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Effects of Nitrogen and Potassium Fertilizers on Blueberry Fruit's Quality

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Abstract. The effects of nitrogen (N) and potassium (K) fertilizers on fruit qualities of blueberry 'Legacy' were studied. A field experiment was conducted using randomized block design. The results showed that the fruit weight and total soluble solids content of blueberry were significantly increased by fertilizations. The water content of Treatment 3(T3), T5 and T6 declined by 9.45%, 10.67% and 13.44% respectively compared with control. In general, T3 and T6 showed higher levels of vitamin C content. T3 was the best treatment in terms of soluble sugar content. The results of double factor variance analysis showed that he optimum fertilization combination was 45g/tree of N and 30g/tree of K_2O.

Introduction

Blueberry (*Vaccinium spp.*) is berry fruit, small-scale and dark purple. It is rich in nutrient substances, especially anthocyanin [1]. Blueberry has high economic value. It has attracted increasing attention in recent years as the third generation of fruits [2], and its industry is developing rapidly. Up to 2015, there were more than 77,000 ha of cultivated blueberry be grown worldwide, which is expected to increase by another 46% on its yield over the next five years [3]. In China, many achievements have been made in the study of blueberry cultivation techniques [4].

Blueberry is a kind of oligotrophic plants. Its response to fertilizer is very sensitive. Inadequate or excessive fertilizing would lead to slow growth, lower yield, plant damage and even death [5]. Blueberry is an ammonium (N)-philic plant, which indicates that blueberry has a great absorption ability of ammonium nitrogen [6]. The application of nitrogen fertilizer significantly increased the content of effective ingredients such as soluble sugar, fruit anthocyanin, flavonoid and total phenolic [7]. Improper nitrogen fertilization would lead to weaker growth and the elimination of fruit quality [8]. Potassium (K) is required by all plants. Previous studies showed that potassium fertilizer application can increase blueberry fruit yields, accelerate the ripeness, and improve tree resistance to cold [9]. Excessive potassium fertilization caused yield reduction and smaller fruits [10,11].

Materials and methods

Materials. A total of 63 Northern highbush "Legacy" trees grown for 3 years were used. The experiment site was in Qionglai, Sichuan, where altitude is 1350m. The average temperature is

16.3℃, and the annual accumulated temperature above 10℃ is 4500 to 5500 approximately. The average annual precipitation is 1100mm, annual sunshine duration is 1107.9h, and frost-free season is 285 d. Soil type is mountain yellow-brown soil [12].

Fertilizers application. The fertilizers in our experiment are ammonium sulfate (N 20%) and potassium sulfate (K_2O 50%). Fertilizers application was showed in Table 1. The nitrogen fertilizer has three levels and the potassium fertilizer has two levels. Fertilizers combinations contain CK(No fertilization), T1 (N1, K1), T2 (N2, K1), T3 (N3, K1), T4 (N1, K2), T5 (N2, K2), T6 (N3, K2). Tested trees were divided into 7 treatments by the randomized blocks design with three repetition per treatment and three trees per repetition. The fertilizer were fertilized around the crown shadow by hole fertilization in a week before germination, combined with irrigation.

Table 1 Levels of nitrogen and potassium fertilizer application

Level	N（g/tree）	K_2O（g/tree）
1	15	20
2	30	30
3	45	/

Determination of fruit qualities. The following indexes were determined: (1) Fruit weight was expressed as: fruit weight (g) = W/10, W was the ten-fruit weighted. (2) Fruit shape index was the ratio of vertical diameter and horizontal diameter: fruit shape index = L1/L2, L1 was the vertical diameter, L2 was the horizontal diameter. (3) The TSS content (%) of the fresh blueberry was measured with a portable refractometer. Zero adjustment was always carried out prior to use. (4) Water content (%) was determined as: water content (%) = (W1–W2)/10W*100, W1 was the weight of 10 fruits at harvest time and W2 was the weight of 10 fruits dried to constant weight at 65℃. (5) Soluble sugar was determined by anthrone and sulphuric acid colorimetry[13]. (6) Vitamin C was determined by Xylene - 2,6 - dichlorophenolindophenol colorimetry [14].

Results

Effects of different fertilizations on fruits weight and shape index. Trees treated with fertilization showed significantly increased on fruits weight compared with control (Fig.1), except for T1 ($p<0.05$). The fruit weight of T6 is 2.46g, which is the best treatment. Fruit shape index of blueberry in all treatments were not significantly different compared with control. Applying level 2 (30g/tree) and level 3 (45g/tree) of Nitrogen fertilizer combined with potassium fertilizer increased the fruit weight significantly ($p<0.05$).

