

The Effect of Nitrogen Fertilizer on Carbon Sequestration of Some Rice Varieties in Paddy Fields, Thailand

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Abstract: This research studied the carbon sequestration of the photo-insensitive rice 2 varieties in the irrigated paddy fields within the central plain. In the sample mixed nitrogen fertilizers contents were applied. The samples were collected during growth stages. The evaluation of carbon contents in the plants was done from the biomass. In addition, carbon contents in soils were studied in soil organic carbon. It was found that the average carbon contents during all seasons of SPR1 and CNT1 cultivation were 9,282.38 and 9,067.01 kg/rai, respectively. Both rice varieties responded best to mixed nitrogen fertilizer 18 kg N/rai. SPR1 had the highest carbon storage rate during the booting stage which was 38.38 kg/rai-day, while the CNT1 had the highest carbon storage rate during the tillering stage which was 32.64 kg/rai-day. The SPR1 variety

demonstrated a higher leaf color value than CNT1 variety and was directly related to the rate of mixed nitrogen fertilizer. The sample soil properties changed according to growth stages of the rice. However, rice varieties and mixed nitrogen rate had no effects on the paddy soil properties.

Keywords: Carbon sequestration, Paddy field, Rice varieties, Nitrogen fertilizer.

Introduction

Climate change forces have led to global warming which is caused by greenhouse effect phenomena [1]. Carbon dioxide gas is the most important greenhouse gas [2]. Although it is claimed that a paddy field is a source of methane gas (CH₄) in the atmosphere [3], it is a CO₂ storage source by plant and soil carbon sequestration mechanism. Variety of rice is an important factor that affects more yields and more carbon storage [4]. Besides, nutrient is also a factor to enhance the number of product, especially nitrogen, important for photosynthesis process of plants, which affect the increasing of carbon storage [5]. If these factors were well managed in paddy fields that are appropriate for carbon sequestration, it could efficiency decrease CO₂ from the atmosphere. UNFCCC stated about the carbon credit trading process that turns carbon sequestration to be “carbon commodity” for a carbon trader country [6]. In addition, farmers could utilize the gained knowledge on carbon sequestration to increase farm income and crop yields.

Methodology

The carbon sequestration in paddy fields was studied on the photo-insensitive rice 2 varieties, Suphan Buri 1 (SPR1) and Chai Nat 1 (CNT1) that applied mixed nitrogen fertilizer at 4 difference rates, 12, 18, 24 and 30 kg N/rai. The carbon storage was studied at 3 different stages: tillering stage, booting stage and maturing stage by the investigation of carbon content in plant and soil. The evaluation of carbon contents in the plants was done by collecting the biomass of the plant both above ground and below ground, and the samples were oven dried at 70°C for 72 hours in order to find the dry weight of the plant. Then the biomass was multiplied by carbon coefficient values of plant biomass using the total organic carbon analyzer (TOC) [3]. In addition, organic carbon contents within the soils were analyzed by the Walkley and Black method (1947) claimed in [7]. Besides, SOC was studied before an experiment in order to know the carbon storage in soil before cultivation. The results of plant and soil properties of each rice cultivation experiments were compared. The results were analyzed by mathematical equation and using a statistical program.

Results and Discussion

Plant-carbon content in above ground, below ground and the sum carbon content of SPR1 were higher than those of CNT1 throughout growth, see Table 1. This was because of the influences from height [8, 9 and 10], seed [8] yield [8, 11-12] characteristics and

suitable environments [8]. The plant-carbon content of two varieties was significant. For soil-carbon content, SPR1 were also higher than those of CNT1. This was because SPR1 had more root biomass than CNT1 which affected the activities of soil microbes surrounding the roots [13].

Table 1. Carbon content in paddy field.

