Comparative assessment of mustard (*Brassica juncea*) genotypes under *Populus dectoloides* and *Eucalyptus teretectornis* based agroforestry systems for soil carbon maintenance: an implication for climate change alleviation

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The current situation of climate variability can be buffered by the inclusion of agroforestry as a critical land management system. The enormous potential of trees to capture and store carbon from the atmosphere and their role in soil nutrient cycling are globally acknowledged. Alongside this, we need to develop crop varieties that could perform well in competition with trees to share resources like sunlight, water, and soil nutrients. Therefore, the present study was undertaken in the *tarai* belt of the Himalayan foothills to screen suitable mustard varieties and under Poplar and Eucalyptus-based agroforestry systems. Besides this, biomass and carbon sequestration potential were also quantified for different components. In. Ten different Indian mustard varieties were screened under *Populus deltoides* and *Eucalyptus tereticornis*. Variety CS56 produced higher biomass in all three land management systems, i.e., poplar, eucalyptus agroforestry system, and open field *E. tereticornis* was found to have larger climate resilience potential with higher biomass production (91.99 ± 18.21 to 270.19 ± 16.55 Mg ha^{-1}) and CO_2 mitigation (151.92 ± 30.08 to 446.21 ± 27.33 Mg CO_2 ha^{-1}). However, biomass production of the mustard crop was better in a poplar-based agroforestry system.. The total Biomass accumulation, carbon content, and carbon dioxide mitigation showed the following trend: eucalyptus + mustard > poplar + mustard> mustard (open field). Biomass deposition in mustard crops varies from sole crop (open field) > Poplar + mustard > Eucalyptus + mustard. The changes in soil carbon stock after two *rabi* season was recorded to be higher in eucalyptus-based agroforestry (1.29 Mg ha^{-1}) system and lowest in open field (0.43 Mg ha^{-1}). SOC showed improvement under an agroforestry system compared to an open field or pure crop system.

AGROFORESTRY system is crucial for climate resilience, due to its tremendous ability to capture carbon by multifarious components than sole cropping. Combating global warming necessitates a seismic shift in our perceptions of the world. There are ways to adapt and live in a changing environment while limiting the negative consequences of climate change. Re-carbonisation of the terrestrial biosphere is a significant tool for eliminating carbon dioxide (CO_2) induced global warming issues and improving other ecological services[1]. The woody perennial elements of the agroforestry system offer enormous potential for capturing and retaining excess CO_2 in plants and soil. In India, ABG (above-ground) carbon sequestration potential of agroforestry varied from 0.23 to 23.55 Mg C ha^{-1} yr^{-1} and below-ground (roots) sequestration ranging from 0.05 to 5.08 Mg C ha^{-1} yr^{-1} (ref. 2).

Planting trees in cropland would therefore result in increased net above- and below-ground carbon sequestration. Thus, agroforestry is a unique approach to accomplish both adaptation and mitigation goals amidst the challenges posed by climate change. However, there is a scarcity of data on biomass deposition and better carbon sinks among diverse agroforestry systems. Our current understanding primarily focuses on tree species, neglecting the vast array of other components and understorey crops within alley cropping. Indian mustard, a significant oilseed crop, is grown in north India during the *rabi* season. However, its susceptibility to shade, fluctuations in carbon dioxide (CO_2), and temperature variations[3], underscores the urgent necessity for identifying resilient mustard varieties capable of thriving under tree shade and in environments with elevated (CO_2) and temperatures.

The majority of available information on biomass accumulation and carbon stocks in agroforestry systems predominantly focuses on perennial components, leaving a noticeable gap in understanding the dynamics of annual components. This paucity of data concerning annual