Estimation of Carbon Sequestration from the Plant Biomass Through Seasonal Crops

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Abstract-Carbon sequestration from plants refers to the process by which plants absorb and store carbon dioxide (CO_2) from the atmosphere, helping to mitigate the effects of climate change. Plants absorb CO_2 from the air during photosynthesis, a biochemical process that occurs in their leaves. They use sunlight, water, and nutrients to convert CO_2 into carbohydrates, releasing oxygen as a byproduct. The carbon captured during photosynthesis is stored in plant biomass, including stems, leaves, and roots. Carbon sequestration from plants is essential for mitigating climate change. The present study was undertaken to measurement of carbon sequestration from seasonal agricultural crops to find out how much amount of CO_2 can be sequestrated from plant biomass. In this study ten different seasonal agricultural crops were selected from the DYP Agricultural Farm, Talsande, Kolhapur. It is found that, at the time of harvesting the total carbon sequestration from plant biomass in onion crop is highest (3095.99 kg/ha) and lowest in bitter gourd crop (91.79 kg/ha). The per hectare plant population is higher in the onion crop than other crops. it shows that, per hectare carbon dioxide is stored (kg/ha) in the plant body is depend on number of plant population of any crops.

Keywords- Carbon sequestration, Greenhouse effect, Photo synthesis.

INTRODUCTION

Carbon cycle is the biogeochemical cycle by which Carbon is exchanging among biosphere, pedosphere, geosphere, hydrosphere and atmosphere of the Earth. Carbon is the main component of biological compounds. Carbon has used throughout the biosphere as well as, a long-term process take part in Carbon sequestration and stored in carbon sinks. Carbon compounds make up the food and it is an important component of the basic energy molecule i.e. glucose, also, provides a major source of energy as fossil fuel, natural gas and biomass and also regulates Earth's temperature.

Climate Change and its Impact

Climate change is an enduring process. Scientist started taking interest in the subject of atmospheric science and protecting layer of atmosphere around the Earth about 200 years ago. It reveals that; the natural greenhouse effect was a major responsible factor for altering the Earth's climate suitable for survival of life on Earth. In 1824, Joseph Fourier, a French physicist started talking about greenhouse effect. Few years later in 1861 Irish physicist John Tyndall found out the gases responsible for warming of atmosphere including carbon dioxide (Alice Bell, 2016).

Impact of global warming and climate change is catastrophic in all fields of ecology and of human survival. Major ecosystems such as ocean, estuarine, wetland, alpine forest is in great danger following with human life supporting systems like agriculture, sea food supply, food security, water security, public health, frequency and intensity of disasters, land use etc. A number of recent modelling studies have anticipated that water stress will be a primary cause of tree death in the southern temperate forests of the Northern Hemisphere. Forest deaths and replacements of forest by grassland will increase net flux of Carbon from terrestrial biome to atmosphere (IPCC, 1990).

Agriculture as GHG source and its effect

Agricultural land-use activities have significantly reshaped our planet, as approximately 40 % of the terrestrial surface is currently under agricultural use, either as cropland or pasture (Popp et al., 2017). Agriculture sector and climate systems are deeply connected and affecting each other in both ways. Agriculture is one of the most vulnerable sectors among those who are going to affect deeply due to global warming and climate change. In India till now about 56.6 % population is directly or indirectly dependent on agriculture for their livelihood as an occupation (Census, 2011).

Agriculture is one of the most vulnerable sectors, on other hand agriculture act as source of GHG also. Farming and allied activities are contributing in emission sources in various ways. About one third of total Carbon emission has come out from agriculture industry starting from fertilizer manufacturing to food packaging (Gilbert, 2012). Currently India is contributing 6.96 % Carbon in global Carbon emission among that, 21.8 % share comes from agriculture (Johannes, 2015).

Mitigation and adaptation techniques for climate change

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change (ACT, 2016). According to IPCC mitigation is the human intervention to reduce the sources or enhance the sinks of greenhouse gases and adaptation is the process of adjustment to actual or expected climate and its effects (IPCC, 2007)

Carbon Sequestration

Carbon Sequestration by plants is the extraction of the atmospheric Carbon dioxide and its storage in terrestrial ecosystems for a very long period of time. Plants store carbon for as long as they live, in terms of live biomass. Once they die, the biomass becomes a part of the food chain and enters the soil as soil carbon. If the biomass is incinerated, the carbon is re-emitted into the atmosphere as Carbon dioxide and is free to move in the carbon cycle. Carbon sequestration refers to all means that "transfer atmospheric CO_2 into long-lived pools and keep it stored securely so that it is not immediately re-emitted back to atmosphere" (Lal et al., 2003).

