Stereoscopic Planting Pattern of Kernel-used Apricot and Medicinal Plants in the Loess Drought Hilly Region in West Henan Province

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Abstract- **[Objective] To guarantee the high yield of quality kernel-used apricot and improve the economic benefits of farmers in the loess drought hilly region in West Henan Province.[Method] The stereoscopic planting pattern with eight cultivars of medicinal plants and three cultivars of kemel-used apricot was adopted to study the effect of different planting pattems on the growth, flowering, fruiting, disease and pest injury as well as the yield of the medicinal plants, [Result] To the same apricot species, *Salvia miltiorrhiza* Bge. and *Pinellia ternata* (Thunb.) Breit. produced weak impact on its growth, but Vaccaria segetalis (Neck.) Garcke and *Malva rotundifolia* L. had obvious influence on its growth and development. The same cultivars of medicinal plant had strong inference on the growths of kernel-apricot cultivars "Yiwofeng" less strong influence on ' Longwang-mao", and the weakest influence on "Chaoren"; the reproductive indexes of the three kernel-apricot cultivars were influenced by the same Chinese medicinal material followed the decrease scope of "Yiwofeng" <" Chaoren" < ' Longwangmao". Under the stereoscopic planting pattern, as the canopy density of kernel-used apricot increased, the weight and medicinal yield of the herbal plants gradually decreased, most of the medicinal plant cultivarsgrew well under the canopy density of 0.5 or below, while the growth and yield of *Pinellia ternata*(Thunb.) Breit. were not influenced under the canopy density of 0.6. [Conclusion] The stereoscopic planting pattern of kernel-used apricot and traditional Chinese medicinal plants should select the apricot cultivars with strong growth vigor and those short herbal plants species.**

Key words- Kernel-used apricot, Chinese medicinal plants, Stereoscopic planting, Loess drought hilly region, China

I. INTRODUCTION

Lage-area western loess drought hilly region is an important forestry distinct in Henan Province. Along with the implernentation of returning farmland to forest and constructing shelter forest projects on the upper-middle reaches of Yellow River,large areas construct kernel-used apricot forest that has both economic benefit and ecological benefit. During the process of cultivation and management, many farmers plant crops such as wheat and com in row spaces of kernel-used apricot that is not only bad for the growth of apricot tree but also not in compliance with the existing management requirements for returning farmland to forest and constructing shelter forest projects on the upper-middle reaches of Yellow River. In view of this, studies on the stereoscopic planting pattern with medicinal plants and kemel-used apricot are carried out in loess drought hilly region that is located in Dougou Village, Hancheng Town, Yiyang County, whose aim is to guarantee the high yield of quality kernel-used apricot and improve the economic benefits of farmers in west Henan Province on the conditions of meeting management requirements for returning farmland to forest projects.

II. MATERIALS AND METHODS

A. Materials

Study location. This test was performed in loess drought hilly region that is located in Dougou Village, HanchengTown, Yiyang County (11204' E, 34027'N), south and northfacing slopes, slope gradient of 150-200, altitude of 260 m,annual average temperature of 14.4℃, extreme minimum temperature of -18.4℃, extreme maximum temperature of 43.7℃, frostless period of 224 d, annual average precipitation of 660 mm (Mainly concentrated in 3 months including July, August and September), soils pH of 7.1, soil layer from 0 to 0.4 m containing 3.1 g/kg organic matter, 38.5 mg/kg available N, 15.3 mg/kg available P and 105.8 mg/kg available K. In addition, the area of study location was 30 $hm^{2.}$

Study objects. In middle November,2004, grafted seedlings from three cultivars of kernel-used apricot including "Yiwofeng", "Chaoren" and "Longwangmao" were planted inloess drought hilly region based on row spacing of 4 m x 3 m(Rows in an east-west direction). Besides, the height of tree trunk was kept at 0.8 m through pruning sparse canopy shape.By 2006, 2007 and 2008, eight cultivars of Chinese medicinal plants were planted in rows of kernel-used apricot, including Dendranthema morifolium (HUANG SHAN GONG JU), Salviamiltiorrhiza Bge. (RADIX ET RHIZOMA SALVIAE MILTIoRRHI-ZAE), Pinellia ternata (Thunb.)Breit.(RHIZOMAPINELLIAE),Scutellaria baicalensis Georgi(RADIX SCUTELLARIAE), Vaccaria segetalis (Neck.) Garcke (SEMEN VACCARIAE) , Platycodon grandiflorum(Jacq.) A.DC. (RADIX PLATYCODONIS),Isatis indigotica.fort(RADIX ISATIDIS) and Malva rotundifolia L (ASTRAGALUS MEMBRANACEUS).

