



Agricultural Management Technology of Fertilizer-saving and Efficiency- improving in Orange Production

Zuzhang LI

**Soil Fertilizer and Environmental Resources Institute,
JXAAS**



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I. preface

orange is the second fruit and only next to apple in China, but both its planting area and the yield is at the first position in the world

Jiangxi has the long history in planting citrus and is rich of germplasm resources. It is one of the important and advantage planting region in China. The planting area is at the second position and the yield is at the third position in China.

According to the statistical results in 2013, the total planting area in Jiangxi was about 331,300 hectare, among which the navel orange was 93,300 hectare, the Nanfeng honey orange was 71,300 hectare, and the others, including the Xinyu honey orange, the Wenzhou honey orange and all kinds of sweet grapefruit, was 166,700 hectare.



I. preface

Existing problems in citrus planting

- (1) Varieties: quality degradation, unreasonable variety structure, and slow variety replacement
- (2) Seedling: production is not standardized; the variety is impure and the quality is uneven; operation is lack of supervision.
- (3) Management Technology: low popularity of new technologies; low degree of mechanization; and low degree of standardization



II. Developing process of nutrients management technology of citrus

1. status of fertilization

investigation on the fertilization status of citrus in Jiangxi (kg/tree) 2000~2001

variety	House hold	manure		Compound fertilizer	Urea	P fertilizer	K fertilizer	N	P ₂ O ₅	K ₂ O
		dung	Oil cake							
Nanfeng honey orange	12	6.0	1.2	0.8	0.4	0.83	0.2	0.385	0.261	0.293
Navel orange	15	14.0	0.4	1.0	0.5	1.0	0.2	0.461	0.307	0.360
ponkan	8	6.4	0.2	0.4	0.4	0.5	0.15	0.282	0.137	0.191
Wenzhou honey orange	13	6.8	0.1	0.5	0.4	0.5	0.1	0.295	0.151	0.177
average		8.3	0.48	0.38	0.42	0.71	0.16	0.356	0.214	0.255



II. Developing process of nutrients management technology of citrus

2. conventional fertilization: generally three times, the detail date is followings

(1) fruit-picking fertilizer: its purpose is to restore the tree vigor so as to enhance the cold-resistance and be exempt from the freeze injury in winter. It is usually applied at 7-10 days before the fruit-picking, accounting for 40% of the total amount of fertilizer. The organic fertilizer and compound fertilizer are the main sources.

(2) Bud fertilizer: is to promote the spring bud and blossom. It is usually done in the early March, accounting for 20% of the total amount of fertilizer. The chemical fertilizer is the main source.

(3) fruit-swelling and shoot-promoting fertilizer: is to promote the fruit swell and the autumn shoot grow. It is usually done in the early July, accounting for 40% of the total amount of fertilizer. The organic fertilizer and chemical fertilizer are the main sources.



II. Developing process of nutrients management technology of citrus

2、conventional fertilization :

Among of the 4 families of citrus planting in Jiangxi, the highest input cost in fertilization was navel orange, followed by Nanfeng honey orange, ponkan and Wenzhon honey orange one by one. The fertilizer input had a significantly positive correlation to product price and its economic benefits. The navel orange and the Nanfeng honey orange had comparative high economic benefits, so the fruit growers were willing to input more to them, while the Wenzhou honey orange and ponkan were on the contrary.

Additionally, the input proportion of organic fertilizer was low for all kinds of citrus.



II. Developing process of nutrients management technology of citrus

2、Conventional fertilization: main existing problems

- (1) Soil available nutrients were uneven among the different citrus gardens
- (2) Fertilizer input was unbalance, including among different varieties and different fertilizers.
- (3) N, P, and K application rates were not enough to meet with the demands of citrus growth in most of areas.
- (4) branches pruning and fruit-thinning were the main measures to keep the balance of tree nutrients and eliminate the biennial bearing. But most of the citrus growers were not fully aware of its importance.

II. Developing process of nutrients management technology of citrus



3. recommend fertilization

the recommended fertilization is generally divided into 4 or 5 times. The detailed date is following:

- (1) fruit-picking fertilizer: done at 7-10 days before fruit-picking. The sources are mainly the organic fertilizer and compound fertilizer, accounting for 30-40% for N, 60% for P and 30% for K respectively.
- (2) Bud fertilizer: done usually in the early March, accounting for 20% for N and 15% for K respectively. The chemical fertilizer is the main sources.
- (3) Fruit protecting fertilizer: done usually in early May, urea is the main source, accounting for 5%. However, it is not encouraged on navel orange.
- (4) Fruit-swelling and shoot-promoting fertilizer: done usually in early July. The organic fertilizer and chemical fertilizer are main sources, accounting for 30-40% for N, 40% for P and 30% f or K respectively.
- (5) Quality and efficiency-improving fertilizer: is to ensure the enough nutrients supply to fruit so as to improve the appearance and the interior quality of fruit. It is done usually in early September. Chemical N and K fertilizer are the main sources, accounting for 5% and 25% respectively.



