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Research Article

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Effects of organic fertilizer on water use, photosynthetic characteristics, and fruit quality of pear jujube in northern Shaanxi

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Abstract: This experiment is based on the 7-year-old dwarf and densely planted pear jujube in northern Shaanxi. The effects of applying organic fertilizer on water use, photosynthetic characteristics, and fruit quality of pear jujube are studied. The test has been carried out for two consecutive years. The results showed that fertilization treatments could promote soil moisture retention and utilization. Compared with the control (CK) in 2011, the average soil water content (SWC) of soybean cake fertilizer (SC) and sheep manure (SM) increased by 3.69 and 3.18 percentage points, respectively. The effect of SC on chlorophyll content was most significant. Fertilization can effectively improve the canopy structure of pear jujube. The transmittance of SC and SM decreased by 20.20% and 17.38%, respectively, in 2012. The gap scores were opposite to the leaf area index (LAI). Continuous application of organic fertilizer can significantly increase the net photosynthetic rate and stomatal conductance of pear jujube. The instantaneous water use efficiency of chemical fertilizer (CF), SC, SM, and biogas fertilizer (BM) increased by 0.44, 1.33, 0.96, and 0.61 percentage points, respectively. Organic fertilizer effectively increased the fruit setting rate, yield, and quality of fruits. After fertilization for two consecutive years, the quality of pear jujube fruit improved significantly. It indicated that long-term fertilization

Keywords: pear jujube, soybean cake fertilizer, water use efficiency

1 Introduction

Pear jujube (Ziziphus jujuba Mill.) is a plant, which belongs to Rhamnaceae family. Pear jujube is a valuable variety of jujube fresh food. It has rich nutritional value. Jujube is resistant to drought and sorghum. It has strong adaptability to soil. It is resistant to barrenness, salt, and alkali. In the hilly and gully regions of the Loess Plateau in northern Shaanxi, the large number of pear jujube planted can not only green the barren hills, maintain water and soil, improve the ecological environment, but also increase the farmers' economic income. Therefore, pear jujube has become the main fruit tree as returning farmland to forest and economic forest in northern Shaanxi [1]. Due to the climatic conditions of northern Shaanxi, the jujube is evenly colored, beautiful in appearance, and high in quality and commodity value. The pear jujube is obviously superior to the origin or other jujube areas. A good water and fertilizer environment can guarantee the long-term sustainable development of mountain jujube forest. However, chemical fertilizer is used to supply fertility for pear jujube, pesticide control pests and diseases in north Shaanxi. This will bring serious environmental pollution and affect the soil structure and the nutritional quality of pear jujube [2,3]. The organic fertilizer can improve soil fertility, provide comprehensive nutrition for long-term crops, improve soil physical and chemical properties, enhance soil water storage capacity, and improve crop quality [4-9]. Studies have

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could effectively promote the growth and development, increase yield, and significantly improve the fruit quality of pear jujube in the loess hilly region of northern Shaanxi. The effect of soybean cake fertilizer was the most significant.

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shown that organic fertilizer can improve soil moisture content and improve crop water use efficiency [10,11]. The application of organic fertilizer can improve the variety of the fruit, including increasing the sweetness, hardness, and vitamin content of the fruit [12,13]. Wu [14] found that organic fertilizer can promote the growth, yield, and quality of the upper part of the Huangguan pear. The research by Wang et al. [15] showed that the organic fertilizer can significantly increase the content of available nitrogen, phosphorus, potassium, and organic matter in the soil of peach forest and increase the porosity of soil capillary. The content of chlorophyll a was significantly increased in peach leaves. Wang et al. [16] also showed that organic fertilizer can improve the net photosynthetic rate and water use efficiency of jujube leaves. At present, there are few reports on the effects of organic fertilizer application on the growth, photosynthetic physiological characteristics, and water use of pear jujube in the hilly and gully regions of the Loess Plateau. Therefore, this study takes the pear jujube in the loess hilly region as the research object. Different organic fertilizer treatments were carried out during the flowering and fruiting period. The comprehensive effects of organic manure on vegetative growth, reproductive growth, photosynthetic characteristics, and water use of pear jujube were analyzed. Explore the source of organic fertilizer suitable for the growth and development of pear jujube. Provide theoretical basis and technical support for the production of organic red dates.