B. Methods

Design of stereoscopic planting pattern with medicinal plants and kernel-used apricot.

Design philosophy of stereoscopic planting pattern.In accordance with systems science, the function of system is determined by structure. In other words, the function of system is maximized at the optimum structure. In order to reflect the types, size and correlations of constituents, the following phiIosophies are put forward for screening Chinese medicinal plants: ① Chinese medicinal plants should be able to bear shade to some extent; ② The height of medicinal plants should be lower than that of the first main branch of kernel-used apricot, which has little influence on the growth of apricot tree; ③ Cultivation technique of medicinal plants should be simple, convenient, economic and easy to be carded out;④ Stereoscopic planting pattern takes advantages of stable structure and long efficacy periods.

Structure design of stereoscopic planting pattern.

Pattern I: "kernel-used apricot-*Dendranthema morifolium*" [1]. *Dendranthema morifolium* seedlings were planted in rows of kernel-used apricot trees at the row-line spacing of 40 cm×30 cm, which were 50 cm far away from apricot trees as protective zone.

Pattern II: "kernel-used apricot-*Salvia miltiorrhiza* Bge.". *Salvia miltiorrhiza* Bge. seedlings were planted in rows of kernel-used apricot trees at the row-line spacing of 25 cm×15 cm, which were 30 cm far away from apricot trees as protective zone.

Pattern III: "kernel-used apricot-*Pinellia ternata* (Thunb.) Breit.". *Pinellia ternata* (Thunb.) Breit. seeds were sowed in line between rows of kernel-used apricot trees as great as 1 500 kg per hm^2, which were 20 cm far away from apricot trees as protective zone.

Pattern IV: "kernel-used apricot-*Scutellaria baicalensis* Georgi". *Scutellaria baicalensis* Georgi seedlings were planted in rows of kernel-used apricot trees at the row-line spacing of 25 cm×15 cm, which were 30 cm far away from apricot trees as protective zone.

Pattern V: "kernel-used apricot- *Vaccaria segetalis* (Neck.) Garcke". *Vaccaria segetalis* (Neck.) Garcke seeds were sowed with a drill between rows of kernel-used apricot trees as great as 30 kg per hm^2, which were 50 cm far away from apricot trees as protective zone.

Pattern VI: "kernel-used apricot- *Platycodon grandiflorum* (Jacq.) A.DC." [2]. *Platycodon grandiflorum* (Jacq.) A.DC. seedlings were planted in rows of kernel-used apricot trees at the row-line spacing of 30 cm×10 cm, which were 50 cm far away from apricot trees as protective zone.

Pattern VII: "kernel-used apricot- *Isatis indigotica* Fort.". *Isatis indigotica* Fort. seeds were sowed with a drill between rows of kernel-used apricot trees as great as 30 kg per hm^2, which were 30 cm far away from apricot trees as protective zone.

Pattern VIII: "kernel-used apricot- *Malva rotundifolia* L." [3]. *Malva rotundifolia* L. seedlings were planted in rows of kernel-used apricot trees at the row-line spacing of 40 cm×20 cm, which were 30 cm far away from apricot trees as protective zone.

Investigation contents. 5 vigorous and uniform plants for each variety in each pattern were chosen as objects for measuring the diameter of trunk that was 5 cm above the ground during the period from November 25 to December 1, and calculating the net increment of trunk, length of new shoots (Defined as the length of developmental branch by selecting 10 branches of that year at random) and thickness of new shoots (Defined as the base diameter of developmental branch).

At full-flowering stage, 200 flowers were randomly selected as investigated objects for calculating pistil abortion rate. Then, fruit-setting rate, apricot stone rate, kernel rate, average kernel yield per plant and single kernel weight were respectively determined.

