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Carbon Dioxide Sequestration Potential of Rice (*Oryza Sativa*) Plant

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Abstract

Carbon dioxide (CO_2) is a naturally occurring component of the atmosphere, comprising approximately 0.04% of atmospheric gases. In recent years, increasing atmospheric CO_2 has received significant attention because of its potential influence on global climate patterns. Anthropogenic activities, including industrialization, deforestation, forest degradation, and fossil fuel combustion, have contributed to increased atmospheric carbon levels and disrupted the global carbon cycle. Plants play an essential role in this cycle by serving as carbon sinks in terrestrial ecosystems. Carbon stored in plants is largely represented by their biomass, with above-ground biomass constituting a major portion of the terrestrial carbon pool. Estimating plant biomass is therefore important for determining carbon storage capacity and assessing carbon loss associated with deforestation. This study investigated the above-ground biomass and carbon dioxide absorption of rice plants, particularly their stems and leaves, and compared carbon capture during the vegetative and reproductive stages. The study was conducted in the Water Quality Analysis Laboratory using 21 samples of rice plant stems and leaves. Results showed that the leaves absorbed more carbon dioxide (0.74739 kg) than the stems (0.64011 kg), which may be attributed to the leaves' primary role in photosynthesis and their greater availability of materials required for the process. The findings also revealed that rice plants captured a higher average amount of CO_2 during the vegetative stage (66.071 g) than during the reproductive stage (27.407 g). These results demonstrate the significant contribution of rice plant biomass, particularly leaves, to carbon sequestration and emphasize the importance of understanding carbon storage across different growth stages.

Keywords

Carbon dioxide, Carbon dioxide sequestration, above-ground biomass, Oryza sativa

1. Introduction

Carbon dioxide (CO2) gas is one of the largest contributors for the increasing of the greenhouse gas levels in the atmosphere and is considered to be the main cause of global warming. Over the past centuries, its concentration in the atmosphere has greatly increased, mainly because of human activities such as fossil fuel burning (Yang et. al. 2008).

The change in climate has affected our economy, health and communities in many ways. In recent years, Philippines, which has long been vulnerable to extreme weather, has suffered from even more violent

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storms like Typhoon Yolanda. Over the past decade, these tropical storms have struck the nation more often and more severely, scientist believe, because of climate change (NASA, 2016).

Abang et. al. cited several methods to reduce CO2 emission in the atmosphere. The first method would require efficient use of energy, the second one requires switching to using of non-fossils fuels such as hydrogen and renewable energy and the third one would be the continuous planting of plant and trees.

Plants and trees are important route for CO2 to move from atmospheric gas to solid form. Plant accumulates more carbon dioxide than the atmosphere and play an important role in global carbon cycle. Lasco et.al. (2000) revealed that carbon is stored in a plant's biomass and in soil that helps protect natural carbon sinks through the improvement of land productivity. Carbon dioxide (CO2) is taken up from the atmosphere during the growing season of vegetation and stored as a plant biomass (Losi, et.al. 2003).

Forests and stable grasslands are referred to as carbon sinks because they can store large amounts of carbon in their vegetation and root systems for long period of time (EPA, 2008b). Plants vegetation takes up the carbon dioxide in the process of photosynthesis. In this natural process, it removes the carbon dioxide from the atmosphere and stores the carbon in the plant tissues, forest litter and soils. Thus, plants ecosystem plays a very important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere (Vashum et. al., 2012).

As of today, we are experiencing sudden change of climate due to the increase production of CO_2 into the atmosphere which was caused by human activities like burning fossil fuels such as coals, oils and gas. Rice as plant, is one of the major crops that the province of Zamboanga del Sur have cultivated. It is one of the plants that grows faster and has the capacity to undergo tillering, enabling the plant to produce multiple stems and leaves necessary for capturing carbon dioxide from the atmosphere (Bell et. al., 1991). It is imperative to study the carbon dioxide sequestration potential of rice (*Oryza sativa*) plant as it plays an important role in the reduction of carbon dioxide (CO2) concentration in the atmosphere which is the major cause of global warming.

