Effects of Functional Materials and Fertilizer Application on the Growth and Physiological Indicators of Pearl Apricot

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Abstract. In order to study the effects of different amount of functional materials (FM) on pearl oil apricot, the study set up 0 g (control), 50 g (FM50), 200 g (FM200) and 300 g (FM300) of functional materials, and mixed with 2 kg of compound fertilizer as the base fertilizer. The growth and physiological indexes of pearl oil apricot and soil physicochemical properties were measured. Results showed that FM treatment significantly improved the pollen viability especially under FM300 treatment. FM200 and FM300 treatments significantly improved leaf carotenoids, anther size and anther quality of 100 seeds compared with the control. The anther width was significantly increased by 0.13 mm at FM300. However, physiological indexes such as filament length, anther length, pistil development type, hundred leaves length, hundred leaves width, hundred leaves thickness, hundred leaves weight and pollen fullness were not affected by FM. It can be seen that FM had a greater effect on growth and physiology indicators of pearl oil apricot, while the effect on soil physicochemical properties was smaller.

Keywords: pearl oil apricot; functional material; soil physicochemical properties; photosynthetic pigment.

1. Introduction

Pearl oil apricot (Armeniaca vulgaris Lam.), a new variety of apricot, commonly known as pearl apricot, flowers are single flowers, flower first, then leaf, large pollen amount and self-pollination but low fruit sitting rate.

The abortion of apricot pistils has always been an important issue of concern related to apricot production. Improve pistil abortion is an important measurement for higher fruit setting rate and yield [4]. The phenomenon of pistil abortion usually related to factors such as genetics, environment, hormones, and nutrition. Autumn application of base fertilizers can significantly increase the storage nutrition of the tree. Applying base fertilizers to apples can act on parts such as flower buds, inflorescences, leaves, and germinating leaf buds. The nitrogen fertilizer in autumn application of base fertilizers can also become a nutritional source for the storage nutrition, flower bud differentiation and flowering, and leaf growth of the apple tree in the following year [5], Flower bud differentiation and growth development have a certain impact on the quality and yield of fruits [6], and tree nutrition can also affect pollen quality and complete flower rate. Some studies have shown that both pollen quality and complete flower rate can affect the fruit setting rate of apricot trees [7]. Applying base fertilizer in early autumn can effectively reduce the proportion of abortive flowers in apricot trees [8].

In this study, functional materials and composite fertilizers were mixed as base fertilizers to study the effects of different application rates of functional materials on the growth physiology and soil physicochemical properties of pearl oil apricot. Furthermore, the effects of functional materials combined with fertilizers on the nutrition of pearl oil apricot trees and flower bud development were further explored, in order to provide a theoretical basis for the yield increase and optimization of pearl oil apricot.

2. Materials and Methods

The research object is five-year-old pearl oil apricot, planted at the experimental base of the School of Agriculture and Forestry, Linyi University (34°48′ N, 117°54′ E). The compound fertilizer is 18-8-25 with total nutrients ≥ 51% of N, P2O5, and K2O. The functional material used in the experiment is a porous sheet-like substance rich in O, Si, Al, and C elements.

2.1 Experimental design

This study set up four treatments and each treatment repeated three times. Under the same compound fertilizer application rate of 2 kg per tree, functional materials(FM) of 0 g (CK), 50 g (T1), 200 g (T2) and 300 g (T3) treatments were established. The experiment was conducted in early November 2022, using a circular ditch application method to apply mixed fertilizers to a soil layer of 0-20 cm.

2.2 Sample and measurements

Based on the length relationship between the stamens and pistils, the pistil development can be divided into: female high type, equal high type, female low type, and female recession type (Table 1). The first two of them are considered as complete flowers, then calculate the complete flowering rate of each pearl oil apricot plant.

Complete flower rate (%) = (number of complete flowers / total flowers)

Table 1. Pistil development types and judgment criterion

Pistil development type	Criterion
Female high type	Pistil length>stamen length
Equal high type	Pistil length=stamen length
Female low type	Pistil length<stamen length
Female recession type	Extremely short or absent pistils

20 pearl oil apricot flowers are randomly collected from the long, medium, and short branches of a single pearl oil apricot in the east, south, west, and north directions during blooming stage. Cut all filaments from the root of the filaments and measure the length of filament. Pick off the anthers, weigh 100 anthers, and measure the length and width of anther.

Randomly remove 5 anthers and place them on a glass slide, add distilled water and stir evenly to disperse the pollen. Then, add 1-2 drops of 0.5% TTC solution, cover the glass slide, and place it in a 28 ℃ water bath. After 15 minutes, using a 4 × 16 low-power microscope and observe the pollen grains. Red colored pollen indicates active pollen, while colorless pollen indicates no vitality; Full and solid pollen is normal and full pollen, while empty and shriveled pollen is deformed pollen grain.