10 middle-upper branches in total from east, west, south and north of each plant were chosen as objects for investigating the number of pests during stage of diseases and pests occurrence, which was accumulated for the whole year as population density of pests. After collecting, the diseased and pest-damaged fruit rates were checked at random.

For Chinese medicinal plants planted in rows at different canopy densities, a total of 30 plants were randomly selected from each variety in 3 replicates and used for measuring the fresh weight per plant during the vigorous growth period and yield of medicinal parts during harvesting period.

III. RESULTS AND ANALYSES

A. *Effects of different stereoscopic planting patterns on the growth of kernel-used apricot plants*

As shown in Table 1, the vegetative growth indexes of kernel-used apricot plants were varied for different stereoscopic planting patterns. The net increment of trunk was the maximum for "Chaoren" and "Longwangmao" kernel-used apricot that was planted in pattern VII, followed by pattern III as the second that was the optimum for "Yiwofeng" and pattern VIII. In addition, the differences between other treatments were not obvious. Kernel-used apricot whose length and diameter of new shoot was relative higher in patterns II, III and VII, followed by patterns I, IV and VI, and the least in patterns V and VIII. In the same pattern, the vegetative growth indexes were the highest for "Chaoren" kernel-used apricot, followed by "Longwangmao" and the least in "Yiwofeng".

B. *Effects of different stereoscopic planting patterns on the flowering and fruiting of kernel-used apricot plants*

As shown in Table 2, there were obvious difference in the quality of flower buds, fruit-setting rate, average kernel yield per plant and single kernel weight between kernel-used apricot plants in different stereoscopic planting patterns. The pistil abortion rate of kernel-used apricot plants was the highest in pattern VIII, followed by pattern IV, V, VI, VII, and the least in pattern I, II, III. Fruit-setting rate of kernel-used apricot plants was the highest in pattern III, VII, followed by IV, VI, and the least in pattern V, VIII. The average kernel yield per plant was the largest in pattern III and II, and lowest in pattern V and VIII. The apricot stone rate was the lowest in pattern VII and largest in pattern V, whose difference was not obvious between other patterns. The kernel rate was the highest in pattern III and II, and lowest in pattern V, and others were similar. Single kernel weight of kernel-used apricot plants was the highest in pattern III, followed by pattern VII, and the least in pattern V and VIII. In addition, the difference in single kernel weight was not significant between other patterns. "Yiwofeng" kernel-used apricot was the optimum that was low in pistil abortion rate, high in fruit-setting rate, kernel stone rate and kernel rate, followed by "Chaoren" and "Longwangmao".

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Table 1 Effects of different stereoscopic planting patterns on the growth of kemel-used apricot plants cm

pattem	Net increment of trunk			Length of new shoot			Diameter of new shoot		
	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng
Ⅰ	0.95	0.94	0.91	69.27	59.27	49.67	0.89	0.87	0.82
Ⅱ	0.99	0.95	0.87	71.67	65.40	54.33	0.95	0.89	0.87
Ⅲ	0.98	0.94	0.92	73.87	68.43	54.47	0.96	0.93	0.87
Ⅳ	0.96	0.94	0.90	68.23	60.90	48.87	0.94	0.92	0.86
Ⅳ	0.96	0.92	0.87	57.07	50.07	44.30	0.82	0.79	0.75
Ⅵ	0.94	0.90	0.85	67.53	62.33	51.47	0.91	0.88	0.81
Ⅶ	1.00	0.95	0.91	71.60	66.20	53.80	0.94	0.94	0.90
Ⅷ	0.94	0.87	0.85	67.27	57.90	46.03	0.88	0.84	0.79

Note:Data in the table is the average of the three years from 2006 to 2008.