2 Materials and methods

2.1 Overview of the test area

The experiment was carried out in 2011–2012 in the jujube microirrigation technology demonstration base in Mizhi County, Yulin City, Shaanxi Province. The site is located at 37.78′N, 110.23′E, at an altitude of 870 m. It belongs to the typical hilly and gully region of the Loess Plateau. It is medium temperature with a semiarid climate. The annual average temperature is 8.5°C. The annual average precipitation is 451.6 mm, mainly concentrated in July to September. The soil is dominated by loessial soil. The bulk density is 1.21 g/cm³. Soil fertility was low. The available nitrogen, phosphorus, and potassium contents were 34.73, 2.90, and 101.9 mg/kg. The organic matter content is 2.1 g/kg. The soil pH is 8.6 [17]. The irrigation quota was 135 m³/hm² during the

test period. The irrigation time during the test period was May 15 and June 10 [18].

2.2 Test design

The 7-year-old mountain dwarf densely planted pear jujube with uniform tree body and good growth was selected as the research object. The study site is a horizontal terrace on the slope. The soil water and fertilizer and other factors along the contour line are basically the same. The test area is 300 m². The planting density is $2 \text{ m} \times 3 \text{ m}$. Fertilization treatments were set under drip irrigation conditions: (1) control (CK): no fertilization; (2) conventional chemical fertilizer (CF): urea application (N 46%) 0.48 kg/plant, superphosphate $(P_2O_5 12\%)$ 1.35 kg/plant, potassium sulfate $(K_2O 50\%)$ 0.61 kg/plant [19]; (3) fermented and decomposed soybean cake fertilizer (SC): 5 kg/plant; (4) decomposed sheep manure (SM): 15 kg/plant; (5) biogas fertilizer (BM): 100 kg/plant. The amount of fertilizer applied is calculated based on the content of nutrients in the organic fertilizer and the amount of chemical fertilizer. Individual plants are treated as one treatment. Set five repetitions per process. Fertilization method: centering on the tree pole, the annular groove is dug in the outer edge of the canopy vertical projection. The groove is 30 cm wide and the groove is 45 cm deep. Mix the fertilizer with the soil and fill it into the ditch (10-45 cm). Soybean cake is oil residue. It was sealed and fermented for 35 days under the condition of relative humidity reaching 70%, which is the decomposed soybean cake fertilizer. BM is a mixture of biogas slurry and biogas residue fermented by biogas. SM is a mixture of pulverized straw and sheep manure buried in a puddle and subjected to microbial anaerobic fermentation. The nutrient content of each organic fertilizer is shown in Table 1.

2.3 Measurement items and methods

Organic fertilizer is applied at the beginning of April 10 each year. On May 31, June 6, June 14, June 22, and July 1, take the fixed eight-point bearing branch in different directions of jujube trees. The number of flowers and fruits was recorded in the flowering and fruiting stages, respectively. Fruit set rate = number of fruits/number of flowers \times 100%.

Table 1: Nutrient content of the experimental organic fertilizers

Organic fertilizer type	Moisture content (%)	Organic matter (%)	Total N (%)	Total P (%)	Total K (%)
Soybean cake fertilizer	22.74	7.69	4.13	0.91	1.57
Sheep manure	8.23	24.72	0.95	0.73	2.25
Biogas manure	99.43	0.17	0.21	0.096	0.11

Each jujube hang is fixed to select the fifth leaf at the top. Chlorophyll content, photosynthetic index, canopy index, and soil water content (SWC) were measured in June 15.

Yield: after the fruit is mature, the single-receipt method is adopted. Every time the fruit is picked, it is recorded until the fruit picking is completed. Calculate individual yield and convert to total yield. Mature fruits were collected for quality determination.

SWC [20]: the soil was taken by conventional soil drilling. The sampling location was 30 cm from the tree. The measured depth was 0–100 cm soil layer. The sampling interval was 20 cm. The soil samples were baked to constant weight at $105 \pm 2^{\circ}$ C to calculate the moisture content.

The chlorophyll content was determined by the acetone method [21]. The photosynthesis index was measured by LI-6400 portable photosynthetic analyzer. The instantaneous water use efficiency (WUEp) was calculated by the leaf net photosynthetic rate (Pn)/transpiration rate (Tr).