Pollen viability (%) = (number of active pollen / total pollen grains) × 100%

Pollen plumpness (%) = (non deformed pollen grains / total pollen grains) × 100%

Chlorophyll a, chlorophyll b, and carotenoids from fresh leaf samples were extracted by 95% ethanol. The extracts were then measured at 665nm, 649nm, and 470nm using a spectrophotometer. Pigment concentrations of chlorophyll a, chlorophyll b, and carotenoids are calculated using the following formulas:

Chla (mg • L-1)=13.95 × A665-6.88 × A649

Chlb (mg • L-1)=24.96 × A649-7.32 × A665

Car (mg • L-1)=(1000 × A470-2.05 × Chla-114.8 × Chlb)/245

Soil pH was measured with sieved moist soil (< 2mm) at 1:2.5 soil/water ratio. The ammonium N and nitrate N was determined by the colorimetric method [9]. The content of available P in soil was determined by anionic exchange resin strips combined with molybdenum blue colorimetry [10].

2.3 Statistical analyses

The differences among treatments were tested by one-way ANOVA using SPSS 16.0 (SPSS Inc., Chicago, Ill., USA).Means separation was determined using Tukey or Dunnett's T3 test based on the results of homogeneity of variances ($p< 0.05$). Values are shown as mean ± standard error in this paper.

3. Results

3.1 Pistil development

Seen from table 2, four types of pistil development among four treatments had no significant difference. The complete flower rate of CK, T1, T2, T3 was 48.1%, 50.4%, 50.7% and 48.6%, respectively. There was no significant difference among treatments. Thus, functional materials had no effects on pistil development type.

Table 2. Pistil development types of different treatments

Treatment	Female high	Equal high	Female low	Female recession	Complete flower rate
	(%)				
CK	18.2±5.04a	16.3±4.17a	17.2±1.30a	48.1±0.47a	34.6±1.24a
T1	13.8±4.11a	14.3±2.51a	21.3±2.88a	50.4±2.17a	28.3±1.93a
T2	18.3±3.80a	13.1±3.36a	17.8±2.13a	50.7±1.79a	31.4±0.80a
T3	17.7±3.29a	15.0±4.64a	18.5±5.08a	48.6±3.29a	32.8±1.92a

3.2 Anther indicators

Data in table 3 showed that FM had no influence on anther length, but influence anther width and 100 anthers weight significantly, especially under 200 and 300g per plant treatments. The pollen viability can be increased by all FM treatments while pollen plumpness was not affected by FM addition.

Table 3. Anther physical indicators, pollen viability and pollen plumpness influenced by FM

Treatment	length	width	100 anthers weight	Pollen viability	Pollen plumpness
	(mm)	(mm)	(mg)	(%)	(%)
CK	1.50±0.02a	1.22±0.03b	27.4±1.99b	57.5±7.49b	75.8±2.22a
T1	1.52±0.01a	1.28±0.02ab	30.2±2.00ab	72.7±2.35a	77.6±1.52a
T2	1.52±0.01a	1.29±0.01ab	36.7±1.74a	77.3±1.65a	80.9±0.57a
T3	1.54±0.02a	1.35±0.01a	38.6±1.72a	80.0±1.09a	78.2±4.31a

3.3 Chlorophyll contents

Functional materials showed positive effects on leaf chlorophyll contents that T3 had most Chla, Chl and carotenoids, which significantly higher than CK (Figure 1). T2 treatment only showed significant influence on carotenoids compared with CK treatment. It is worth noting that FM had no effect on Chlb and T1 treatment had no significant effects on Chla, Chlb, Chl and carotenoids.

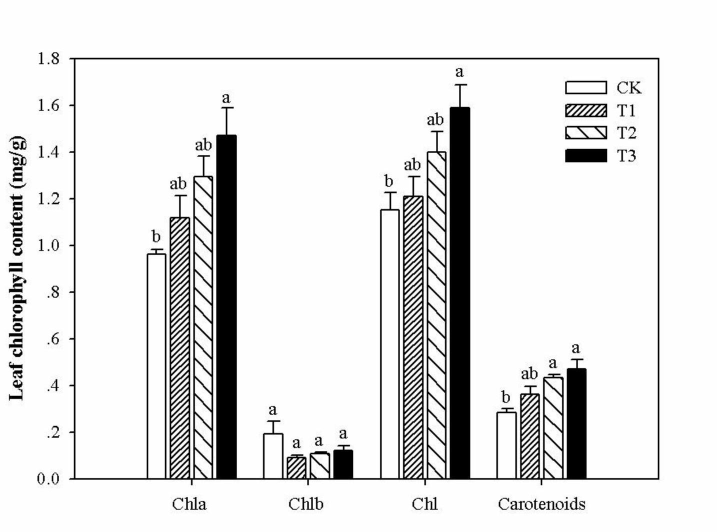

Fig. 1 Leaf chlorophyll contents influenced by FM

3.4 Soil properties

From table 4, clear trend showed that FM can significantly decrease the soil pH, while there was no difference among different amount of FM. There was no difference on NH4+-N among treatments. FM application significantly decreased NO3—N concentration compared to CK treatment. For resin-P concentration, only T2 was higher than CK, but T1 and T3 has higher concentration but there was no significant difference.