Table 2 Effects of different stereoscopic planting patterns on the flowering and fruiting of kernel-used apricot plants

pattem	Pistil abortion rate//%			Fruit-setting rate//%			Average kernel yidld per plant//kg		
	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng
Ⅰ	7.67	6.83	7.00	18.45	17.10	19.15	0.80	0.66	0.87
Ⅱ	7.50	7.67	6.67	18.05	16.85	19.20	0.86	0.70	0.85
Ⅲ	8.00	7.33	6.83	18.60	17.95	21.15	0.90	0.84	0.93
Ⅳ	7.33	8.67	9.50	19.25	18.45	18.00	0.69	0.70	0.74
Ⅳ	8.33	7.67	9.00	17.15	16.95	15.05	0.71	0.55	0.60
Ⅵ	8.33	9.33	7.17	17.40	18.00	20.30	0.78	0.65	0.78
Ⅶ	7.83	8.50	7.33	19.00	17.00	20.00	0.82	0.64	0.81
Ⅷ	9.67	10.67	8.17	17.15	16.70	19.35	0.68	0.63	0.66

pattem	Apricot stone rate//%			Keenel rate//%			Single kernel weight//g		
	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng
Ⅰ	18.15	19.65	19.40	31.80	28.10	32.85	0.89	0.81	0.75
Ⅱ	18.00	18.20	19.75	30.75	29.20	33.00	0.89	0.81	0.75
Ⅲ	18.55	18.95	19.50	31.80	30.00	33.50	0.90	0.82	0.76
Ⅳ	18.75	19.10	19.65	30.85	28.20	28.65	0.88	0.80	0.73
Ⅳ	20.05	20.00	21.10	28.30	27.40	28.10	0.85	0.79	0.71
Ⅵ	18.40	18.60	19.25	30.55	28.10	32.00	0.87	0.81	0.74
Ⅶ	18.30	18.35	19.15	30.25	28.35	32.65	0.88	0.83	0.74
Ⅷ	18.50	18.30	20.15	30.10	27.85	31.75	0.87	0.80	0.73

Note:Due to the cold injury in 2007, the detected pistil abortion rate is the average of the three years from 2006 to 2008, other data are the two years average of 2006 and 2008. The same in the following table.

Table3 Diseases and pests damage of kernel-used apricot cultivars under different stereoscopic planting plants

pattem	Aphids			Mite			Defoliators		
	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng
Ⅰ	23.45	20.95	29.90	14.40	11.95	20.40	1.05	0.65	1.10
Ⅱ	4.7	6.00	9.55	4.85	3.95	4.05	0.45	0.55	0.35
Ⅲ	11.00	9.35	11.90	10.60	10.40	10.35	0.40	0.20	0.00
Ⅳ	13.60	10.15	12.65	12.45	9.60	11.00	0.65	0.65	0.45
Ⅳ	1.25	1.80	1.30	2.35	3.65	2.15	0.10	0.00	0.50
Ⅵ	11.35	11.30	11.35	12.85	10.30	10.75	0.95	0.80	0.60
Ⅶ	17.00	15.75	24.25	9.00	8.25	10.00	1.50	0.50	1.15
Ⅷ	16.85	14.90	18.25	8.75	11.00	13.00	0.25	0.00	0.00
pattem	Scale insects			Diseased fruit rate // %			Rate of pest-damaged fruits // %		
	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng	Chaoren	Longwangmao	Yiwofeng
Ⅰ	0.00	1.10	1.90	0.35	0.90	1.20	1.75	1.80	2.60
Ⅱ	0.70	0.90	1.50	0.85	0.75	1.40	1.10	1.35	1.90
Ⅲ	0.60	1.55	0.95	0. 90	1.15	1.25	1.35	1.65	2.10
Ⅳ	2.05	1.35	1.55	0.75	0.90	1.35	1.20	1.60	1.80
Ⅳ	0.70	0.95	1.40	0. 95	0.80	1.35	1.30	1.80	2.00
Ⅵ	0.80	1.05	0.85	0.85	0.80	1.75	1.15	1.30	1.95
Ⅶ	1.35	0.80	1.10	1.00	1.25	1.15	1.90	2.15	2.25
Ⅷ	1.05	0.90	1.15	0.65	0.85	1.45	1.35	1.35	1.70

Note: Due to the cold injury in 2007, the date in the table is the average of 2006 and 2006.