II. Developing process of nutrients management technology of citrus

3. recommend fertilization

Additionally, besides above 4 or 5 times of recommend fertilization, foliage top-dressing is also done usually from May to July according to local production reality. The main foliage nutrients are Zn, B, Mu and other micro-elements fertilizer. Sometime, urea and potassium dihydrogen phosphate are applied as foliage top-dressing to promote fruit-swelling and shoot grow.

The ratio of NPK for 4 kinds of citrus in Jiangxi is following:

Nanfeng honey Orange N:P₂O₅:K₂O=1:0.68:0.76

Navel orange N:P₂O₅:K₂O=1:0.67:0.78

Ponkan N:P₂O₅:K₂O=1:0.48:0.68

Wenzhou honey orange N:P₂O₅:K₂O=1:0.51:0.60



III. Management technology of fertilizer-saving and efficiency-improving on citrus

Generally, citrus fertilization was a labor-intensive work. Fertilization times increase is bound to increase the labor input. It was difficult to adopted by growers and popularize. Additionally, most of growers were inclined to apply the fixed compound fertilizer such as N-P₂O₅-K₂O 15-15-15 or 16-16-16. it was easy to lead the waste of phosphorus resource because of excessive phosphorus.

Based on the above reasons, the development of slow controlled release and formula fertilizer was one of the main technical measures to reduce labor input and fertilizer waste and increase fertilizer use efficiency. With the application of drip irrigation technology, the technology of integration management of water and fertilizer became one of the main technical measures to save fertilizer and improve the efficiency.



III. Management technology of fertilizer-saving and efficiency-improving on citrus

1. Application technology of slow controlled release formula fertilizer

In accordance with the characteristics of red soil nutrients and citrus nutrients demand, a new slow controlled release and formula fertilizer was developed based on the original coated fertilizer. The field experimental results showed that all applied as the basal fertilizer, it increased the orange yield by 6.9% and the recovery of fertilizer by 10.8%, which would reduce the negative impact on the soil environment caused by the loss of fertilizer.

III. Management technology of fertilizer-saving and efficiency-improving on citrus



2. Mulching technology of green manure

(1) effect on the loss of soil nutrients

treatment: 1) natural exposed ; 2) natural exposed + citrus ; 3) bahia grass + citrus。3 replicates, the slope of runoff plot was 10° and the area of plot was 64m²(8m×8m)。

Effect of mulching green manure on surface runoff and soil erosion (Jiangxi Jinxian)

year	Treatment	Erosion amount (kg/hm ²)	Runoff amount (m ³ /hm ²)
2011	natural exposed	8756.4 a	598.5 a
	Natural exposed+citrus	5619.2b	201.4 b
	Bahia grass +citrus	60.9 c	87.3 c
2012	natural exposed	2641.8 a	385.6 a
	Natural exposed+citrus	1962.6 b	191.2b
	Bahia grass +citrus	78.5c	81.4 c
2013	natural exposed	2324.2a	360.3a
	Natural exposed+citrus	2010.2b	181.2b
	Bahia grass +citrus	56.7c	58.7c



III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(1) effect on the loss of soil nutrients

Effect on the loss of soil available nutrients (jiangxi Jinxian)

Year	Treatment	A. N (g/hm ²)	A. P (g/hm ²)	A. K (g/hm ²)
2011	natural exposed	1.85b	0.42a	6.73a
	Natural exposed+citrus	1.95a	0.30b	6.52a
	Bahia grass +citrus	0.41c	0.04c	2.94b
2012	natural exposed	1.38b	0.34a	6.15a
	Natural exposed+citrus	1.75a	0.28a	6.06a
	Bahia grass +citrus	0.40c	0.02b	2.57b
2013	natural exposed	1.32b	0.31a	5.03a
	Natural exposed+citrus	1.70a	0.26a	4.68a
	Bahia grass +citrus	0.34c	0.02b	2.25b



III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(1) effect on the loss of soil nutrients

Effects on the loss of total soil nutrients in citrus garden (Jiangxi Jinxian)

