Optimization of organic manure application for blueberry vegetative growth and photosynthesis

Wanyi Yang¹, Jinqiu Huang², Yongwang Wu, Xiaotian Li, Xun Wang²*

¹College of Horticulture, Sichuan Agricultural University, Chengdu, Sichuan, 611130, China
²Institute of Pomology and Olericulture, Sichuan Agricultural University, Chengdu, Sichuan, 611130, China

Sichuan Chengdu Key Research and Development Program (2019-YF05-01367-SN)

*Corresponding author’s e-mail: wx0104@sicau.edu.cn

Abstract. Take blueberry as the test material, we studied the effects of organic fertilizer on the growth and Photosynthesis of blueberry. We evaluated the efficiency of three organic fertilizers, namely rapeseed residue (RS-R), cattle manure (Cat-M), and chicken manure (Chi-M), produced from locally accessible resources. Plant vegetative growth and leaf photosynthetic parameters were measured for analysis. Animal manure, applied as 2 kg Cat-M plant⁻¹ or 3 kg Chi-M plant⁻¹, was the most beneficial fertilizer for plant vegetative growth and leaf photosynthesis.

1. Introduction

Blueberry, with a high economic value, has been listed as one of the five health foods by the international food and agriculture organization. Recently, blueberry planting scale in southwestern China has gradually expanded with a rapid speed of popularization. Fertilization is a key link in blueberry planting. The quality of fertilization is directly related to the growth of blueberries and the absorption and utilization of nutrients. Application of organic fertilizer can improve soil texture, structure, humus, aeration, water holding capacity and microbial activity. The present study investigated organic manure of southern highbush blueberry cultivated in southwestern China.

The oil cake is a kind of nutrient rich organic fertilizer, which is the residue of oil crops such as rapeseed, peanut, sesame, coconut, soybean and neem. Animal manures contain different amounts of chemical nutrients that are available to the plant and promote growth [1]. Rapeseed residue is the most common oil-cake fertilizer applied in southwestern China. Previous studies have confirmed these positive effects of oil cake and animal manures on blueberry growth [2-4].

We investigated the efficiency of organic fertilizers derived from locally accessible resources, namely rapeseed residue, cattle manure, and chicken manure. We aim at establish a referential fertilization scheme for blueberry orchards in southwestern China in order to promote stable and sustainable development of the blueberry industry.
2. Materials and methods

2.1 Plant materials and study site
The southern highbush blueberry cultivar ‘O’Neal’ was used in the study. In 2018, the plants fruited for the third year. Plants were spaced 2 m × 1 m apart.

We sited the experiment in the Sichuan Agricultural University’s cooperative research blueberry orchard on Nanbao Mountain (30°43′ N, 103°22′ E) at Qionglai, Chengdu city, Sichuan Province, China. The soil at the location is a yellow soil of high fertility [5]. The altitude of the site is 1350 m. The average temperature is 14.3 °C, and the annual accumulated temperature above 10 °C is 4500–5500 °C, and the frost-free period is 280 d. The average annual precipitation is 1100 mm, and the annual sunshine duration is 1107.9 h.

2.2 Experimental design and treatments
This experiment were totally applied in 10 treatments, including a control check [CK(OF), no organic fertilizer]; In addition, three organic fertilizer treatments (OF), namely rapeseed residue (RS-R), cattle manure (Cat-M), and chicken manure (Chi-M), were applied, and three amounts (1, 2, and 3 kg) of each organic fertilizer were administered. The organic fertilizers were applied on 30 November 2017, after 20 d of flowering, then, to treated the plants a single inorganic fertilizer application (100 g) of a sulfur-based compound fertilizer. The experimental treatments were replicated on six plants in a same area, and we sit a guard plant situated between each treatment in order to avoid mutual interference between different treatments.

2.3 Vegetative growth
Plant height increment, canopy width increment, and stem diameter increment were determined. The plant height was the vertical height measured from ground level to the uppermost shoot tip; each plant was measured in three different aspects. The canopy width was the diameter of the outer circumference of the branches measured in the north–south direction. The diameter of the stem, 10 cm above ground level, was measured with a vernier caliper, and three major basal branches were measured. The growth parameters were measured before bud burst (25 February 2018) and during fruit ripening (20 July 2018). The increment for each parameter was determined by subtracting the latter measurement from the former measurement.

