Extended Abstract
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Paper Title	**Carbon sequestration potential of sustainable agricultural management practices in Indian agriculture: A meta-analysis of evidences and economic assessment**

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Abstract	***200 words max***

Ensuring food and nutritional security for ever growing population is one of the key challenge of 21st century. As compared to conventional practices, sustainable agricultural practices (SAPs) help to mitigate negative effects of climate change through carbon sequestration. In this study, we assessed carbon sequestration potential of SAPs using meta-analysis framework. After removing outlier, a total of 2362 paired observations from 295 studies were selected for the final analysis. Biochar proved to be most effective in improving soil carbon storage with a mean effect of 41.28%. The higher C sequestration of SAPs was found under semi-arid followed by semi-arid subtropical regions and moderately fine textured soil groups. Further, economic assessment revealed that relative soil carbon gain represents a carbon credit of ₹3400 to ₹70236 $ha^{-1}year^{-1}$ with net economic gain were ranges from ₹3254 to ₹67220 $ha^{-1}year^{-1}$. Inclusion of legumes in the cropping system, clay-rich soils, irrigation, rainfall and climates were major factors associated positively with carbon sequestration. Thus, carbon sequestration potential of sustainable agricultural practices were found technically and economically viable. Therefore, effort should be directed towards promotion of SAPs to combat climate change and conserve natural resources and improve livelihoods of small holders in India.

Keywords	Climate change; Sustainable agriculture practices; Carbon sequestration; Carbon credit
JEL Code	Q54,Q55 and Q56 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***

Agriculture plays central role in sustainable growth and development of India and contributes 19.9 percent of total GDP and supports livelihood for more than two-third of the population. However, population growth and sever degradation of natural resources coupled with detrimental impacts of climate change has threaten the food and nutritional security of India. Although, conventional agricultural management practices helps to achieve food security but often leads to indiscriminate use of farm inputs, higher emission of greenhouse gases and also loss of soil carbon and other nutrients. Adoption of unsustainable practices in agricultural lands resulted in lesser carbon sequestration compared to natural vegetation and also removal of essential nutrients. Nevertheless, agriculture also acts as natural carbon sink and provides huge opportunity to capture atmospheric carbon through adoption of sustainable agricultural

practices. Therefore, it is indispensable to identify the agricultural practices which enhances carbon sequestration without comprising the other ecosystem services.

In recent years, large number of field experiments and research studies were conducted to compare the carbon sequestration potential of SAPs with conventional practices. However, the SOC content of SAPs are influenced by various agronomic and geographical factors. Therefore, to draw a broader conclusion on carbon sequestration potential of SAPs which increases is necessary. This study is an attempt to synthesize the results of various studies of SAPs in Indian agriculture by using meta-analysis framework. This study quantifies the carbon sequestration potential and economic feasibility of integrated nutrient management (INM), organic amendment, zero/minimum tillage, crop rotation, residue retention, intercropping and biochar.

Methodology *100 – 250 words*

We conducted a comprehensive search of peer-reviewed research articles comprising various SAPs in India by using online search engines viz., Google Scholar, Science Direct, Web of Science and Scopus up to June 2021. The different combination of search keywords was used to identify the peer reviewed studies are "soil organic carbon", "soil organic matter", "carbon sequestration", "integrated nutrient management", "organic amendment", "zero tillage", "minimum tillage", "crop rotation", "residue retention", "intercropping" and "biochar", "India", "Indo-Gangetic Plains". After excluding extreme data points, a total of 2362 pair-wise observations from 295 studies were considered for the final analysis.

Meta-analysis is becoming popular tool in recent past due to its flexibility in analysis of data compared to other methods. Effect size of each study was estimated as response ratio (RR), which is ratio between outcome variable of SAPs and their control group. Further, random-effect model was performed to understand the response of carbon sequestration under different SAPs. Finally, the obtained RR were transformed in terms of percentage change.

To examine the agronomic and environmental factors which determine the carbon sequestration potential, mixed effect model was estimated by using response ratio as depended variable. As heteroscedasticity was detected, so the states/study location of the experiment was added as a random effect variables and modelled using an identity covariance matrix. Further, economic assessment of the SAPs was carried-out based on country level social cost of Carbon, soil C: N ratio of arable lands and cost of urea.

Results *100 – 250 words*

Among different sustainable agricultural practices, application of biochar has proved most effective practice to enhance carbon sequestration (33.75% to 49.26%) with a mean effect of 41.28%. On the other hand, crop rotation showed lower yet significant effect on soil C stocks with a mean effect of 7.19% compared to control. Overall, the higher C sequestration of SAPs was found under semi-arid regions compared to humid subtropical. Crop rotation, zero/minimum tillage, INM had increased 18.01%,13.02% and 11.13% additional C sequestration compared to humid subtropical respectively. Whereas, the effect of climate on C sequestration potential of biochar has not varied significantly. However, organic amendment had increased 27.82% additional C sequestration under humid-subtropical region compared to semi-arid region.

The effect of soil texture on C sequestration showed that overall moderately fine soil groups are having higher C sequestration potential. Organic amendment (56.11%), biochar (51.10%), crop rotation (26.82%) had positive effect on SOC change in this group. Whereas inm (20.29%), zero/minimum tillage (12.65%) and intercropping (22.58%) had shown highest C sequestration potential under moderately course soil groups. The dynamics of C sequestration of SAPs indicated that the additional C can be sequestrated till 40 years (2.62 $Mg^{-1}ha$), then afterwards it starts declining. Inclusion of legumes in the cropping system, clay-rich soils, irrigation, rainfall and climates were the major factors associated positively with carbon sequestration. The economic assessment revealed that the relative soil carbon gain represents a carbon credit of ₹3400 to ₹70236 $ha^{-1}year^{-1}$ with net economic gain ranges from ₹3254 to ₹67220 $ha^{-1}year^{-1}$.

Discussion and Conclusion

100 – 250 words

All the SAPs are considered under this study are having potential to increase C sequestration from agricultural soils, thereby to mitigate detrimental impacts of climate change. Application of biochar resulted in highest C sequestration potential mainly by addition of soil carbon which due to improvement improves CO_2 flux and stabilization of soil organic carbon. The results of our study is also supported by the findings of earlier studies. All the SAPs had potential to improve various physical, chemical and biological properties of soil, thereby influence the carbon sequestration and also minimizes the soil erosion. Higher C sequestration potential was found under semi-arid climate as soils of these regions accumulates high amount of soil carbon through proper agricultural management practices. However, application of biochar enhances C sequestration in all climate types. Similarly, moderately fine soils groups sequestered higher C as these soils forms strong bonds which provides better physical and chemical protection to soil. Further, sufficient irrigation is also necessary for higher C sequestration as sufficient moisture is crucial for decomposition of organic matter and also growth of microbes. The implementation of all the SAPs were showed technically as well as economically viable in Indian agriculture. Thus, all the SAPs have potential to contribute India's climate pledge target (creation of additional carbon sink 2.5-3 billion tons of CO_2 equivalent by 2030). Therefore, effort should be directed towards promotion and outscaling of SAPs deserves to combat climate change, conserve natural resources, and enhance livelihood of small holders in the region.