Effects of Soil Amelioration on Photosynthetic Physiology and Soil Respiration of Blueberry

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Abstract. The best soil for blueberries is a sandy loam that is well drained and contains lots of organic matter. And soil for blueberries should also be acidic. In order to modify the crop land to be fit for blueberry growth, we added several soil conditioners, peat, manure, commercial fertilizer slag, sawdust, pine needle and fungus, to test the abilities to provide nutrition for blueberry. Results showed that all experimental treatments have a role in promoting the growth of blueberry. Peat adding was proved the best soil conditioner here, that it improved soil organic matter content of 94.86%, raised photosynthetic rate of 96.5%, and enhanced soil respiration rate of 4.8%.

Introduction

Blueberry, also known as cranberry, belongs to family *Ericaceae* genus *Vaccinium*. Blueberry is rich in vitamins, proteins and anthocyanins, which known to be free radical scavenging, anti-aging, and anti-cancer. Blueberry is so called the "21st century functional health berry"[1-2], and listed as one of the five healthiest foods by FAO [3-4].

Blueberry has shallow root system and require low level of nutrients, but has higher requirements for soil conditions. Many previous researches have studied the effects of soil modification [5-6], fertilization [7-8] and physiological characteristics of blueberry [9-10]. Some suggested that peat, sawdust, pine needles, moss, straw, urea and other materials can be used in soil conditioners [11-12]. However, the influence of the soil conditioners on the growth of blueberries is less involved.

This experiment used the combined acceptable materials to modify the soil. The objects were to determine the effects on photosynthetic physiology and soil respiration of blueberry and find a high-quality low-cost soil improvement material applying to south blueberry cultivation.

Materials and Methods

Materials

Experimental land was in Hanyuan, Sichuan, China. Southern high bush cultivation O'Neal was used. Soil conditioners were peat (labeled P), pig manure (labeled PM),

commercial fertilizer (labeled CF), sawdust (labeled S), pine needle (labeled PN),and fungi residues (labeled FR).

Experimental Design

Eight treatments were performed (table 1). All the fields were applied sulfur powder [60kg/ha], pesticides and biocides. Soil conditioners were mixed with original soilat a ratio of 1:1.The soil field without adding any soil conditioner was regarded as the control treatment. Two replicates, which contain 3 plants, were for each treatment. Implemented the soil improvement trial in November 2014, and planted blueberry seedlings one week later.

Table 1. Experimental design

Treatment	Soil improvement programme
Control	original clay
P	peat
CF	commercial fertilizer
CF+P	commercial fertilizer+ peat
PM+P	pig manure+ peat
PM+S	pig manure+ sawdust
PM+PN	pig manure+ pine needle
PM+FR	pig manure+ fungi residues

Note. The treatment with fungi residues applied additional sulfur powder [10kg/acres] to balance the pH.

Data Determination

Soil Nutrient Contents. Took soil samples near Blueberry plants and determined the physical and chemical properties of soil 6 months after soil improvement. The following methods were used: drying method [13] for measuring soil moisture content, potassium bichromate method [14] for measuring soil organic matter content, semi-micro Kjeldahl method [15] for measuring total nitrogen content, HClO4-H2SO4 Colorimetric method [16] for measuring total phosphorus content, NaOH melting method [17] for measuring total potassium content, extraction method [18] for measuring Available P, flame photometry [19] for measuring Available K, and alkaline hydrolysis diffusion method [20] for measuring alkali-hydrolysis nitrogen.

Photosynthetic Parameters Determination. Using the LI-6400XTP portable photosynthesis measuring system to determine the photosynthetic parameters of blueberry plants six months after planted. Measured parameters include Photosynthetic rate (Pn), transpiration (Tr), intercellular CO2 concentration (Ci) and stomatal conductance (Gs).

Soil Respiration Determination. Determined the soil respiration nearby blueberry plants six months after planted, using the LI-6400-09 portable soil respiration measuring system. Measured parameter was soil CO_2 Efflux.

Results

Physical and Chemical Properties of Soil

Soil Water Content. Effects of soil modification on soil water content are shown in the Fig. 1. In the control treatment, original soil without adding soil conditioners, the water content was 32.63%. In the treatments CF, CF+P and PM+S, the water contents were higher than the control. The treatment PM+S showed the maximum water content and PM+FR showed the minimum. It's probably because peat, pine needle and fungus residues have loose structure, which help to increase soil porosity. Results also suggested that peat mixed with commercial fertilizer had better water holding capacity than that using peat solo.