The canopy index was determined by WinsCanopy2005a canopy analysis, including leaf area index, gap fraction (GFR), total radiant flux on the canopy, and total radiant flux under the canopy. Canopy light interception density = average photosynthetically active radiation density above the canopy – average total photosynthetically active radiation density below the canopy [22].

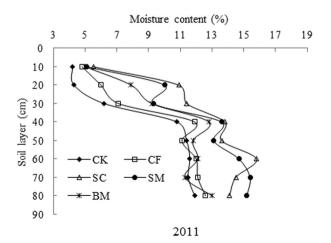


Figure 1: Effects of different fertilizer treatments on SWC.

Soluble solids (TSS) were measured using a 2WAJ-Abbe refractometer. The titratable acid (TA) was titrated by 0.1 mol/l NaOH standard solution [23]. Reduced vitamin C was titrated with 2,6-dichlorophenol [24]. The total flavonoid content was determined by Na- NO_2 -Al(NO_3)₃ spectrophotometry [25].

The test data were statistically analyzed using Microsoft Excel 2003 and DPS 7.05 software.

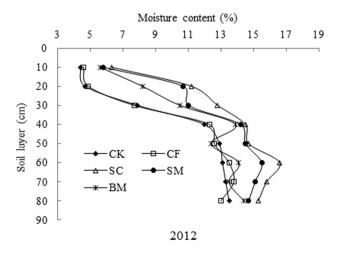
Ethical approval: The conducted research is not related to human or animal use.

3 Results and analysis

3.1 Effects of different organic fertilizers on water use of pear jujube during flowering and fruiting period

3.1.1 Effect of different organic fertilizers on SWC of flowering and fruiting period of pear Jujube

The SWC of each treatment in different years increases rapidly with the depth of the soil layer and then tends to be slow in Figure 1. The SWC of organic fertilizer treatment is significantly higher than CF and CK. The



moisture change of SC and SM is most significant. The reason is that the organic fertilizer can make the soil absorb a large amount of water and prevent the infiltration of water. In 2011, the average SWC of SC, SM, BM, and CF increase by 3.69, 3.18, 1.11, and 0.40 percentage points, respectively, compared with CK (9.37%). The SWC in 2012 is significantly higher than in 2011. On the one hand, it is due to external factors such as rainfall; on the other hand, the organic fertilizer is conducive to increasing the water content of the soil. The increase of SC is the largest, and the difference is significant compared with CK (probability P < 0.05).

3.1.2 Effects of different organic fertilizers on leaf water content of flowering and fruiting period of pear jujube

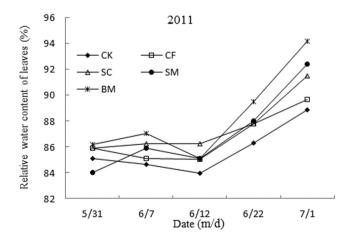
Pear jujube maintains a high leaf water content (RWC) which plays an important role in seating fruit and photosynthesis of pear jujube. Figure 2 shows that RWC of organic fertilizer treatment is higher than CK and CF in 2012. This may be because long-term application of organic fertilizer can improve soil moisture and protect the water requirements of plant leaves. On June 12, RWC decreased slightly. And the downward trend in the second year of fertilization has slowed down significantly. This may be due to the fact that the jujube tree enters the fruiting period in mid-June and requires a lot of water. Application of organic fertilizer can increase the RWC of pear jujube leaves. It can supply the water needed for flowering to the fruiting period then slowed down the trend of moisture. The RWC of each treated reached the highest in July 1. RWC of BM, SM, and SC are 94.20%,

92.40%, and 91.47% in 2011. They are significantly different from CK (P < 0.05). Therefore, application of organic fertilizer can increase the RWC of the pear jujube. RWC of BM, SM, and SC is increased by 4.52, 2.72, and 1.79 percentage points, respectively, compared with CF. The RWC gap between treatments decreased after 2 years of application of organic fertilizer. Among them, the change of SC is the most obvious.