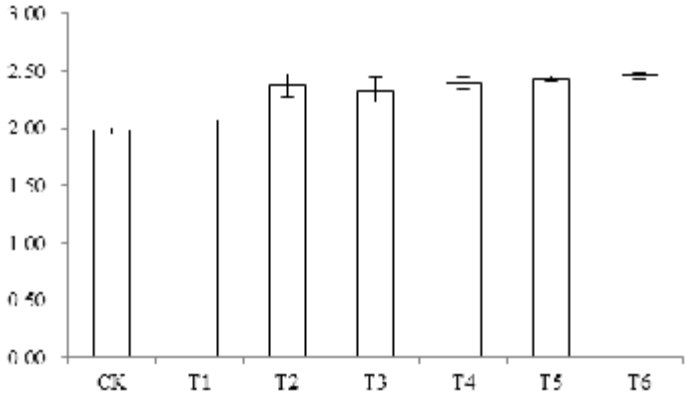

Fig. 1 Effect of various fertilization treatments on fruits weight

Table 2 Effects of various fertilization treatments on horizontal and vertical diameters and shape index of blueberry

No. treatment	Horizontal diameter (mm)	Vertical diameter (mm)	Shape index
CK	16.95±0.41b	12.82±0.14ab	0.76±0.02a
T1	16.7±0.72b	12.44±0.77b	0.74±0.02a
T2	17.47±0.26ab	13.58±0.40a	0.78±0.03a
T3	17.48±0.54ab	13.03±0.13ab	0.75±0.02a
T4	18.25±0.51a	13.26±0.89ab	0.73±0.03a
T5	17.44±0.47ab	12.93±0.49ab	0.74±0.03a
T6	17.44±0.22ab	13.24±0.49ab	0.76±0.03a

For the same index，statistical significant difference at $p<0.05$ was expressed by using different letters after each value.

TSS content. Inadequate fertilization had little effect on the accumulation of TSS. The rank of all treatments on TSS content was T3>T6>T2>T4>T5>T1>CK. The least TSS content occurred in CK, with all treatments significantly better than this ($p<0.05$) except for T1. As shown in Fig.2, nitrogen fertilizer application of level 2 (30g/tree) and level 3 (45g/tree) combined with potassium fertilizer application have significantly higher TSS content than control ($p<0.05$).

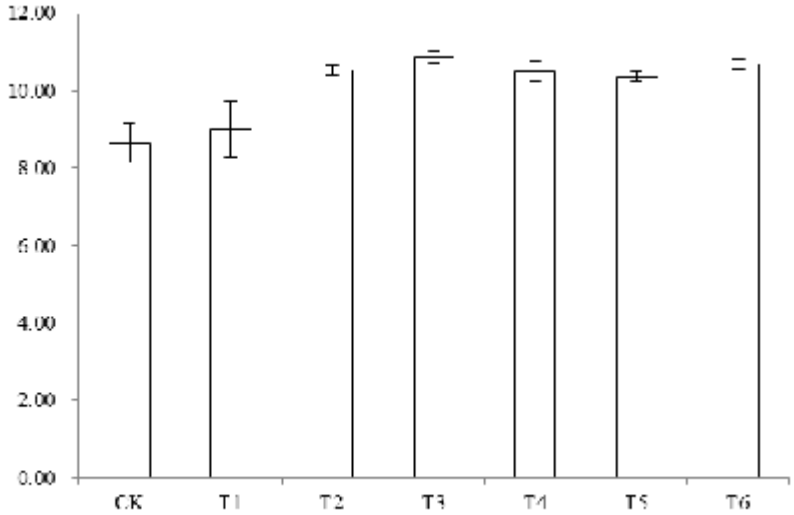

Fig. 2 Effect of various fertilization treatments on TSS

Water content. Treatments T1 maintained water content at higher levels than the other treatments. Water content of T3, T5 and T6 were 78.99%, 77.92%, 75.51% respectively, while CK was 79.61%. The coefficient of dispersion revealed little difference in the water content of treatment T6, and the other treatments also achieved great results for their values were less than 0.2.