Growth stage	Variety	Carbon content (kg/rai)				
		Plant			Soil	Total
		Above ground	Below ground	Sum		
Tillering	SPR1	168.12	102.78	270.90	8,841.52	9,112.42
	CNT1	157.14	88.27	245.41	8,966.80	9,212.21
Booting	SPR1	449.15	137.66	586.81	8,900.38	9,487.19
	CNT1	432.95	129.48	562.42	8,512.08	9,074.50
Maturing	SPR1	689.38	134.25	823.62	8,423.92	9,247.54
	CNT1	634.86	103.79	738.65	8,175.68	8,914.33

Plant-carbon content at booting and maturing stages in each fertilizer rate were significant. Highest carbon content of both varieties was observed when applied with fertilizer rate 18 kg N/rai as shown in Figure 1 and 2. When increasing mixed nitrogen fertilizer rate, it was found that carbon content decreased [14, 15].

Figure 3 illustrates the responsiveness of carbon content to mixed nitrogen fertilizer rates in a quadratic manner: $y = -ax^2+bx+c$.

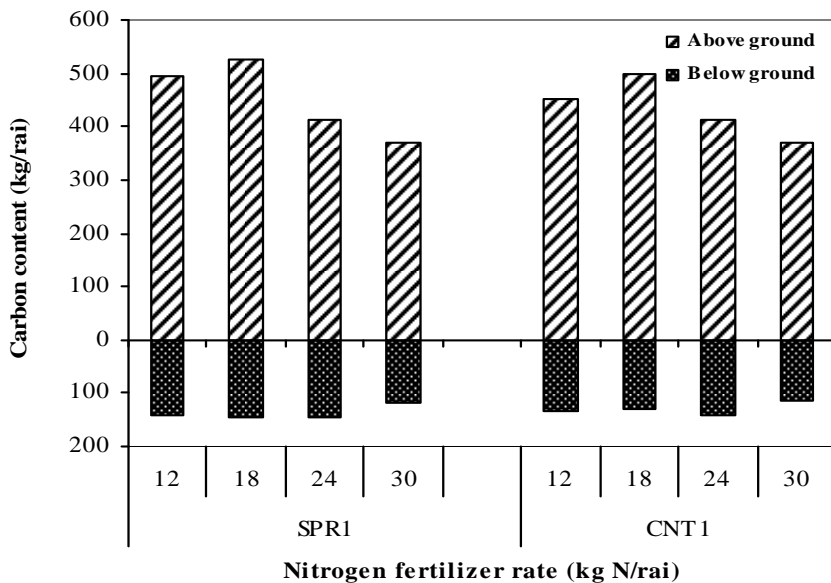


Figure 1. Carbon content of plant in booting stage.

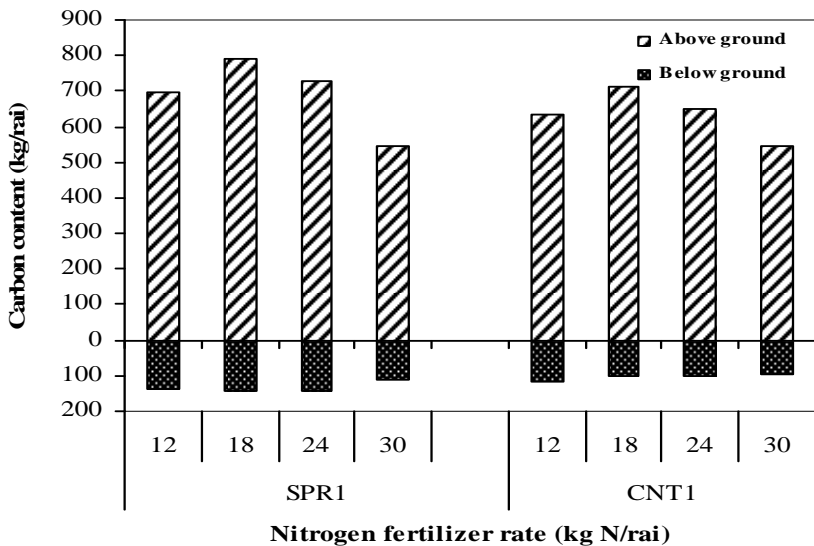
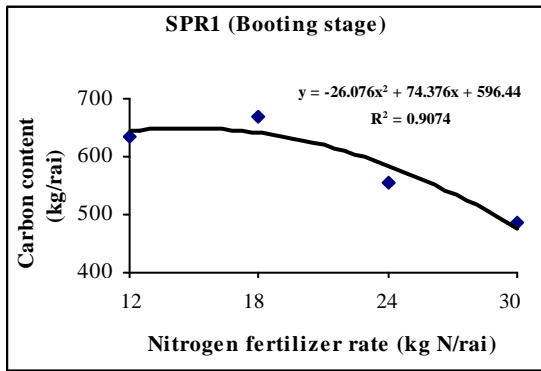
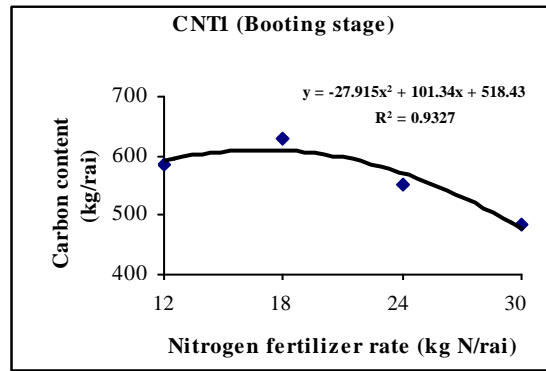