2.4 Leaf photosynthetic capacity
The photosynthetic capacity was analysed by using portable photosynthesis apparatuses (Li-6400x, LI-COR Inc., Lincoln, NE, USA). Four photosynthesis indices, namely net photosynthesis rate (NPR), stomatal conductance (SC), intercellular CO2 concentration (Ci), and transpiration rate (TR), were determined. The fourth, fifth, and sixth leaves from the shoot tip of an outer branch on the south-facing side of the canopy were measured. Measurements were recorded from 08:00 to 10:00 on 10 August, 2018 on two consecutive sunny mornings.

2.5 Statistical analysis
One-way analysis of variance (ANOVA) and the Student–Newman–Keuls q test were performed at the 5% significance level with IBM SPSS Statistics 19.0 software (IBM Corporation, Armonk, NY, USA). Contrast analyses were used to separate the interactions.

3. Results

3.1 Vegetative growth in organic fertilizer treatments
All plants treated with OFs showed an increased plant height compared with that of the CK(OF) plants (Fig. 1a). Among the OF-treated plants, those treated with Chi-M 1kg showed the tallest plant height. Consistent with the results for plant height increment, the canopy width increment of all OF-treated
plants was greater than that of the CK(OF) plants (Fig. 1b). The greater increments in canopy width were recorded in the Cat-M 1kg (34.6 ± 6.8 cm), Cat-M 2kg (37.5 ± 2.1 cm), and Chi-M 2kg (35.0 ± 4.2 cm) treatments. Cat-M 3kg treatment, similar to CK(OF) plants, showed less impact on canopy width. Stem diameter increment was the greatest in the treatments Cat-M 3kg (6.21 ± 0.93 mm) and Chi-M 2kg (6.67 ± 0.13 mm). All OF treatments displayed higher increments in stem diameter than that of the CK(OF) plants (Fig. 1c).

Figure 1. Vegetative growth in organic fertilizer test. CK(OF): control treatment in organic fertilizer test. RS-R: rapeseed residue. Cat-M: cattle manure. Chi-M: chicken manure.

3.2 Photosynthesis indices in organic fertilizer treatments
The treatment Cat-M 2kg showed the highest NPR (13.587 ± 0.674 μmol m⁻² s⁻¹) followed by Chi-M 3kg (12.680 ± 0.622 μmol m⁻² s⁻¹) (Table 1). The SC was highest in the treatment Chi-M 3kg (0.212 ± 0.014 μmol m⁻² s⁻¹) followed by Cat-M 2kg (0.203 ± 0.023 μmol m⁻² s⁻¹), but no statistically significant differences were observed among the treatments (Table 1). The average Ci value in leaves was 264.761 ± 27.038 μmol m⁻² s⁻¹. The Ci of CK(OF) plants was in the mid-range of all treatments and no statistically significant differences among the treatments were recorded (Table 1). The TR was highest in the treatment Chi-M 3kg (2.589 ± 0.141 μmol m⁻² s⁻¹) followed by Cat-M 2kg (2.482 ± 0.248 μmol m⁻² s⁻¹) (Table 1).

Table 1. Photosynthesis indices in organic fertilizer test.
CK(OF): control treatment in organic fertilizer test.RS-R: rapeseed residue. Cat-M: cattle manure. Chi-M: chicken manure.

