ผลของการใส่ถ่านต่อความอุดมสมบูรณ์ของดินผลผลิตของข้าวนาลุ่ม ในจังหวัดนครพนม ภาคตะวันออกเฉียงเหนือ ประเทศไทย

Effects of Biochar Amendment on Soil Fertility and Lowland Rice Yield in Nakhon Phanom Province Northeast Thailand

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บทคัดย่อ

ความจำเป็นในการผลิตอาหารเพื่อความยั่งยืนเป็นประเด็นที่สำคัญของโลกเราในปัจจุบัน โดยภาคตะวันออกเฉียงเหนือเป็นแหล่งสำคัญในการผลิตข้าว อย่างไรก็ตาม ผลผลิตข้าวเฉลี่ยต่ำ เนื่องจากดินส่วนใหญ่เป็นดินทรายที่มีความอุดมสมบูรณ์ต่ำ ถ่านเป็นอีกเทคโนโลยีหนึ่งที่กำลังได้รับความสนใจในการปรับปรุงความอุดมสมบูรณ์ของดินอย่างยั่งยืน งานวิจัยนี้มีสมมุติฐานว่า การใส่ถ่านในนาข้าวจะช่วยเพิ่มความเป็นประโยชน์ของธาตุอาหาร และการกักเก็บคาร์บอน และส่งผลให้เพิ่มผลผลิตของข้าว ถ่านที่ใช้ในการศึกษาถูกผลิตจากวัตถุดิบ 3 ชนิดที่แตกต่างกัน คือ ไม้ไผ่, ยูคาลิปตัส และแกลบ ซึ่งมีอยู่ทั่วไปในท้องถิ่น เมื่อใส่ถ่านลงไปในดินทำให้ค่า pH, CEC, total C และ N, K, Ca และ Mg ในดินเพิ่มขึ้น อย่างไรก็ตาม ในกรรมวิธีที่ใส่ถ่านแต่ไม่ใส่ปุ๋ยไนโตรเจนไม่ได้ทำให้ผลผลิตของข้าวเพิ่มขึ้น โดยเฉพาะอย่างยิ่ง ถ่านที่ผลิตจากยูคาลิปตัสเมื่อใส่ลงไปในดินจะทำให้ผลผลิตข้าวลดลง การใส่ถ่านร่วมกับการใส่ปุ๋ยไนโตรเจนที่ระยะข้าวเปลี่ยนตาใบเป็นตาดอก ผลผลิตของข้าวเพิ่มขึ้นเป็น 20%, 42% และ 15% ในถ่านไม้ไผ่ ถ่านยูคาลิปตัส และถ่านแกลบ ตามลำดับ ยิ่งไปกว่านั้น ผลผลิตข้าวไม่มีความแตกต่างทางสถิตระหว่างการใส่ถ่านไม้ไผ่ร่วมกับการใส่ปุ๋ยไนโตรเจนกับการใส่ปุ๋ยไนโตรเจนอย่างเดียวไม่ใส่ถ่าน งานวิจัยนี้จึงแสดงให้เห็นว่า การใส่ถ่านลงไปในดินช่วยเพิ่มความอุดมสมบูรณ์ และประสิทธิภาพในการให้ผลผลิตของดินนาที่ความอุดมสมบูรณ์ต่ำแต่ในถ่านที่มีค่า C/N สูงจะต้องมีการให้ปุ๋ยไนโตรเจนในช่วงเปลี่ยนตาใบเป็นตาดอกให้เพียงพอเพื่อเพิ่มผลผลิตให้สูงขึ้น