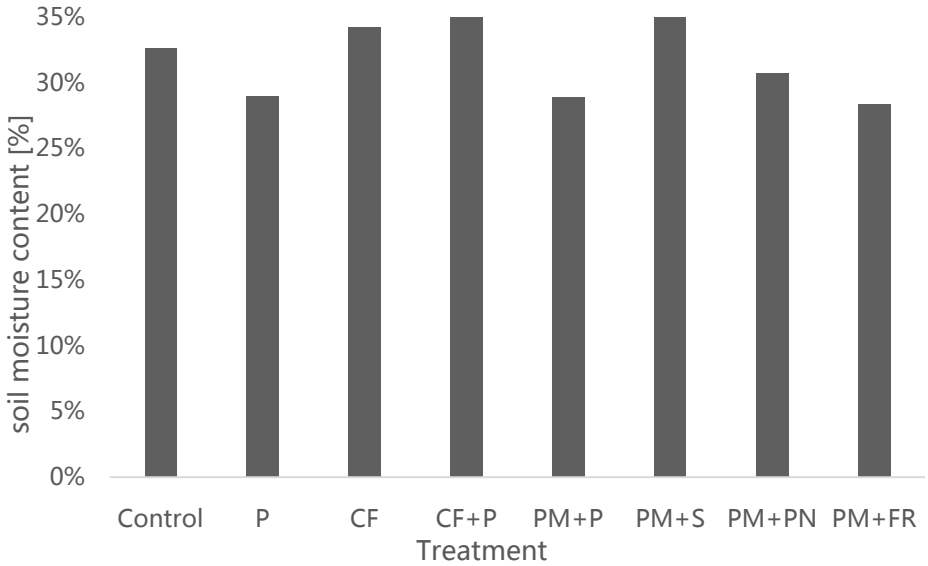

Figure1. Variation of soil moisture content

Soil Organic Matter Content. Effects of soil modification on soil organic matter content are shown in the Fig. 2. Comparing the control, organic matter contents in soil were all increased in the modification treatments. The modification treatment used P+CF improved organic matter content of 59%. The treatments with peat or/and commercial fertilizer had better effects than which with pig manure.

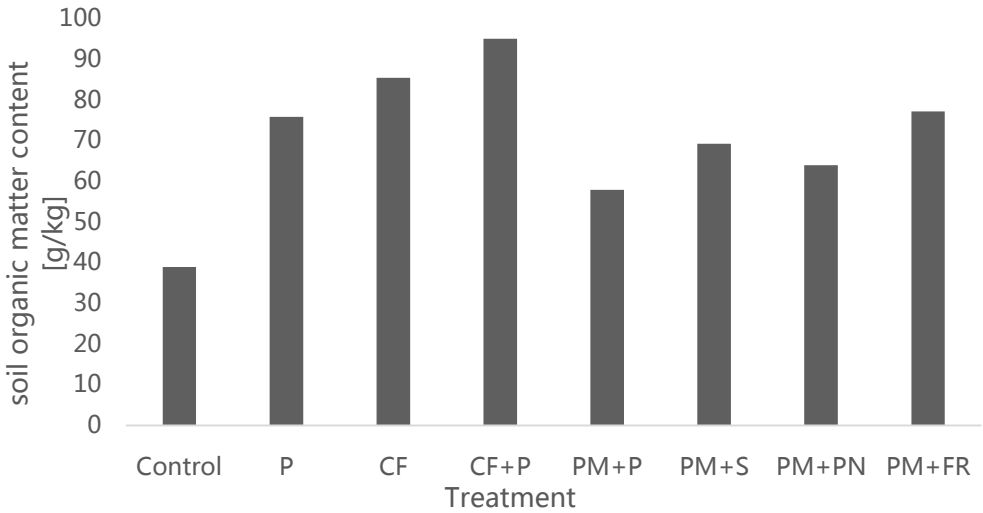

Figure2. Variation of soil organic matter content

Soil Major Mineral Nutrition Content. Effects of soil modification on soil major mineral nutrition content are shown in Table 2. Generally, adding soil conditioners contributed to soil major mineral nutrition content increasing. The results of soil improvement on total nitrogen, total phosphorus, alkali-hydrolysis nitrogen and phosphorus content all showed that the CF+P worked best. It might be due to the sulfur powder applied before soil modifying, which reduced the soil pH, and enhanced assimilation of potassium.

Table2. Variation of soil major mineral nutrition content

Treatment	Total N [g/Kg]	Total P [g/kg]	Total K [g/kg]	A-P [mg/kg]	A-K [mg/kg]	A-h N [g/kg]
Control	0.849d	0.265c	20.274a	12.375d	108.823e	76.924d
P	1.403b	0.354b	10.922c	14.797cd	139.032d	140.098b
CF	0.823d	0.320b	8.155d	19.670c	315.445b	97.552c
CF+P	2.400a	0.632sa	11.023c	50.123a	370.786b	165.207a
PM+P	1.029bc	0.328b	15.654b	49.463a	214.639c	123.695bc
PM+S	1.310b	0.331b	10.461c	34.290b	340.501b	141.004ab
PM+PN	1.293b	0.347b	16.091b	34.348b	315.294b	144.397ab
PM+FR	1.454b	0.324b	15.606b	38.521b	491.700a	106.300c

Soil Improvement on Soil Respiration. The soil respiration represents soil carbon turnover rate and the overall activity of microorganisms reflect, in part, the soil nutrient transformation and supply capacity [21-22]. Soil CO_2 efflux is an important evaluation standard of soil quality and soil fertility. We used the LI-6400-09 to measure soil CO_2 efflux, and the results showed in figure 3.All treatments had varying degrees of increase comparing to the control. The treatment PM+FR has the best effect with 76.25% rise of efflux. In addition, treatments PM+PN and CF also showed great effect.