This study aims to determine the carbon dioxide captured potential of rice (*Oryza sativa*) plant. It seeks to answer the following:

1. What are the biomass properties of rice plant such as dry matter content and organic matter content during vegetative and reproductive stage?

2. How much is the carbon dioxide captured by the rice plant in its leaves and stems?

3. In what part of the rice plant's above ground biomass capture more carbon dioxide?

4. In which growth stages does the rice plant capture more carbon dioxide?

2. Methodology

The researchers used the descriptive-quantitative design based on the plant's above-ground biomass; stem and leaves. The collection of samples of the study was conducted at Zamboanga del Sur, Philippines and the laboratory activities were carried out in the Water Quality Analysis Laboratory located at Zamboanga del Sur.

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On the collection of samples for the laboratory analysis, a 1,500 g of leaves, and 1,500 g of stems were considered. Rice samples were gathered, described and quantified in terms of its dry matter and organic matter content. Its weight was determined using the weighing scale.As suggested by Walker et.al, 1993, the collected fresh samples were weighed and subjected to oven drying at 100 degrees Celsius within 24 hours. After drying, dried samples from the oven were weighed again to calculate the dry and organic matter content. The samples were placed in an improvised furnace for combustion. After burning, the ashes were weighed using analytical balance in order to compute for the organic matter content of the leaves and stem.

To get the biomass of the leaves and stem, the following formula were used based on the fresh weight and dry weight of the samples:

$$\text{Moisture Content (\%)} = \frac{\text{Fresh Weight} - \text{Dry Weight (oven)}}{\text{Fresh Weight}} \times 100$$

$$\text{Organic Matter Content (\%)} = \frac{\text{Dry Weight} - \text{Ash Weight (furnace)}}{\text{Dry Weight}} \times 100$$

$$\text{Dry Matter Content (\%)} = \frac{\text{Dry Weight}}{\text{Fresh Weight}} \times 100$$

To know the value of carbon content, the difference between the dry weight and ash weight were multiplied by 0.496 which was taken from the estimate of Aerts and Ragland (1991) where the percentage of carbon from the organic matter (97.75%) is 48.5. Hence, the value of 0.496 was known through the percentage of carbon divided by the organic matter (%). The formula is:

$$Carbon\ content = [dry\ weight\ (g) - ash\ weight\ (g)\ x\ 0.496]$$

To estimate the carbon dioxide captured by the plant, the weight of carbon content in a plant was multiplied with 3.6663 (since the atomic weight of carbon is 12. 001115, atomic weight of oxygen is 15.9994 and the weight of CO2 is C + (2x0) = 43.99915, thus the ratio of CO2 is 43.999915/12.001115 = 3.6663).

The actual data from the field and laboratory analysis was used to estimate the carbon dioxide captured of a rice plant with the use of some parameters such as aboveground biomass, moisture, organic and dry matter content. Computer program (Microsoft Excel Statistical Function) was used to aid in the analysis of data gathered.

3. Results and Discussion

The percents MC, DM and OM from the stem and leaves of rice plant on its vegetative and reproductive stage are illustrated in Table 1 and Table 2. Table 1 shows the data on the vegetative stage of rice. In the vegetative stage, the average MC of the plant ranges from 83.43% - 84.03% with DM content of 15.97% - 16.57% and OM of 64.66%- 65.17%. Among the two (2) parameters (stem and leaves) considered in the study, the stem appeared to have higher MC (84.03%) compared to leaves (83.43%). In terms of percent OM content of the plant, leaves are higher (65.17%) than the stem (64.66). The percent DM content of the samples indicated 16.57% in the leaves which is higher than the stem that has 15.97%.