The study has been carried out at DYP Agricultural Farm, Talsande, Kolhapur (Maharashtra, India). The specific objective of study to measure of carbon sequestration from seasonal agricultural crops to find out how much amount of CO_2 can be sequestrated from plant biomass.

MATERIALS AND METHODS

Site Selection

Site selection for the measurement of carbon sequestration from the agricultural crops is an important task through which suitability of monitoring at site such as security, accessibility, availability of electricity and related crops for measurement and its importance to the carbon sequestration, economic value of that crops would be considered. The experiment was conducted during the year 2022-23 on sample plot selected from DYP Farms is located in the Talsande village is located in Hatkanangle taluka of Kolhapur in Maharashtra, India. It is situated at 160^0 43'N and 740^0 14'E longitude and altitude of 605 m. The site of project is situated in 32 km northward of Kolhapur.

The climate of Talsande (Kolhapur region) is semi-arid sub-tropical with hot dry summer and cold winter. Generally, the monsoon starts in the first week of June. The climatic condition for the site is typically coastal (dry and temperate with average annual rainfall of 1047.57mm). Maximum temperature occurs during April-May is 25^0C to 38^0 C and minimum temperature in December-January 11.9^0C to 21.9^0C. The soil of the experimental site classified as sandy loam. Different types of other crops are also grown in Talsande farm like sugarcane, wheat, broccoli, turmeric, wheat, sorghum, chikpea, different types of leafy vegetables, coconut, mango, sapota etc.

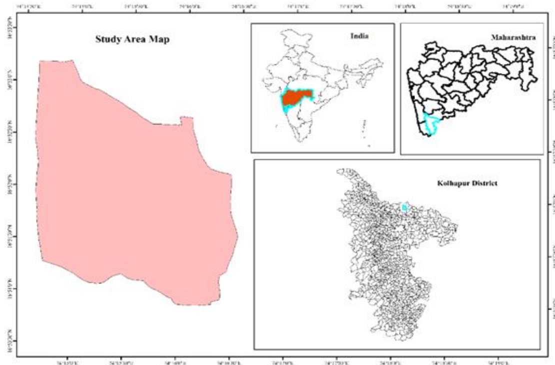

Figure 1. Study area map of DYP Farms, in Talsande (16.8648° N, 74.2557° E)

Plot selection and sampling

For this research study selected ten agricultural crops of different species and family. From each plot 20 plants were selected first 10 at the time of planting and another 10 at the time of harvesting. The main criterion for selecting the specific crop was the age of the crop, for this study select same age of crops and age of the plantation was evaluated and confirmed from the official plantation record. one plot measuring 5m x 5m area were selected randomly from each of the different crops and calculating crop density from row to row and plant to plant spacing.

Types of crops

As we know, plants produce food by photosynthesis, which is the bonding together of carbon dioxide with water to make sugar and oxygen using the sun's energy. There are at least three different pathways in which photosynthesis can occur to achieve the same results. They are known as C3, C4 and CAM, because the first chemical made by the plant is a three- or four-chain molecule. For this research study selected ten seasonal crops of different types and family which shown in following table.

Table 1: Selection of agricultural crops

Sr. No.	Name	Botanical Name	Family	Type	Crop Spacing (cm)	Mulching type
1	Tomato	*Solanum lycopersicum L*	*Solanaceae*	C3	137.16 X 45	Plastic
2	Brinjal	*Solanum melongena*	*Solanaceae*	C3	137.16 X 60	Plastic
3	Chili	*Capsicum annuum*	*Solanaceae*	C3	137.16 X 45	Plastic
4	Ridge Gourd	*Luffa acutangula L*	*Cucurbitaceae*	C3	137.16 X 60	Plastic
5	Bottle Gourd	*Lagenaria siceraria*	*Cucurbitaceae*	C3	137.16 X 60	Plastic
6	Bitter Gourd	*Momordica charantia*	*Cucurbitaceae*	C3	137.16 X 45	Plastic
7	Field Beans	*Vicia faba*	*Fabaceae*	C3	137.16 X 45	No Mulching
8	Cabbage	*Brassica oleracea*	*Brassicaceae*	C3	137.16 X 40	Plastic
9	Cauliflower	*Brassica oleracea*	*Brassicaceae*	C3	137.16 X 45	Plastic
10	Onion	*Allium cepa*	*Amaryllidaceae*	C4	15 X 15	No Mulching

Measurement of Crop Parameter

After selecting crops plant some of crop parameters like shoot height, root length, root to shoot ratio, green weight (wet condition) and dry weight (dry condition) were determined.