คำสำคัญ : ถ่าน / ความอุดมสมบูรณ์ของดิน / ข้าวนาลุ่ม / ผลผลิต

ABSTRACT

The need to increase food production in a sustainable way is one of major challenges facing our world today. In Northeast of Thailand rice is the most important food production system, however, the average yield is low due to the widespread unfertile sandy soils. Biochar is receiving a growing interest as a sustainable technology to improve soil fertility and crop growth. This research hypothesized that biochar amendments to paddy fields will increase soil nutrient availability and C-sequestration and hence increase rice yield. Biochars from three different origins were tested, i.e. bamboo, eucalyptus and rice husk which are commonly available in the region. Biochar soil additions cause increases in pH, CEC, total C and N, exchangeable K, Ca and Mg. However, without fertilizer additions biochar amendments did not improve yield. Particularly, biochar derived from eucalyptus depressed rice grain yield. With N fertilizer application at panicle initialization stage, rice grain yield increased following biochar amendment by 20%, 42% and 15% in bamboo, eucalyptus and rice husk biochar treatments, respectively. Furthermore, rice yields were not significantly different between bamboo biochar with N fertilizer and no-amended biochar with N fertilizer treatments. This study showed that biochar amendments increased the fertility and productivity of poor paddy soils but high C/N ratio biochar types will require adequate N fertilizer application at initiation panicle stage to improved rice grain yield.

Keywords : Biochar / Soil Fertility / Lowland Rice / Yield

Introduction

The need to increase food production in a sustainable way is one of major challenges facing our world today. Thailand is a food surplus country at macro level but food accessibility at the household level remains a problem, particularly in remote rural areas. In Northeast of Thailand rice is the most important food production system, however, the average yield is low due to the widespread unfertile sandy soils. Biochar is receiving a growing interest as a sustainable technology to improve soil fertility, nutrient use efficiency and to increase crop growth and yield (Zhang et al. 2010; Asai et al. 2009). In most paddy fields in Northeast of Thailand, agriculture faces large constraints due to low nutrient contents, limited inputs and accelerated mineralization of soil organic matter. As a consequence, the CEC of the soils, which is often low due to their 1:1 clay mineralogy and sandy nature, decreases further. Application of mulches, composts and manures have frequently been shown to increase soil fertility. However, under tropical conditions soil organic matter is usually mineralized very rapidly and only a small portion of the applied organic compounds will be stabilized in long-term, and successively released as CO_2. An alternative is the use of more stable compounds such as biochar. Biochar is responsible for maintaining high levels of soil organic matter, CEC, pH and available nutrients in anthropogenic soils, as for example shown in the, terra preta' soils in the Amazon. (Norsuwan et al. 2011) found that biochar application at rate 2,560 kg rai^{-1} significantly increased rice tiller and panicle number under lowland rice condition. While currently, several studies on biochar amendments are performed in upland systems, information on its effect on growth of lowland rice and on physical-chemical properties in soils is limited. Hence, the research questions of this research included: i) what are the effects of biochar on growth and yield of lowland rice?, and ii) what are the characteristics of biochar from different plant material on soil fertility and crop productivity? This research hypothesized that biochar will increase nutrient availability and C-sequestration to improve soil fertility and soil properties and hence increase rice yield. Also, the source of biochar material strongly influences the direct effects of biochar amendments on soil organic matter, nutrient content and availability. The objective of this experiment was study the different of biochar quality on growth and yield of rice and its potential of biochar to improve soil fertility and productivity of lowland rice.

Materials and Methods

The glass house experiment was established on paddy soil at Plant Science Section at Nakhon Phanom University, Nakhon Phanom, Thailand. Soil samples were collected from depths of up to 15 cm, and then dried, ground, and passed through a 2.0 mm sieve. 6 kg of ground soil was then put in a plastic pot with an inside diameter of 30 cm and biochars were added to pots in 60 g biochar per kilogram soil. The types of biochar were be used: i) no biochar (control), ii) N chemical fertilizer, iii) bamboo biochar iv) eucalyptus biochar and v) rice husk biochar. The experiment was laid out in a randomized complete block design with 4 replications. Rice seeds will be germinated in background soil for 30 days, and then seedlings were transplanted into each pot. The soils in pots were be kept submerged for the whole growth period. At the beginning, basal fertilizer were be applied at recommended rates of 25 kg P and 30 kg K ha^{-1}. After 45 days after transplanting, they were be fertilized with 3.2 kg N ha-1 to test if biochar can substitute the commonly used basal mineral N fertilizer application at rice transplanting. The plants were be harvest at 30, 60 and 90 days after transplanting and final harvest determined and measurement were be done for plant height, number of tillers, dry weight and nutrient contents. Soils were be sampled from each pot before and after rice transplanting, and dried. Soil samples were be analyzed for chemical properties, i.e. pH, CEC, soil organic matter, total N, extractable P, exchangeable K and Ca.