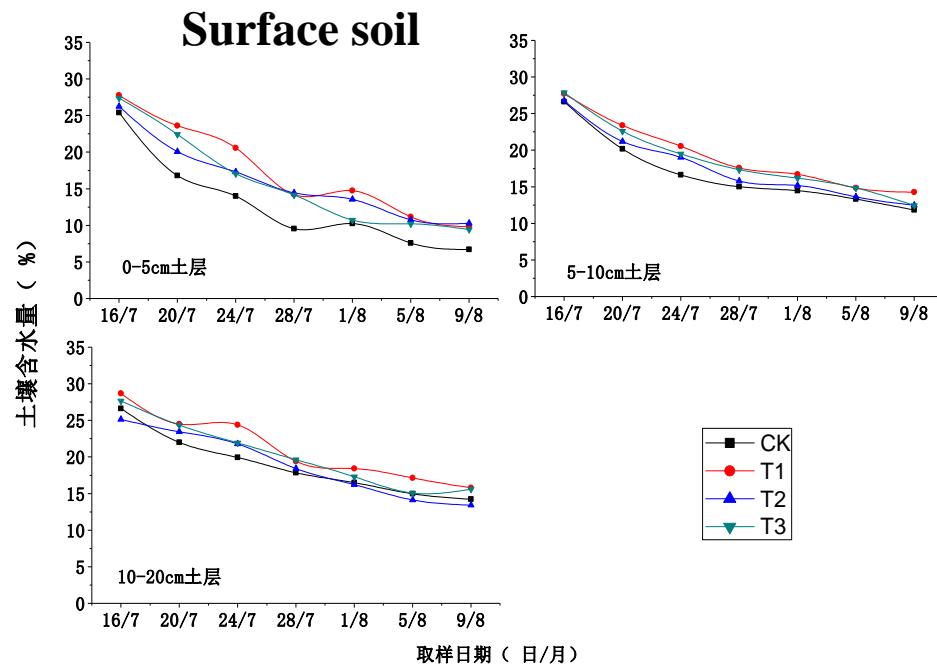
Year	Treatment	OM (g/hm ²)	T.N (kg/hm ²)	T.P (kg/hm ²)	T.K (kg/hm ²)
2011	natural exposed	131.3b	7.1b	3.4b	82.1b
	Natural exposed+citrus	148.2a	9.2a	4.2a	132.5a
	Bahia grass +citrus	34.6c	1.8c	1.0c	20.6c
2012	natural exposed	104.5a	5.5b	2.7a	81.3b
	Natural exposed+citrus	104.2a	8.0a	3.3a	118.6a
	Bahia grass +citrus	20.5b	1.1c	0.5c	20.4c
2013	natural exposed	98.7a	5.0b	2.5a	78.6b
	Natural exposed+citrus	97.8a	6.3a	3.0a	112.6a
	Bahia grass +citrus	21.6b	1.0c	0.4b	19.6c

III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(2) effect on the soil moisture

4 treatments : CK, villose vetch (T1), chamaecrista (T2), and white clover (T3). The area of plot was 60 m². the experiment was conducted in Nanfeng honey orange garden in Jinxian, the tested citrus tree was 5 year-old.