Table 4. Soil properties of different treatments

Treatment	pH	NH_4^+-N	NO_3^--N	resin-P
		mg/kg	mg/kg	mg/kg
CK	7.4±0.2a	17.2±1.64a	4.43±0.28a	18.1±0.17b
T1	6.5±0.1b	16.4±1.17a	3.26±0.10b	19.3±0.93ab
T2	6.6±0.2b	13.6±1.18a	3.44±0.18b	21.4±0.40a
T3	6.5±0.1b	15.3±0.34a	3.69±0.15ab	20.3±1.37ab

3.5 Relationship between soil properties and anther indicators

This article takes the stamen index and chlorophyll content of pearl oil apricot leaves as the dependent variables (prediction results), and the soil physical and chemical indicators as the independent variables (control factors) to perform Pearson correlation analysis. Results showed that Anther length was negatively influenced by soil pH but positively affected by soil available P contents. Pollen viability was only influenced by soil NO3—N contents negatively. The leaf Chla and carotenoids were negatively correlated with soil pH while Chlb was positively related with soil NO3—N contents.

Table 5. Correlation between crop indexes and soil properties

Indexes	pH	NO_3^--N	resin-P
Anther length	-0.641*		0.688*
Pollen viability		-0.582*	
Chla	-0.634*		
Chlb		0.717**	

Cartenoids	-0.602*		

4. Discussion

4.1 Effect of FM on the pistil and stamen of pearl oil apricot

Apricot flowers are single and hermaphroditic, with both male and female flowers. Both male and female stamens can develop simultaneously and undergo self pollination. However, there are multiple varieties of apricot that have low or even non fruiting self pollination or cross pollination, as well as the phenomenon of mutual incompatibility and unilateral incompatibility [12]. This often manifests as self fertilization infertility or low self pollination fruiting rate, resulting in lower yield of apricot trees. Among them, pollen viability plays an extremely important role in the pollination and fertilization process of apricot trees. Therefore the level of pollen vitality directly affect the pollination and fertilization process of apricot flowers, and even the fruit setting rate in the later stage [13]. The application of functional materials can significantly improve the pollen viability of apricot stamens, especially the treatment with a dosage of 300 g of functional materials, which has the best effect on improving pollen viability. This indicates that the application of functional materials can promote pollination and fertilization of pearl oil apricots, and has a positive impact on fruit setting rate.

4.2 Effect of FM on photosynthetic pigments of pearl oil apricot leavess

This study found that the chlorophyll content and carotenoids content were significantly increased under the treatment of functional materials compared to the control. Bakır et al. (2022) found that applying silicon to apricot trees can significantly increase the chlorophyll content of apricot leaves [14]; Other studies also found that silicon application can promote nitrogen absorption by apple plants and significantly increase chlorophyll content in leaves [15]; Zhu et al. (2010) found that the chlorophyll content in sugar beets was high in nitrogen fertilization treatment, and the photosynthetic rate of plants also increased, indicating a certain relationship between chlorophyll and nitrogen levels [16]. The functional materials used in this experiment contain 27.7% Si, which may have a certain relationship with promoting chlorophyll synthesis. On the other hand, FM promoted nitrogen absorption, which is beneficial for the synthesis of Rubisco enzymes in chloroplast photosynthetic organs [17]. The increase in chlorophyll content in pearl oil apricot leaves contributes to the accumulation of tree nutrients and the synthesis of dry matter, which is of great significance for promoting fruit tree growth and improving fruit quality.

4.3 Effects of FM on soil properties

Functional materials reduced soil pH and nitrate nitrogen content. Soil pH decrease possibly due to the high content of elements such as Al, Si, and Ca in functional materials that can exchange with Na^+ in the soil, thereby reducing the soil pH value [18]. The nitrate nitrogen content in the soil was significantly lower under FM treatments compared to the control. As discussed earlier, functional materials can promote the absorption of nitrate nitrogen by pearl oil apricots, thereby promoting the synthesis of chlorophyll. However, there was no significant difference in soil ammonium nitrogen content among the treatments.

5. Conclusion

One functional material rich in O, Si, Al, and C elements was applied into soil to five-year-old pearl oil apricot. Results showed that FM influence more on anther width, 100 anthers weight and pollen viability rather than pistil development types and pollen plumpness. In addition, FM have positive effects on leaf chlorophyll content, thus might influence the production. The influence of FM on soil properties showed that FM could affect soil pH, nitrate nitrogen and available P contents. Further research should be conduct to study the long-time effects of FM.

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