Measurement of carbon content by the plants

Calculating carbon storage (C) Carbon storage is the amount of carbon in the parts of that plants. This is the total amount of carbon that is captured from the atmosphere during photosynthesis as well as the amount of carbon sequestered by the plants. The carbon concentration in the plant body was determined using a loss-on-ignition method (Allen et al., 1986). Using this method, 2 g of oven-dried plants sample were placed into preweighed crucibles and ignited at 550 °C for four hours in a muffle furnace. After cooling, the crucibles were weighed.

Carbon dioxide sequestration by plant biomass

Determine the weight of carbon dioxide sequestered in the plantbiomass, the following procedure were used. CO_2 is composed of one molecule of Carbon and 2 molecules of Oxygen. The atomic weight of Carbon is 12.001115. The atomic weight of Oxygen is 15.9994. The weight of CO_2 is C+2*O = 43.999915. The ratio of CO_2 to C is 43.999915/12.001115 = 3.6663. Therefore, to determine the weight of carbon dioxide sequestered in the plant, multiply the weight of carbon in the plant by 3.6663.

RESULT AND DISCUSSION

Measurement of Crop Parameter

The Table 2 shows the average value of height, root length, root to shoot ratio, green weight and dry weight of different agricultural crops at the time of planting and at the time of harvesting. The average height, root length, root to shoot ratio, green weight and dry weight of all the crops at the time of planting and at the time of harvesting.

Table No. 2 Measurement of Crop Parameters

Sr. No.	Name of Crop	Height (cm)			Root Length (cm)			Root to Shoot Ratio		Green Weight (gm)			Dry Weight (gm)			Plant OC (gm/2gm Sample)		
		Before	After	t Stat	Before	After	t Stat	Before	After	Before	After	t Stat	Before	After	t Stat	Before	After	t Stat
1	Tomato	21.0	62.5	16.71**	5.1	18.2	18.14**	0.24	0.29	5.0	221.0	17.34**	1.1	60.3	22.55**	0.39	0.40	7.06**
2	Brinjal	26.7	78.1	28.04**	5.4	24.5	33.7**	0.20	0.31	8.3	239.0	11.42**	4.0	72.8	23.25**	0.40	0.42	5.47**
3	Chilli	26.9	56.0	9.25**	8.1	18.9	6.02**	0.30	0.34	10.5	115.5	39.37**	2.9	30.3	14.65**	0.39	0.42	3.19*
4	Ridge Gourd	24.0	126.7	41.39**	3.5	19.9	17.99**	0.14	0.16	3.4	207.0	32.59**	0.7	30.9	37.38**	0.46	0.51	6.57**
5	Bottle Gourd	22.1	161.2	44.71**	3.7	35.6	27.07**	0.17	0.22	10.2	243.0	13.66**	2.6	38.1	11.68**	0.40	0.45	39.21**
6	Bitter Gourd	18.3	122.8	30.32**	4.2	21.3	24.2**	0.23	0.17	4.2	168.5	9.84**	1.4	44.1	14.23**	0.06	0.07	6.92**
7	Field Bean	11.9	71.8	42.72**	4.5	24.9	42.84**	0.38	0.35	2.6	190.0	13.49**	0.7	63.0	13.02**	0.42	0.50	52.92**
8	Cabbage	11.4	26.0	14.56**	4.3	7.2	6.69**	0.38	0.28	8.3	107.0	13.68**	1.7	23.8	11.81**	0.46	0.47	3.87**
9	Cauliflower	12.8	35.6	15.46**	3.3	16.6	21.6**	0.26	0.47	7.4	145.5	13.33**	1.7	31.8	12.92**	0.40	0.45	32.12**
10	Onion	26.2	46.7	8.44**	1.3	4.0	3.77**	0.05	0.09	5.0	37.9	15.58**	1.9	19.0	25.36**	0.19	0.20	5.57**

Note: * - 5% level of significance
** - 1% level of significance
NS - Non-significant

