering the conservation agriculture:

Despite potential benefits to the farming communities in reducing the cost of production in coupled with improvement in yield level and mitigating climatic ill- effects the conservation agriculture in India is

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in nascent stage mainly due to the mindset on the farming soil tillage which is the prerequisite for agriculture. Further, in fostering the CA systems their lack of skills and expertise and inaccessibility of suite of machines (laser land levers, ridge furrow making machine, straw chopper/ shredder, combine harvester, zero-till seed cum fertilizer drill). The predominance of small and marginal farmers who are economically weak and not able to afford high - end machines. Additionally, adequate financial resources and social capital are dire need to upscale the technology in India to unleash the potentiality of the CA.

There is no proper system developed for on-farm and off-farm organic residue recycling in the field and also lack of tailored made farm machinery suitable to farm conditions yet another obstacle for up-scaling the CA. The one study conducted by the Aryal et al, who reported that lack of machinery availability in an adequate manner was the major hurdle for fostering the CA in India and about 68 per cent of non-adopters reported that lack of knowledge was the main issue in up-scaling the -conservation agriculture.

The major drivers for conservation agriculture

1. Farming community drivers: Reduced cost of production, the marginal increase in the productivity level and water and fertilizer use efficiency, diversification of the crop enterprise.

2. Policy and institutional and social drivers: The extent to which suite of CA implements and machinery and technology and need-based service made available to the farmer's doorstep through Information and communication Technologies (ICTs) tools and Artificial intelligence. The policies are must be tailored and suitability to the local condition because of agricultural practices are diverse and the preponderance of small and marginal farmers. The subsidies and credit facilities need to up-scale to achieve the need-based target. Furthermore, capacity building and training, communications and support for the farmer's initiatives through the aggregation of farmers and land pooling may foster conservation agriculture.

Conclusion

Conservation agriculture is the potential paradigm approach in the management of the sustainable and resource-conserving agricultural system. The conservation agriculture embodied with three principles minimum tillage, soil covers and crop diversity. The previous studies clearly describe that conservation agriculture has the potential to mitigate climate change and in the reduction of cost of production and improvement in the productivity of crops. The marginal net returns under the CA mainly because of cost-saving and positive yield effects. Despite this, the conservation agriculture in India is in nascent stage largely due to lack of skills and expertise and suite of machines are not affordable particularly marginal and small farmers and economical infeasibility to afford the related machines. There is no proper system developed for on-farm and off-farm organic residue recycling in the field and also lack of tailored made farm machinery suitable to farm conditions yet another obstacle for up-scaling the CA. The subsidies and credit facilities need to up-scale to achieve the need-based target. Furthermore, capacity building and training, communications and support for the farmer's initiatives through the aggregation of farmers and land pooling may foster the conservation agriculture.

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