| Treatment | Net photosynthesis rate(μmol m⁻² s⁻¹) | Stomatal conductance(μmol m⁻² s⁻¹) | Intercellular CO₂ concentration(μmol m⁻² s⁻¹) | Transpiration rate(μmol m⁻² s⁻¹) |
|-----------|-----------------------------------|-----------------------------------|-----------------------------------------------|----------------------------------|
| CK(OF)    | 11.975±0.971ab                     | 0.180±0.003a                      | 252.70±12.51a                                 | 1.985±0.112abc                   |
| RS-R 1kg  | 10.784±1.491ab                     | 0.155±0.048a                      | 194.75±31.23a                                 | 1.736±0.483abc                   |
| RS-R 2kg  | 11.416±0.312ab                     | 0.158±0.014a                      | 275.45±47.01a                                 | 2.108±0.683ab                    |
| RS-R 3kg  | 11.143±0.693ab                     | 0.137±0.007a                      | 281.68±29.91a                                 | 1.644±0.092bc                    |
| Cat-M 1kg | 9.655±1.562b                       | 0.160±0.014a                      | 240.83±38.56a                                 | 2.191±0.219ab                    |
| Cat-M 2kg | 13.587±0.674a                      | 0.203±0.023a                      | 281.02±28.01a                                 | 2.482±0.248ab                    |
| Cat-M 3kg | 10.713±0.915ab                     | 0.164±0.015a                      | 285.60±44.16a                                 | 1.680±0.153abc                   |
| Chi-M 1kg | 11.012±1.328ab                     | 0.167±0.036a                      | 202.67±47.37a                                 | 1.202±0.225c                     |
| Chi-M 2kg | 10.961±2.235ab                     | 0.182±0.042a                      | 267.38±15.23a                                 | 2.259±0.426ab                    |
| Chi-M 3kg | 12.680±0.622ab                     | 0.212±0.014a                      | 265.52±14.39a                                 | 2.589±0.141a                     |

4. Conclusion
The present research major focused on the effects of organic fertilizers on blueberry growth in order to provide a certain extent help to the optimization of fertilization of high bush blueberry in Southwest China. We confirmed the important influence of organic fertilizer application on blueberry plants.
Muñoz-Vega previous studies have compared the effects of six organic fertilizers derived from locally accessible resources. The results indicated that fruit yield was elevated in response to lupine meal, and leaf chlorophyll contents were increased in response to urea, lupine meal, and blood meal [2]. Worm castings are an additional effective organic fertilizer for blueberry [6]. It was verified that worm casting application increased not only vegetative growth, e.g., canopy width, height, and stem diameter, but also anthocyanin content. In the current study, we compared the effects of three organic fertilizers (rapeseed residue, cattle manure, and chicken manure) on blueberry growth. A moderate amount of cattle manure (2 kg) was of greatest benefit for vegetative growth and promoted increment in canopy width and stem diameter. With regard to photosynthesis, the treatments Cat-M 2kg and Chi-M 3kg most efficiently increased the photosynthesis rate.

5. Acknowledgement
I would like to show my deepest gratitude to my supervisor, Dr. Wang Xun, a respectable, responsible and resourceful scholar, who has provided me with valuable guidance in every stage of the writing of this thesis. And thanks for the support of this project named Sichuan key research and development program (2018NZ0147) Sichuan Chengdu Key Research and Development Program (2019-YF05-01367-SN)

References
[1] Brown, C., (2013) Available nutrients and value for manure from various livestock types. Nutrient Management Field Crop Program Lead/OMAFRA. 13-043. http://omafra.gov.on.ca/english/crops/facts/13-043.htm
[2] Larco, H., Strik, B.C., Bryla, D.R., Sullivan, D.M. (2013) Mulch and fertilizer management practices for organic production of highbush blueberry. Plant growth and allocation of biomass during establishment. HortScience., 48:1250–1261.
[3] Larco, H., Strik, B.C., Bryla, D.R., Sullivan, D.M. (2013) Mulch and Fertilizer Management Practices for Organic Production of Highbush Blueberry. Impact on plant and soil nutrients during establishment. HortScience., 48:1484–1495.
[4] Muñoz-Vega, P., Paillán, H., Serri, H., Donnay, D., Sanhueza, C., Merino, E., Hirzel, J. (2016) Effects of organic fertilizers on the vegetative, nutritional, and productive parameters of blueberries 'Corona', 'Legacy', and 'Liberty'. Chil. J. Agr. Res., 76: 201–212.
[5] Zeng J.T. (1979) The principle, gauge, and system of agricultural soils division in Sichuan province. Soils and Fertilizers., 6: 14–19.
[6] Panicker, G.K., Sims, C.A., Spiers, J.M., Silva, J.L., Matta, F.B. (2009) Effect of worm castings, cow manure, and forest waste on yield and fruit quality of organic blueberries grown on a heavy soil. ActaHortic., 841:581–584.