3.2 Effects of different organic fertilizers on photosynthetic effects of flowering and fruiting stage of pear jujube

3.2.1 Effects of different organic fertilizers on the chlorophyll content of pear jujube flowering fruit

The content of chlorophyll affects the absorption and conversion of light energy. The ratio of chlorophyll a to chlorophyll b (chl a/b) can reflect the photosynthetic activity of the leaves and the amount of light energy utilization by plants [26]. The photosynthetic performance of pear jujube directly affects the supply of nutrients required for flowering fruit of pear jujube. It is of great significance to the final production. Figure 3 shows that the total chlorophyll content of fertilization treatment is significantly higher than CK. In 2011, the total chlorophyll content of CF, SC, SM, and BM increased by 22.86%, 26.73%, 39.31%, and 43.01%, respectively, compared with CK. The organic fertilizer can significantly increase the content of chlorophyll *a* in plants. The chlorophyll b content was consistent with the total content. However, the chlorophyll content of



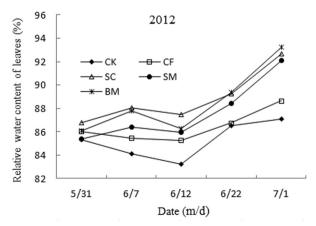
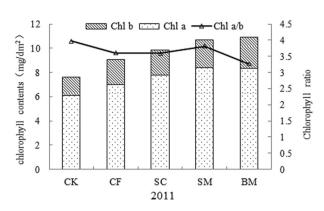


Figure 2: Effects of different fertilizer treatments on the relative leaf water content of pear jujube.



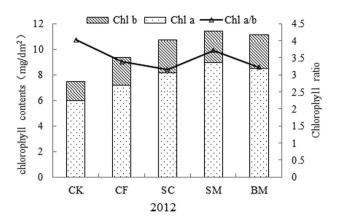


Figure 3: Effects of different fertilizer treatments on the chlorophyll contents of pear jujube.

each organic fertilizer treatment was not significant. Figure 3 shows that the CK-treated chl a/b is the highest, and the BM, SC, and CF are significantly smaller than CK. It may be that the effect of BM, SC, and CF treatment on chlorophyll b synthesis is greater than that of chlorophyll a, which significantly increases the absorption of blue-green light and enhances the photosynthetic activity of leaves. Among them, the effect of SC treatment on chlorophyll content in 2012 was the most significant. Total chlorophyll was $10.72 \, \text{mg/dm}^2$ and Chl a/b only was 3.16.

3.2.2 Effects of different organic fertilizers on canopy structure and canopy optical properties of pear jujube flowering

Table 2 shows that the canopy structure of fertilization in the flowering and fruiting period has been found to be

significantly changed for two consecutive years. Canopy photosynthetically active radiation is the most important indicator for evaluating canopy transmittance and light interception ability. The canopy light interception density of different treatments was significantly higher than CK. The canopy transmittance was consistent in 2011 and 2012. In 2012, the light transmittance of each treatment reduced by 25.17%, 20.20%, 17.38%, and 8.16%, respectively. Fertilization treatments were significantly different from CK (P < 0.05). However, the difference in organic fertilizer treatment was not significant. The LAI of pear jujube after fertilization for 2 years was significantly higher than CK. In 2012, the SC is increased by 31.49% compared with CK. The gap scores of different treatments were opposite to those of LAI. The canopy structure of pear jujube changed significantly after application of organic fertilizer for 2 years. This change is more conducive to photosynthesis of pear jujube. It provides adequate nutritional support for fruit setting.

Table 2: Effects of different fertilizer treatments on canopy characteristics of pear jujube

Year	Treatment	Transmittance (%)	Gap fraction (%)	The density of light (%)	LAI
2011	СК	27.53 ± 2.04 a	27.41 ± 1.44 a	33.06 ± 1.57 c	1.74 ± 0.17 c
	CF	25.15 ± 1.35 ab	$24.91 \pm 1.03 b$	$36.87 \pm 2.06 \text{ ab}$	$2.01 \pm 0.21 \; b$
	SC	$23.46 \pm 1.07 bc$	$27.49 \pm 1.62 a$	35.98 ± 1.95 b	$1.96 \pm 0.15 b$
	SM	$21.58 \pm 1.28 \text{ c}$	24.97 ± 1.53 b	35.69 ± 1.38 b	$2.02 \pm 0.11 b$
	ВМ	$18.13\pm0.97\mathrm{d}$	$21.64\pm1.02c$	$38.06 \pm 2.00 a$	$2.17 \pm 0.09 a$
2012	CK	$26.34 \pm 1.47 a$	26.55 ± 1.04 a	34.45 ± 1.53 b	1.81 ± 0.10 c
	CF	24.19 ± 1.58 b	23.72 ± 1.11 b	36.71 ± 1.53 ab	$2.22 \pm 0.07 b$
	SC	$21.76 \pm 1.33 c$	25.31 ± 2.03 ab	37.26 ± 1.53 a	2.38 ± 0.09 ab
	SM	$21.02 \pm 1.08 \ c$	$23.89\pm1.47b$	37.08 ± 1.53 a	$2.31 \pm 0.11 b$
	ВМ	19.71 ± 1.85 c	21.77 \pm 1.16 c	37.98 ± 1.53 a	2.57 ± 0.08 a

