The Investigation of Biomass Production and Soil Carbon Storage of Pangola grass Under Fertilization and Mowing Management Practices

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Abstract

In 2010, Food and Agricultural Organization of the United Nations stated that the grassland could be the option in releasing climate change and fixing the carbon dioxide. In order to carbon dioxide fixation in Taiwan's grassland, this research focused on the fertilization and mowing management of Pangola grass in Taiwan. The responses of biomass quantity and soil organic carbon change of the Pangola grass grassland were investigated. Different Nitrogen quantity (90,120 and 150kg/per year per ha) and mowing frequency (4,5,6 annual) of forage managements were used as treatments in field experiment. The forage heat values, soil organic carbon content, biomass quaintly, and carbon biomass analysis were investigated. There was significant difference on mowing frequency of biomass response. Mowing 4 and 5 times per year yielded 48.3 and 53.9 ton (per ha) were significantly higher than mowing 6 times per year which yielded 20.7 tons (per ha). There is no significant difference among different fertilization treatments on biomass and soil organic carbon. There was also no significant difference among fertilizer treatments on cumulative biomass, but 150kg/ha treatment had the highest biomass quantities. The cumulative soil organic carbon increased with increased mowing frequency. The relationship between the soil organic carbon content and the time period showed significantly positive correlation ($P<0.05$, $r=0.97$). The biomass of the grass was removed each time after mowing in this experiment, which led to the slow soil organic carbon accumulation as compare to the usual grassland data. This research shows that under recommended forage management practice the Pangola grass could be an option in increasing Carbon Dioxide fixation in the grassland.

Keywords: Carbon Dioxide Fixation, Pangola grass, Grass management

Introduction

From the IPCC (Intergovernmental Panel on Climate Change) 2007 Forth AssessmentReport (4AR), the global average temperature and sea level steadily increased in past 50 years. In the IPCC report, the CCS (Carbon Capture and Storage, CCS) technology is suggested to reduce Carbon Dioxide emission. Technologies must be developed to avoid the global warming become worsening [Taiwan Executive Yuan, 2009]. Thus, many countries try to focus the technologies, which can be applied in controlling the Green House Gas emission. Some CCS researches were focused in geological storage, sea storage and plant storage.

From the International Energy Agency (IEA) 2004 perspective, Plant will store the carbon dioxide (CO_2), when it grows [IEA, 2004]. There were some researches focused on forest to fix the carbon dioxide in Taiwan. But less research has been applied to the grassland or forage to fix carbon dioxide. Grass and forage are easy to grow under low fertilizer and water supplement and can quickly establish vegetation in the park, wasteland, pasture and other public areas. Grassland could capture the carbon dioxide in plant and soil via photosynthesis.[Lin C.I and C.H. Hsieh, 2009]。In 2010, Food and Agricultural Organization of the United Nations stated that the grassland could be the option in releasing climate change and fixing the carbon dioxide.

The major functions of forage are the resource of animal feed and leisure usage in Taiwan. There are other functions of forage such as fixing carbon dioxide, increasing soil carbon tank and fertilization, reducing the heat radiation and supplying the energy. [Fang, 1992; Huang and Sheng 2006; Hang, 1999; Su, 1993]。Those functions could help to release the increasing serious Green House effects.

Material and Methods

Most of the *Gramineae* species can grow well under the low fertility and with relative low maintain cost, which will help to control the bio-energy feedstock production input [3]. It is estimated that total planting acreage of Pangola grass is around 6000 ha in Taiwan. Pangola grass is the major perennial forage for the dairy use in Taiwan [4]. It is applied daily and provides nutrition, protein, and vitamin for the animal use. Forage also plays an important role in the soil recover, biodiversity, leisure use, micro-climate adjustment. Pangola grass is native in Africa, a semi-erect with creeping habit growth, high density, and well digestibility grass. Taiwan imported it from Hawaii and Philippine. Pangola grass show well adaptation to the high temperature, high moisture and long sunshine of Taiwan climate. The annual dry Pangola grass biomass is around 20-25 tons. Because Pangola grass has high carbohydrate quality, it is good for the dairy application. Pangola grass could reach 100 cm height.