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Table 1. Above-ground Biomass of Rice on its Vegetative Stage

	Stem			Leaves		
Sampling Period	%MC	%DM	%OM	%MC	%DM	%OM
1	83.00	17.00	62.35	84.10	15.90	72.33
2	83.10	16.90	68.05	84.00	16.00	62.50
3	86.00	14.00	63.57	82.20	17.80	60.67
Total	252.10	47.90	193.97	250.3	49.7	195.5
Mean	84.00	15.97	64.66	83.43	16.57	65.17

*fresh weight basis

**dry weight basis

***average value for %MC, %DM and %OM based on three (3) samples each from stem and leaves in a given sampling

On the other hand, in the reproductive stage of rice, as shown in Table 2, the average MC of the rice plant ranges from 62%-68.67%, with the OM content of 72.07%-74.76% and DM content of 31.33%-38%. In this stage, the result is the same with the vegetative stage in which the stem has the higher MC (68.67%) compared to leaves (62%). In terms of the percent OM content, stem with 74.76&% is higher than the leaves which has 72.07%. With regards to percent DM, the leaves appeared higher (38%) than the stem (31.33%).

Table 2. Above-ground Biomass of Rice on its Reproductive Stage

	Stem			Leaves		
Sampling Period	%MC	%DM	%OM	%MC	%DM	%OM
1	70.00	30.00	72.67	59.00	41.00	72.68
2	65.00	35.00	77.14	65.00	35.00	71.43
3	71.00	29.00	74.48	62.00	38.00	72.11
Total	206.00	94.00	224.29	186.00	114.00	216.22
Mean	68.67	31.33	74.76	62.00	38.00	72.07

*fresh weight basis

**dry weight basis

***average value for %MC, %DM and %OM based on three (3) samples each from stem and leaves in a given sampling

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Table 3. Carbon Dioxide Captured by the Rice Plant (n=30)

	Vegetative Stage				Reproductive Stage			
Plant Part	g Carbon		g Carbon Dioxide		g Carbon		g Carbon Dioxide	
	Average	Total	Average	Total	Average	Total	Average	Total
Stems	10.98	76.88	40.27	281.86	24.94	174.59	98.59	690.11
Leaves	11.44	80.10	41.95	293.68	29.12	203.05	106.77	747.39
Total	22.42	156.98	82.22	575.54	54.06	378.44	205.36	1,387.50
Mean	1.068	7.475	3.915	27.407	2.579	18.021	9.779	66.071

Comparing the two growing stages of the rice plant, (vegetative and reproductive) observed in this study, reproductive stage of rice is higher than the vegetative stage in terms of OM content and DM content but is lower in terms of MC. The OM content of the rice plant on its reproductive stage is 9.82% and 6.9% higher than the vegetative stage on its stems and leaves respectively. In terms of DM content, the difference is 15.36% in the stem and 21.43% in the leaves. However, in terms of MC, the vegetative stage is 15.36% (stem) and 21.43% (leaves) higher than the reproductive stage of rice. This observed difference is due to the age of the plant. Moisture content decreases as the age of rice increases (Kurosu et.al., 1995).

The Carbon dioxide captured by the leaves and stem of the rice plant has the total amount of 575.54g (=0.58 kg) for the vegetative stage and 1, 387.5 g (=1.39 kg) for the reproductive stage as presented in Table 3. Among the parts of the plant considered in this study, the leaves accumulates higher amount of CO2 which is equivalent to 293.68g with an average of 13.98 g (= 0.01398 kg) in the vegetative stage and 747.39 which is equivalent to 35.40g (= 0.0354 kg) in the reproductive stage while the stem have 13.42g (=0.01342kg) in the vegetative stage and 32.86g (=0.03286kg) in the reproductive stage.

4. Conclusion

Comparing the two stages, the rice captures more carbon dioxide during its reproductive stage. With the data given, the amount of CO2 captured by the rice during its reproductive stage is about 811. 96g (= 0.81196kg) higher than its vegetative stage.

This data implies that even if how tiny the rice plant is, it still absorbs considerable amount of carbon dioxide from the atmosphere that contribute in the reduction of CO2 concentration in the atmosphere. Otherwise, rice plants accumulate more CO2 than the atmosphere and play an important role in global carbon cycle (Losi et. al., 2003). It is important to note that rice farming does not only help the world's economy but also it gives a great contribution to the environment.

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