Note: Values followed by different letters in a column are significant among treatment at the 5% level. The two treatments have the same letter to indicate that the difference is not significant, and the different letters indicate significant differences. It was the same as below.

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3.2.3 Effects of different organic fertilizers on photosynthetic characteristics and leaf water use efficiency of flowering and fruiting period of pear jujube

It can be seen from Table 3 that application of organic fertilizer can significantly increase the net photosynthetic rate (Pn) and stomatal conductance (Gs) of pear jujube. In 2011, BM processed the highest Pn and Gs. In 2012, the Pn of SC reached the maximum. The intercellular CO₂ concentration (Ci) of fertilization was less than CK. The Ci for each fertilization treatment decreased in 2012 compared with 2011. The concentration of Ci treated by SC was the largest, Transpiration and photosynthesis are regulated by many factors. Stomatal transpiration was the main mode of transpiration [27]. In 2012, the Tr of BM reached a maximum. This may be related to a higher LAI. The application of organic fertilizer can effectively improve the instantaneous water use efficiency of pear jujube. The effect is more significant after continuous fertilization. In 2012, the instantaneous water use efficiency of SC treatment was the highest. The instantaneous water use efficiency (WUEp) of CF, SC, SM, and BM increased by 0.44, 1.33, 0.96, and 0.61, respectively, percentage points compared with CK. Fertilization treatment was significantly different from CK (P < 0.05). The WUEp of leaves with SC, SM, and BM was higher than CF. They were increase by 0.89, 0.52, and 0.17 percentage points, respectively.

3.3 Effects of different organic fertilizers on reproductive growth of pear

Table 4 shows that the total number of flowers of SC, SM, and BM increased by 73.1%, 26.9%, and 39.1%, respectively, in 2012. The yield per plant was increased by 195.8%, 102.7%,

and 152.0%, respectively, compared with CK. In 2012, fruit setting rate of BM and SC have increased by 2.17 and 1.90 percentage points, respectively. The difference was not significant. The yield of different fertilization treatments was significantly higher than CK. The different organic fertilizers have different effects on the reproductive growth of pear jujube. Based on the above indicators, SC has the most significant effect on the reproductive growth of pear jujube.

3.4 Effects of different organic fertilizers on the nutritional quality of pear jujube

Table 5 shows that each fertilization treatment can significantly improve the quality of pear jujube fruits. The water content of fruit (FWC) of SM in 2011 was slightly lower than CK. The FWC was higher than CK after continuing fertilization. The FWC of SC and BM increased by 9.54 and 8.87 percentage points, respectively, compared with CK; TA of SC is 0.28 percentage points lower than CK. The indexes of soluble solids (TSS), solid acid ratio (TSS/TA), vitamin c (Vc), and total flavonoids were higher than CK. The Vc and total flavonoid content of SC are increased by 82.6% and 45.6% than CK. The application of organic fertilizer significantly improved the quality indicators of pear jujube. After applying organic fertilizer for two consecutive years, the quality of pear jujube fruit is better.