Table No. 3 Measurement of carbon content from the agricultural plant biomass

Sr. No.	Name	Botanical Name	Family	Type	Mulching type	Carbon Content (kg/ha)		CO_2 Sequestration (kg/ha)	
						Before	After	Before	After
1	Tomato	*Solanum lycopersicum L*	*Solanaceae*	C3	Plastic	3.479	195.62	12.76	717.20
2	Brinjal	*Solanum melongena*	*Solanaceae*	C3	Plastic	9.671	181.56	35.46	665.64
3	Chili	*Capsicum annuum*	*Solanaceae*	C3	Plastic	9.173	100.75	33.63	369.40
4	Ridge Gourd	*Luffa acutangula L*	*Cucurbitaceae*	C3	Plastic	1.963	95.86	7.20	351.44
5	Bottle Gourd	*Lagenaria siceraria*	*Cucurbitaceae*	C3	Plastic	6.326	104.29	23.19	382.35
6	Bitter Gourd	*Momordica charantia*	*Cucurbitaceae*	C3	Plastic	0.693	25.04	2.54	91.79
7	Field Beans	*Vicia faba*	*Fabaceae*	C3	No Mulching	2.384	255.47	8.74	936.65
8	Cabbage	*Brassica oleracea*	*Brassicaceae*	C3	Plastic	6.940	102.06	25.44	374.19
9	Cauliflower	*Brassica oleracea*	*Brassicaceae*	C3	Plastic	5.353	116.06	19.62	425.50
10	Onion	*Allium cepa*	*Amaryllidaceae*	C4	No Mulching	80.222	844.44	294.12	3095.99

The Table 3 shows botanical name, types of crops, mulching type and the total CO_2 Sequestration (kg/ha) from the plant biomass of different crops at the time of sowing and at the time of harvesting.

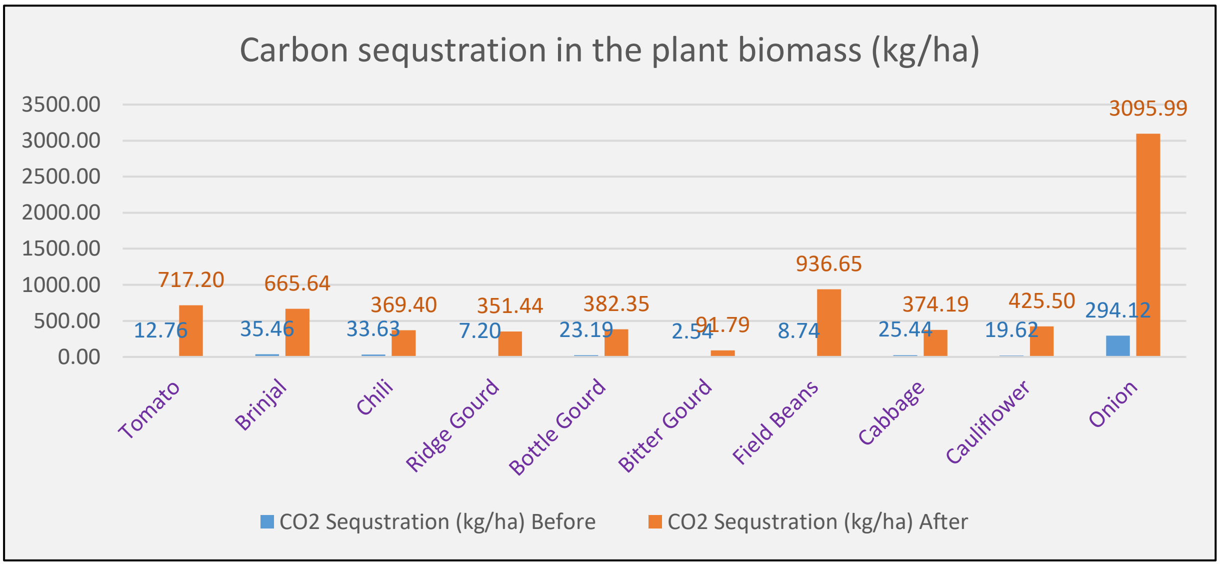

Fig. No. 2 Measurement of total carbon sequestration through the plant biomass

The Fig. 2 shows measurement of carbon sequestration from the agricultural plant biomass of different crops. It is shows that at the time of harvesting total carbon sequestration from plant biomass in onion crop is highest (3095.99 kg/ha) and lowest in bitter gourd crop (91.79 kg/ha).

CONCLUSION

1. The amount of carbon sequestration by the plant is higher in onion plant (3095.99 kg/ha) and lowest in bitter gourd (91.79 kg/ha). This is because no of plants per hectare is higher in onion crops due to less crop spacing.
2. The plant to plant spacing and row to row spacing is very low in the onion crop than other crops, due to that number of plants per hectare is higher in onion crops. It is shows that the amount of carbon sequestration by the plant is depend on the number of plants per hectare.

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