Pangola grass (A254)(*Digitaria decumbens Stent*) was used as plant material in this experiment. The grasses were planted in the 2X3 m($6m^2$) sandy soil. The forages were fertilized in three different quantities for grassland management Nitrogen (90,120 and 150kg/per year per ha) The annual mowing frequency for for Pangola grass were 4, 5, 6 times. The combination of fertilization rate and mowing frequencies were tested. Each unit treatment was replicated 3 times. The experimental design was a factorial experiment in Replicated Complete Block Design (RCBD).

For the evaluating the soil organic carbon content, soil samples were collected every 6 months.

The sampled soil column was 20cm under the surface in each area. The biomass of each sample was collected after mowing (Pangola grass at 10cm height). For checking the moisture content, the fresh biomass was dried in oven for 24 hours in 70°C. The soil organic carbon content, soil nitrogen content, biomass carbon content, biomass nitrogen content and biomass cellulose content ratio of 54 experimental units were investigated.

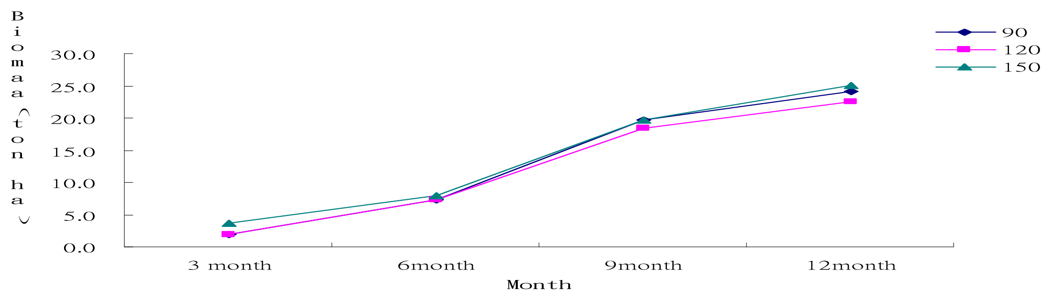
Results

The date of the experiment was collected and analyzed for the past 15 months. The data included forage heat values, soil organic carbon content, biomass quaintly, biomass analysis in carbon and nitrogen content. After 15 months, there was significant difference on mowing frequency of biomass response. From the Table 1, it showed that there were no significant differences on heat values of the fiber between, before and after management practice.

Table 1: The heat values under different management practices

Forage	HV before Management (Kcal/Kg)	HV after Management (Kcal/Kg)	HV change (Kcal/Kg)
N 90kg/ha	3916	3877	-39
N 120kg/ha	3943	3958	15
N 150kg/ha	3996	4006	10

There was no significant differences among fertilizer treatments on cumulative biomass, but 150kg/ha had the highest biomass quantities. There were no significant differences among fertilizer treatments along with soil organic carbon. The cumulative soil organic carbon of each treatment increased by time (Figure 1b). The relationship between the soil organic carbon content and the time period was positively significant correlated ($r=0.97$ $P<0.05$)(Figure 2). The biomass of the grass was removed each time after mowing, which made slow soil organic carbon accumulation as compare to the usual grassland data.