4 Discussions

The jujube flowering and fruiting period lasts longer. The vegetative and reproductive growth are coexisting in

Table 3: Effects of different organic fertilizers on photosynthetic characters of pear jujube

Year	Treatment	Pn [μmol/(m² s)]	Gs [mmol/(m² s)]	Ci (µmol/mol)	Tr (µmol/mol)	WUEp (%)
2011	СК	18.30 ± 1.87 c	0.401 ± 0.030 c	270.2 ± 3.16 a	8.54 ± 0.31 a	2.14 ± 0.12 d
	CF	$20.80\pm1.61\;b$	$0.455 \pm 0.046 b$	255.3 ± 4.67 bc	$8.30 \pm 0.45 a$	2.51 ± 0.17 c
	SC	$22.19 \pm 0.90 a$	0.491 ± 0.032 a	252.0 ± 4.11 c	$6.57 \pm 0.33 c$	$3.38 \pm 0.26 a$
	SM	$22.37 \pm 0.49 a$	$0.499 \pm 0.035 a$	255.9 ± 3.57 b	$7.67 \pm 1.06 b$	$2.92 \pm 0.19 b$
	ВМ	$22.38 \pm 0.97 a$	0.501 ± 0.033 a	$240.8 \pm 3.74 d$	$8.66 \pm 0.20 a$	2.58 ± 0.13 bc
2012	CK	$18.16\pm0.78c$	$0.399 \pm 0.021 c$	278.1 ± 2.59 a	$8.67 \pm 0.24 a$	$2.09\pm0.12~d$
	CF	$21.10\pm1.24b$	$0.462 \pm 0.035 b$	257.5 ± 3.22 bc	$8.33 \pm 0.35 \text{ ab}$	2.53 ± 0.17 c
	SC	23.65 ± 0.86 a	0.514 ± 0.019 a	243.7 ± 2.98 cd	$6.91 \pm 0.33 \text{ c}$	$3.42 \pm 0.26 \ a$
	SM	23.49 ± 1.02 a	0.516 ± 0.044 a	$247.2 \pm 3.10 c$	7.71 ± 1.06 b	3.05 ± 0.19 b
	ВМ	23.47 ± 0.99 a	0.517 ± 0.027 a	238.6 ± 3.08 d	8.68 ± 0.13 a	2.70 ± 0.13 bc

Note: Values followed by different letters in a column are significant among treatment at the 5% level. The two treatments have the same letter to indicate that the difference is not significant, and the different letters indicate significant differences.

Table 4: Effects of different fertilizer treatments on reproductive growth of pear jujube

Year	Treatment	Flower no. (no./plant)	Fruit no. (no./plant)	Fruit setting rate (%)	Yield (kg/hm²)
2011	СК	14,790 ± 1,061 c	383 ± 19 c	2.59 ± 0.20 c	8,040 ± 568 d
	CF	21,564 ± 1,660 b	748 ± 81 b	$3.47 \pm 0.65 b$	11,797 ± 741 c
	SC	27,629 ± 4,552 a	985 ± 121 a	$3.57 \pm 0.20 \text{ b}$	19,177 ± 836 a
	SM	18,246 ± 2,044 bc	646 ± 51 b	$3.54 \pm 0.58 b$	12,025 ± 891 c
	ВМ	21,232 ± 5,072 bc	951 ± 132 a	$4.48 \pm 0.61 a$	14,142 ± 812 b
2012	CK	15,045 ± 1,201 c	$404 \pm 20 c$	$2.69 \pm 0.14 d$	$8,428 \pm 479 d$
	CF	22,785 ± 1,217 b	814 ± 51 b	3.57 ± 0.52 c	12,356 ± 511 c
	SC	$26,047 \pm 3,218 a$	1,195 ± 102 a	$4.59 \pm 0.49 \text{ ab}$	$22,018 \pm 422 a$
	SM	19,094 ± 1,984 bc	$819 \pm 48 b$	$4.29 \pm 0.57 \text{ bc}$	$14,479 \pm 567 c$
	ВМ	20,925 ± 2,108 bc	$1018 \pm 94 a$	$4.86 \pm 0.61 a$	17279 ± 601 b

Note: Values followed by different letters in a column are significant among treatment at the 5% level. The two treatments have the same letter to indicate that the difference is not significant, and the different letters indicate significant differences.