C. Diseases and pests damage of kernel-used apricot cultivars under different stereoscopic planting patterns

As shown in Table 3, the disease and pest damage indexes of kernel-used apricot were varied in different stereoscopic planting patterns under the integrate conditions of disease and pest control. From Table 3, the occurrence density of aphids was the highest in kernel-used apricot planted in pattern I and lowest in Pattern II and V. Mite occurred seriously on kernel-used apricot trees that were planted in pattern I and occurred rarely in pattern II and V. In addition to pattern I, II and V, differences regarding the incidence density of mite in other patterns were not significant. The incidence density of defoliators was relatively higher in pattern I, VI, VII and lower in pattern III, V, VIII. Except pattern IV with higher incidence density of scale insects, there were no significant differences about the incidence density of scale insects in kernel-used apricot trees that were planted in other patterns. Besides, the differences regarding the diseased fruit rate and pest-damaged fruit rate between kernel-used apricots in different patterns were not significant.

D. Effects of different canopy density on the yields of eight Chinese medicinal plants

As shown in Table 4, as the canopy density of kernel-used apricot increased, the weight and medicinal yield of herbal plants gradually decreased. Most of medicinal plant cultivars could grow well under the canopy density of 0.5 or below, while the growth and yield of *Pinellia ternata* (Thunb.) Breit. were not influenced under the canopy density of 0.6. Generally, kernel-used apricot with the canopy density of more than 0.5 would seriously influence the growth and medicinal yield of medicinal plants, or even lead to abnormal growth and development if the canopy density was more than 0.7.

Table4 Effects of different canopy density on the yields of eight Chinese medicinal plants

Canopy density	2-year-old *Salvia Miltiorrhiza Bge*		*Scutellaria baicalensis* Georgi		*Malva rotundifolia* L.		*Vaccaria segetalis* (Neck.)Garcke	
	Fresh weight	Medicine yield	Fresh weight	Medicine yield	Fresh weight	Medicine yield	Fresh weight	Medicine yield
0.3-0.4	593	177	260	90	687	133	510	21.0
0.5-0.6	460	143	177	80	660	167	370	15.0
0.7-0.8	367	110	130	60	350	103	186	8.1
≥0.9	190	100	67	25	160	50	23	0

Canopy density	*Platycodon grandiflorum* (Jacq.) A.DC.		*Pinellia ternata* (Thunb.) Breit.		*Isatis indigotica* Fort.		*Dendranthema morifolium*	
	Fresh weight	Medicine yield	Fresh weight	Medicine yield	Fresh weight	Medicine yield	Fresh weight	Medicine yield
0.3-0.4	187	123	25	20	325	19	2 348	689.0
0.5-0.6	133	73	28	23	248	16	1 674	382.0
0.7-0.8	97	39	15	12	173	12	840	29.0
≥0.9	65	15	3	3	92	5	915	5.6

IV. CONCLUSIONS AND DISCUSSIONS

(1) This stereoscopic planting pattern presented obvious influences on the vegetative growth, reproductive growth of kernel-used apricot plants and commodity quality. Judging from experimental results, the growth, flowering, fruiting, and commodity quality of kernel-used apricot cultivars was influenced mostly by *Vaccaria segetalis* (Neck.) Garcke and *Malva rotundifolia* L. planted in rows, followed by *Dendranthema morifolium*, *Scutellaria baicalensis* Georgi, *Platycodon grandiflorum* (Jacq.) A.DC. and *Isatis indigotica* Fort., and the least by *Salvia miltiorrhiza* Bge. and *Pinellia ternata* (Thunb.) Breit.. This may be because that the first two medicinal plants whose growth increment was large and height was high affected the growth of kernel-used apricot.

(2) The same cultivars of medicinal plant had strong inference on the growth of kernel-apricot cultivars "Yiwofeng", less strong influence on "Longwangmao", and the weakest influence on "Chaoren". Besides, it showed the weakest influence on the reproductive growth and commodity quality of "Yiwofeng" kernel-used apricot.

(3) In stereoscopic planting pattern, vigorous cultivars of kernel-used apricot should be planted with tall and vigorous medicinal plants, and weak cultivars are generally planted with low and weak medicinal plants or to increase row spaces to reduce its stress effects on the growth of tree body. Under the stereoscopic planting pattern, the canopy density of 4 to 5 year-old kernel-used apricot could reach about 0.7. In most gardens, kernel-used apricot should be planted with medicinal plants in stereoscopic pattern prior to full fruiting periods in order to achieve the goal of ensuing high quality and high yield [4].

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