Table 1 Chemical properties of biochar

Biochar type	pH	Total C	Total N	C/N
		g kg^{-1}		
Bamboo	9.90	545	8.9	61.5
Eucalyptus	9.00	661	5.7	117.3
Rice husk	6.78	307	10.4	29.9
SED	0.04^{***}	17^{**}	1.4^{ns}	7.6^{*}
C.V. (%)	1	3	17	10

*** = Significant different at *P*<0.001 and = significant different at *P*>0.05. not Significant at *P*>0.05

Results

Results from a large pot experiment in the glasshouse revealed that biochar soil additions cause increases in soil pH (from 4.59 to 5.83), cation exchange capacity (CEC; from 3.89 to 9.03 cmol kg^{-1}), total C (from 3.94 to 15 g kg^{-1}), and total N (from 0.46 to 0.46 g kg^{-1}), exchangeable K (from 0.016 to 0.052 cmol kg^{-1}), Ca (from 0.50 to 0.78 cmol k^{g-1}) and Mg (from 0.007 to 0.016 cmol kg^{-1}). However, the C/N ratio of the biochar produced from eucalyptus (117) was higher than those from bamboo (62) and rice husk (30) derived biochars (Table 1). This resulted in lowest rice grain yield (*P*<0.05) when using eucalyptus biochar without fertilizer (7 g $hill^{-1}$) as compared to bamboo (12 g $hill^{-1}$) and rice husk (11 g $hill^{-1}$) biochars without fertilizer (Table 2). In addition, N fertilizer application at panicle initiation stage (PI), increased rice grain yield following the biochar amendments were 20%, 42% and 15% in bamboo, eucalyptus and rice husk biochar treatments, respectively, as compared to treatments without fertilizer application. Furthermore, rice yields were not significantly different between bamboo biochar with N fertilizer and no-amended biochar with N fertilizer treatments (15 g $hill^{-1}$). With regards to the harvest index (HI), however, the no-amended biochar treatment with fertilizer application had a significantly lower HI (0.15) (data not shown), while biochar amendments increased rice harvest index (range 0.32 - 0.40). This suggested that biochar amendment improved soil fertility properties and grain yield in well managed conditions.

Table 2 Effects of biochar application on rice spike numbe and grain yieid

Treatment		Spike number $hill^{-1}$	Grain yield g $hill^{-1}$
- Fertilizer	No-amended	11	10
	Bamboo	10	12
	Eucalyptus	9	7
	Rice husk	10	11
+ Fertilizer	No-amended	25	15
	Bamboo	12	15
	Eucalyptus	10	12
	Rice husk	11	13
SED		3^{***}	2^{*}
C.V. (%)		36	23

*** = Significantly different at *P*<0.001 and^{ns} = not significant at *P*<0.05

Table 3 Effects of biochar application on soil

Treatment	pH	Total N g kg^{-1}	CEC cmol kg^{-1}
No amended	5.18	0.70	1.72
Bamboo	5.68	0.79	4.12
Eucalyptus	5.53	1.36	9.03
Rice husk	5.60	0.88	4.91
SED	0.36^{ns}	0.04***	0.44***
C.V. (%)	6	4	9

*** = Significantly different at P<0.001 and^{ns} = not significant at P<0.05

Discussion and Conclusions

This study suggested that biochar amendments can increase fertility and productivity of poor paddy soils with adequate mineral fertilizer supplementation. However, not all tested biochars were equally suited for soil amendments under low input conditions, e.g. high C/N ratio biochar types like that derived from eucalyptus may suffer from strong N deficiency and need to been supplemented with N fertilizer at initiation panicle stage to improve rice grain yield. The technology needs to be further tested under farmers field conditions before further recommendation can be obtained. The combined use of biochar for energy and soil improvement can be achieved readily, especially because the small-scale biochar production by farmers is a conventional practice in Thailand or Asia and could be used to produce energy and serve to recycle nutrients and maintain or even improve soil fertility where sufficient plant or plant residues are available.

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