Table 5: Effects of different fertilizer treatments on nutrient quality of pear jujube

Year	Treatment	FWC (%)	TSS (%)	TA (%)	TSS/TA	Vc (mg/kg)	Total flavones (mg/kg)
2011	СК	77.15 b	15.45 c	0.69 a	22.39 c	25.81 c	11.52 c
	SC	86.30 a	18.48 a	0.46 c	40.17 a	46.18 a	14.35 a
	SM	76.32 b	16.63 bc	0.53 b	31.38 b	37.00 b	13.48 b
	ВМ	85.41 a	17.05 b	0.51 b	33.43 b	41.19 b	12.58 b
2012	CK	78.01 b	15.91 c	0.72 a	22.10 c	25.92 c	11.01 c
	SC	87.55 a	20.14 a	0.44 c	45.78 a	47.33 a	16.03 a
	SM	79.21 b	17.55 bc	0.50 b	35.10 b	39.71 b	14.98 b
	ВМ	86.88 a	18.67 b	0.47 b	39.72 b	43.52 b	14.11 b

Note: Values followed by different letters in a column are significant among treatment at the 5% level. The two treatments have the same letter to indicate that the difference is not significant, and the different letters indicate significant differences.

this period. It is sensitive to nutrition and water status. Whether the nutrient supply is sufficient is directly related to the growth and yield of jujube. Therefore, scientific fertilization and soil fertility are necessary. Organic fertilizer can activate nutrients in the matrix, improve soil physical and chemical properties, promote plant nutrient absorption, and increase nutrient content [28]. It provides the nutrients needed for dry matter accumulation, promote vegetative growth, and reproductive growth [6,29].

In this study, organic fertilizer significantly improves the SWC in the rhizosphere, especially in roots widest distribution layer (40–80 cm). The SWC of SC and SM was significantly higher than CK and CF. The reason is that organic fertilization can increase SWC and reduce soil water loss rate [30]. Organic fertilizer increased the relative water content of the leaves during flowering. The reason may be that organic fertilizer can improve soil total porosity and nutrient status [31,32]. It ensures the absorption and utilization of water by the roots of plants. Both SM and SC have higher SWC. However, the comprehensive utilization efficiency of water in SC is the best. Therefore, the soybean

cake fertilizer can significantly improve water utilization, achieve water retention holding water, and meet the water demand of pear jujube flowering period.

Wang [33] showed that organic fertilizer can significantly increase the chlorophyll content of wheat leaves. The soil and plant analyzer development (SPAD) value is 58% higher than CK. Liu et al. [34] showed that organic fertilizer increased the net photosynthetic rate of golden pear. The transpiration rate of the leaves is adjusted. These are consistent with the results of this pilot study. The total content of chlorophyll in the fruiting period of pear jujube was significantly higher than CK. The change trend of Pn and Gs was consistent with the chlorophyll content. The intercellular CO₂ concentration was opposite to Pn and Gs. This may be due to nonporosity factors that reduce the utilization of CO_2 , resulting in the accumulation of CO_2 [31–33]. Therefore, organic fertilizer significantly increased the chlorophyll content of the fruiting period. Photosynthesis intensity was enhanced. It also reduced intercellular CO₂ concentration and accelerated the synthesis and accumulation of photosynthesis products [31].

The total number of flowers CF was higher than SM and BM, while the fruit setting rate was lower than SM and BM. The reason is that chemical fertilizer could guarantee the nutrient supply during flowering period and promote flowering of plants, but the subsequent lack of fertility, water, and other factors affect the fruiting of pear jujube. These reasons ultimately affect the yield of pear jujube. The water content, solid acid ratio, and other qualities of the fruit directly affect the taste of pear jujube. After application of organic fertilizer, the water content of the fruit is significantly increased. SC and CK reached significant difference (P < 0.05). The soluble solids, solidacid ratio, Vc, and total flavonoids were all higher than CK. The titratable acid was lower than CK. Zhu [35] through the study of citrus showed that organic fertilizer can increase the ratio of soluble solids and solid acid in citrus. Luo et al. [36] shows that organic fertilizer can increase the Vc content of Feicheng peach and reduce the content of titratable acid. The sustained slow release of organic fertilizers is conducive to synchronizing with the physiological needs of crops. It can effectively promote the balance of nutrient metabolism in crops. Thereby, it can ensure the high yield and quality of crops [37].

5 Conclusions

Organic fertilizers can promote the vegetative growth, reproductive growth, quality improvement, and water utilization of pear jujube. Soybean cake fertilizer is relatively effective. It can provide theoretical basis and reference for scientific fertilization of organic pear jujube in the loess hilly region. In future, we need further research about the amount of organic fertilizer added. Applying organic fertilizer will bring comprehensive effect. Long-term application of organic fertilizers will produce cumulative effects and effect on soil fertility.

Conflict of interest: Authors declare no conflict of interest.

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