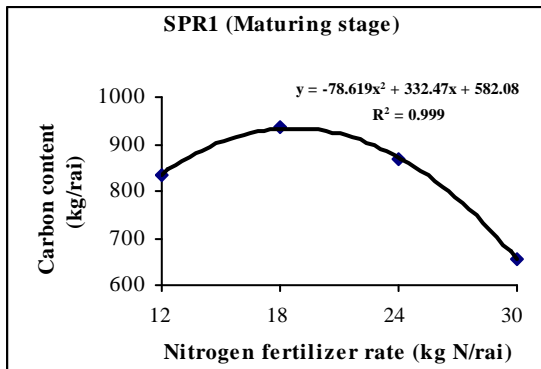
Figure 2. Carbon content of plant in maturing stage.



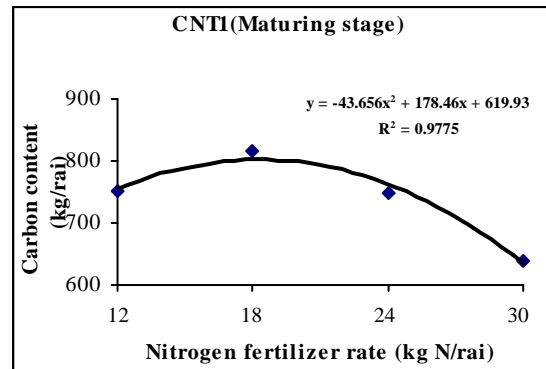
(a)



(b)



(c)



(d)

Figure 3. Responsiveness of each rice variety to fertilizer rate (a) SPR1-Booting stage, (b) CNT1-Booting stage, (c) SPR1-Maturing, (d) CNT1-Maturing.

Highest soil-carbon content was observed when applied with fertilizer rate 18 kg N/rai as shown in Figure 4. Soil-carbon content in each fertilizer rate was not significant. Microbes are more related to content of soil organic carbon than N [16].