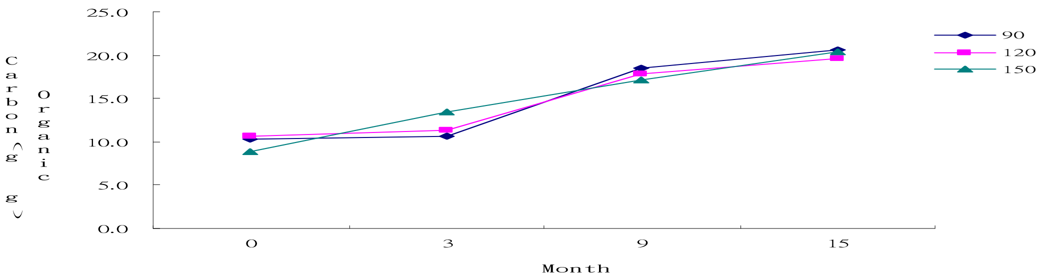


Figure 1a： Cumulative biomass (every 3 months) under different N treatments

Figure 1b：Change of fertilizer and soil organic carbon under different N treatments

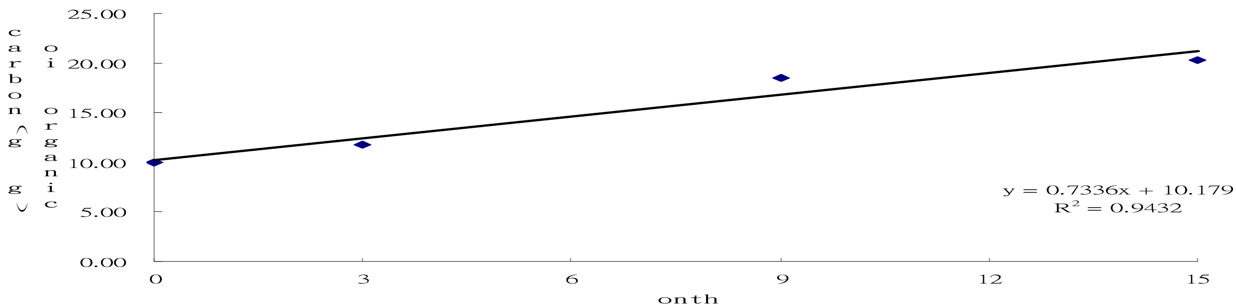


Figure 2: The correlation test between soil organic carbon content and time of experiment.(r=0.97,p<0.05)

Significant differences were found among mowing frequencies on the cumulative biomass. The cumulative biomass of the mowing 4 or 5 times per year was significantly more than 6 times per year. (Table 2) However, there were no significant differences among mowing frequency treatments on soil organic carbon. But the low mowing frequency (4 times/year) showed higher trend of soil organic carbon content.

Table 2：The influence of soil organic carbon and total cumulative biomass under difference mowing frequency

Mowing Frequency	Cumulative biomass (Ton/ha)	Soil Organic Carbon(g/Kg)	
		9th month	15th month
4	25.32 a*	18.53a	20.66a
5	27.29 a	17.82a	19.56a

6	19.19 b	17.11a	20.40a

*：The difference alphabet in the small row means the average of treatment not reach 5% level significance difference.（L.S.D.）

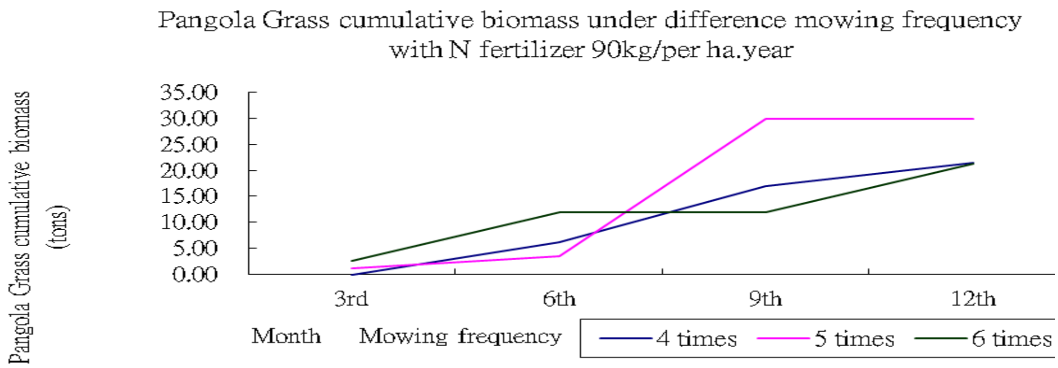


Figure 4: Pangola Grass cumulative biomass under difference mowing frequency with N fertilizer 90kg/per ha.year