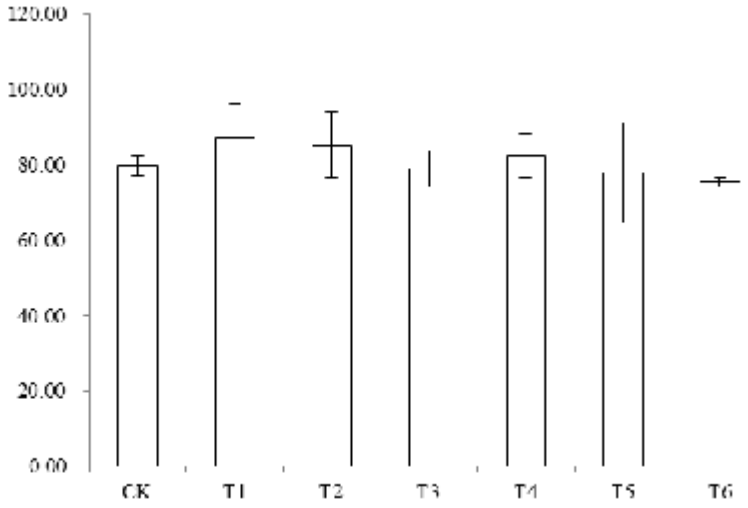

Fig. 3 Effect of various fertilization treatments on water

Soluble sugar. As shown in Fig.4, the treatment of great soluble sugar content was T3 (11.55%), which was significantly better than CK ($p<0.05$). The next great content of soluble sugar occurred in T6 (10.60%) and T2 (8.71%). According to Table 4 and 5, nitrogen fertilizer application of level 3 (45g/tree) had significantly more beneficial effects than the others, while potassium fertilizer application had little effects on the accumulation of soluble sugar.

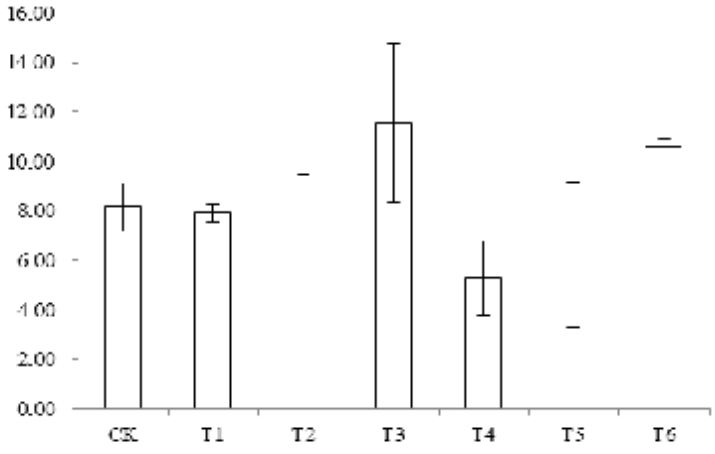

Fig. 4 Effect of various fertilization treatments on soluble sugar

Vitamin C. Comparing all treatments on vitamin C contents indicated that the great treatments were T3 (1.78 mg/100g FW) and T6 (1.77 mg/100g FW) (Fig.5). Nitrogen fertilizer application of level 2 (30g/tree) and level 3 (45g/tree) combined with potassium fertilizer application showed higher contents of vitamin C than the control.

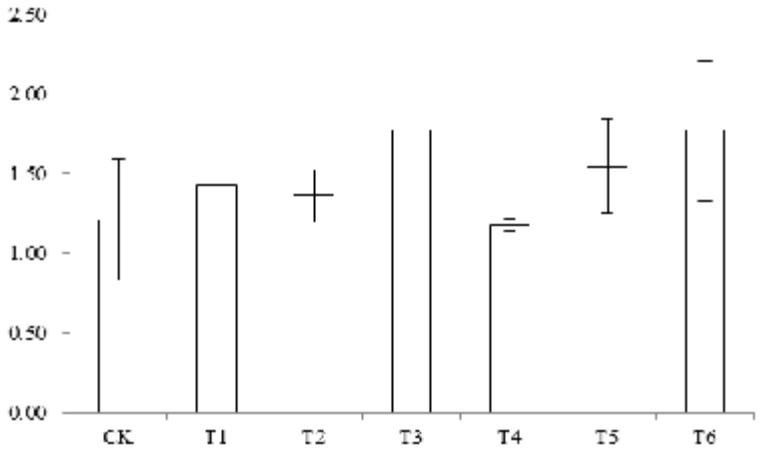

Fig. 5 Effect of various fertilization treatments on vitamin C

Discussion

Fertilizers with different N, P, K contents have different effects on blueberry fruit weight [15]. From our results, increasing nitrogen and potassium fertilizer application significantly increased the single fruit weight. Due to the low content of nitrogen and potassium in soil and the low fertilization level of our experiment, the accurate trend need to be ascertained by more tests with higher fertilization level setting. In T3, T5 and T6 treatment, water contents of fruits were relatively low, which was beneficial to extend shelf life [16]. Our results indicated that higher levels of fertilizer application are effective in maintaining fruit water content in lower levels. Blueberries are sensitive to fertilization [6], which was reconfirmed by our research results. Among all the treatments, T3 and T6 maximally enhanced the content of TSS and soluble sugar compared with the control. In this study, we found that the optimum fertilization combination was N (45g/ tree) and K_2O (30g/ tree) via double factor variance analysis.

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