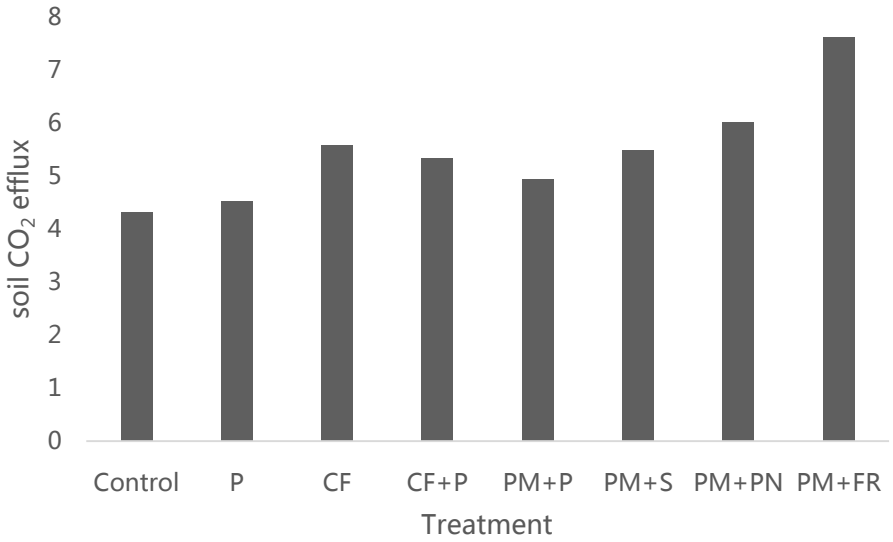

Figure 3. Variation of soil CO_2 efflux

Soil Improvement on Photosynthetic Physiology of Blueberry. Effects of soil modification on photosynthetic physiology of blueberry are shown in Table 3. Photosynthesis of blueberry plants showed significant increase in all soil modification treatments comparing to the control. The treatment using peat showed the best performance, increasing 96.50% of Pn, 86.27% of Gs and 108.91% of Tr, and

reducing 4.12% of Ci. The treatment using CF+P also showed better performance, in which Pn increased 61.73%, Gs increased 64.05%, Tr increased 52.80%, and Ci reduced 10.18%.

Table 3. Variation of photosynthetic parameters

Treatment	Pn [μmol·m^{-2} s^{-1}]	Gs [mmol m^{-2} s^{-1}]	Ci [μmol/mol]	Tr [mmol m^{-2} s^{-1}]
Control	2.770d	0.057d	296.834a	1.282d
P	5.442a	0.106a	284.409ad	2.679a
CF	3.428c	0.07c	272.603b	1.500c
CF+P	4.479b	0.073d	266.619b	1.759b
PM+P	4.242b	0.080b	272.834b	1.806b
PM+S	4.765b	0.086b	234.097d	1.980b
PM+PN	3.850c	0.067bc	257.576bc	1.495c
PM+FR	3.967c	0.060d	241.409c	1.515c

Conclusions

The present research investigated the effects of seven soil modification treatments on soil respiration of blueberry planting lands and photosynthesis of blueberry plants.

The treatment using CF+P (commercial fertilizer + peat) significantly improved the fertility of the soil. As commercial fertilizer and peat are rich in nutrients and have plenty of organic matter content, soil adding both the soil conditioners will have longer and faster fertilizer efficiency [23]. CF+P showed best comprehensive improve to the physical and chemical properties of soil.

In the treatment PM+FR (pig manure+ fungi residues) soil respiration rate significantly improved. For the reason that the microbial activity in fungi residues was beneficial to decomposition of soil organic matter, increase of soil CO_2 efflux, improvement of microorganisms' abilities[24], and there by enhanced soil fertility. Nevertheless, the treatment PM+FR showed weak effect on blueberry growth, probably because fungi residues was alkaline and the pH was not suitable for blueberry growth.

The treatment using P (peat) significantly improved blueberry photosynthesis. As peat is rich in nutrients and has characteristics of loose structure, it benefits soil structure and conducive to plant growth and root respiration.

Comparing the two treatment, adding P and CF+P, we found that supplementing commercial fertilizer into peat, soil organic matter content was significantly increased, but plant growth weakened, that respiratory rate decreased 17.69%. The reason may be due to that the blueberries are low demand plant [25], it was not conducive to blueberry growth but supplementing commercial fertilizer into peat, which lead to high nutrient content. Meanwhile, economically, supplementing commercial organic fertilizers cost more. In general, peat was the best soil conditioner for blueberry cultivating in south area, for the reason that it could promote the plant growth and reduce costs as well.

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