Figure 4 and 5 showed mowing frequencies influence the Pangola grass cumulative biomass ay various N treatments. Under different rate of N applications(120 and 150kg/ha), mowing 6 times per year all had the least cumulative biomass. And mowing 5 times per year showed highest cumulative biomass, but was not significantly different from mowing 4 times per year.

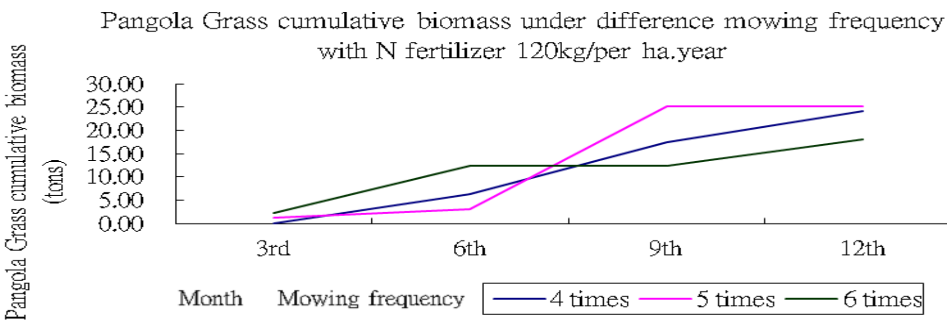


Figure 5: Pangola Grass cumulative biomass under difference mowing frequency with N fertilizer 120kg/per ha.year

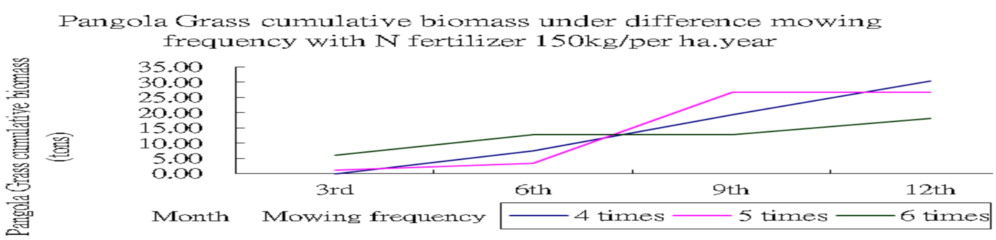


Figure 6: Pangola Grass cumulative biomass under difference mowing frequency with N fertilizer 150kg/per ha.year

Discussion

From the results of 15 months experiment showed that, Pangola grass could store the organic carbon in the soil when it grows. After conversion of yield mowing 4 and 5 times per year yielded 48.3 and 53.9 ton (per ha) as compare to 20.7 tons (per ha) in mowing 6 times per year. There were no significant differences among fertilizer treatments on cumulative biomass, but 150kg/ha treatment had the highest biomass quantities. The cumulative soil organic carbon increased with increased mowing frequency. The relationship between the soil organic carbon content and the time period showed significantly positive correlation ($P<0.05$, $r=0.97$). In Taiwan the biomass of the grass was removed as common practice for forage feed each time after mowing in this experiment, which led to the slow soil organic carbon accumulation as compare to the usual grassland data. Comparing the previous research on the *Phragmites communis* carbon reserve in the wetland, the organic carbon content of 0-20cm soil was 95.3g/kg[Chen and Hsu, 2008]. This research showed the 0-20cm soil organic carbon of Pangola grass was 20g/kg. However,this research indicated that under recommended forage management practice of the Pangola grass it still could be an option in increasing Carbon Dioxide fixation in the soil in the long run.

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