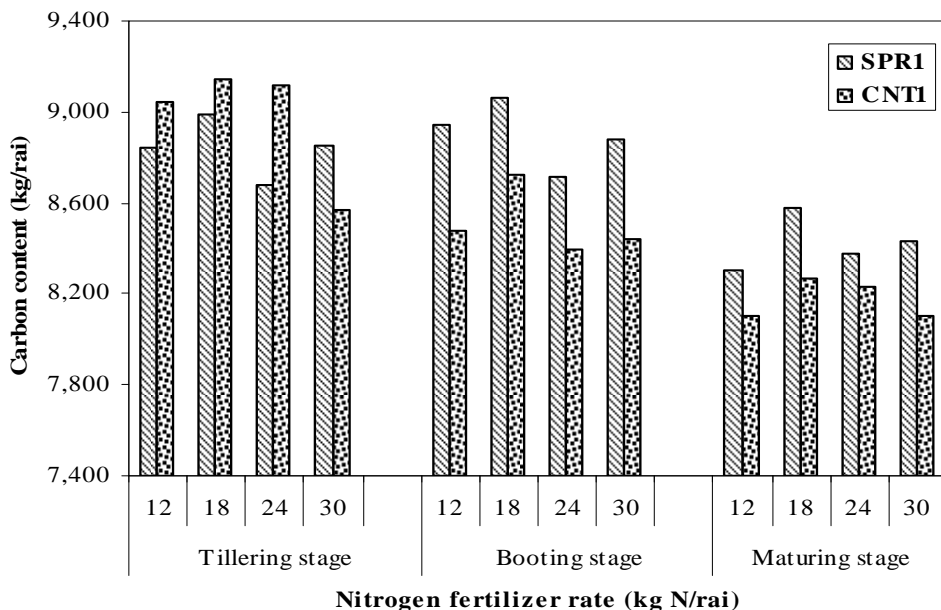


Figure 4. Carbon content of plant in each stage.

Plant-carbon storage rate of above ground reached highest level during booting stage, see Table 2. This was the result of complete growth in vegetative phase preparation for reproduction phase [17]. Moreover, photosynthesis rate and CO₂ absorption rate in SPR1 and CNT1 occurred mostly during booting stage [12]. Root growth occurred mostly during tillering stage and declined until maturing stage (Table 2) [11,17]. SPR1 showed the highest rate of soil-carbon storage during booting stage while CNT1 showed the highest rate during tillering stage. This was influenced by rice varieties which affect root characteristics [13].

Table 2. Carbon storage rate in paddy field.

Variety	Growth stage	Carbon storage rate (kg/rai-day)				
		Plant			Soil	Total
		Above ground	Below ground	Sum		
SPR1	Tillering	4.20	2.57	6.77	23.37	30.15
	Booting	8.63	1.36	9.99	28.39	38.38
	Maturing	6.86	-0.10	6.76	14.78	21.54
CNT1	Tillering	3.93	2.21	6.14	26.51	32.64
	Booting	8.44	1.49	9.93	17.30	27.23
	Maturing	5.77	-0.73	5.04	7.69	12.72

It could be concluded from the two methods of SPAD and LCC that rice varieties were significant. This was the result of variety characteristics and environmental surroundings [8]. Although leaf color in different fertilizer rate was not significant, the value of leaf color tended to coincide with the fertilizer rate. The estimation of rice leaf color of both methods was in direct relationship [18]. The studied soil properties were pH, EC, OC, CEC, TKN, Avai-P and Avai-K. The cause of different carbon storage rate is according to the growth of plant which is different microbes presented in submerged and upland soil [19 and 20].

Conclusions and Recommendations

Rice variety for farmers is the Suphan Buri 1 variety which is good quality rice with high preference both locally and internationally. It meets the market requirements, is highly

productive and has a high tendency for more cultivation in the future. It also has high potential for carbon sequestration.

Farmers should apply the mixed nitrogen fertilizer rate at 18 kg N/rai because the rice can uptake nitrogen best at this rate of fertilizer for its optimal growth, resulting in high productivity and farmers can save much from fertilizers costs. This rate of fertilizer also enables high carbon sequestration in paddy fields.

The carbon storage in the paddy field was estimated as the following equations

$$\begin{aligned} \text{Total Carbon Storage} &= \text{Paddy Field Area} \times \text{Carbon Storage Rate} \\ &\quad \times \text{Rice Cultivation Period} \\ &= \text{Paddy Field Area (rai)} \times 27.11 \text{ kg/rai-day} \\ &\quad \times 120 \text{ days} \end{aligned}$$

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