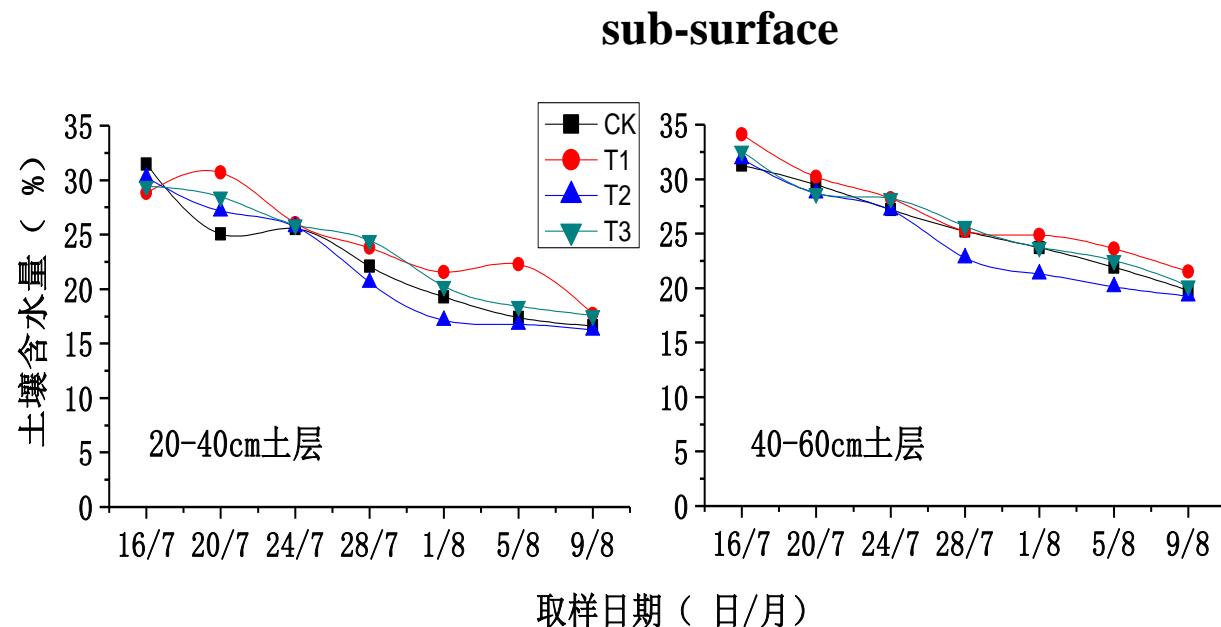


Effect of green manure mulching on the surface soil moisture under draught stress

III. Management technology of fertilizer-saving and efficiency-improving on citrus

2、 mulching technology of green manure

(2) effect on the soil moisture

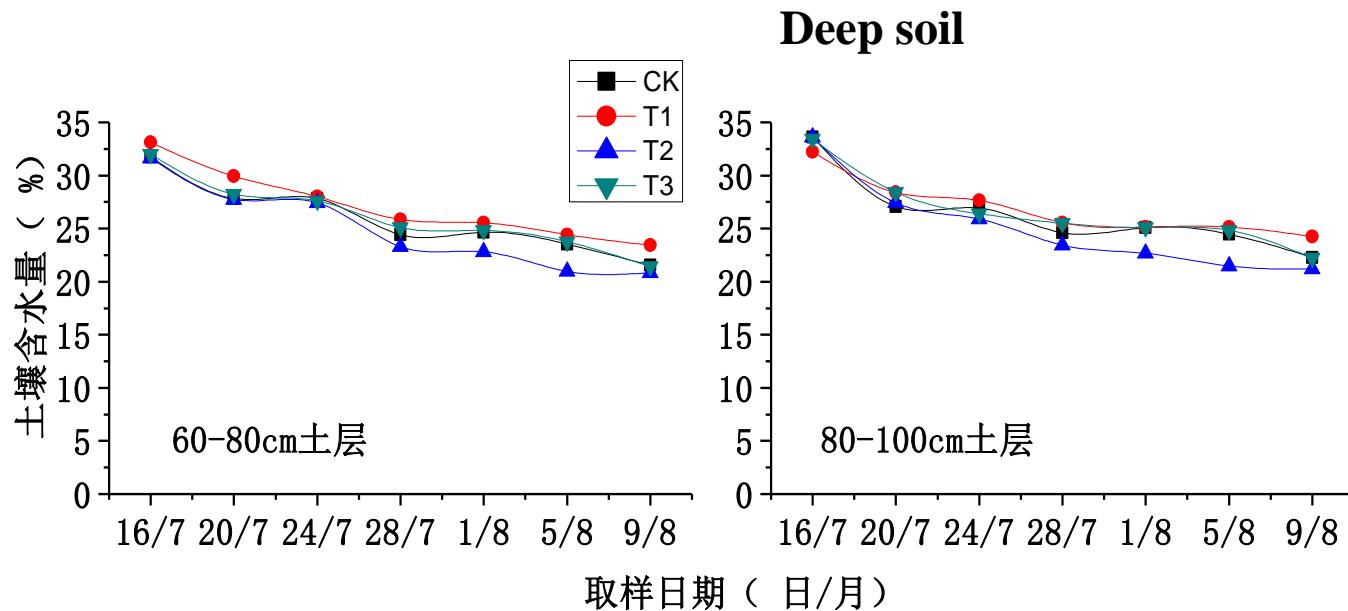


Effect of green manure mulching on the surface soil moisture under draught stress

III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(2) effect on the soil moisture



Effect of green manure mulching on the surface soil moisture under draught stress



III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(3) Effect on the soil quality

Effect on the soil nutrients

Compared with CK, mulching treatment raised soil pH value by 0.15-0.25 unit, soil organic matter by 9.8%-18.4%, alkali solution N 8.3%-19.2%, available P2.3%-31.8%, and available K by 6.7%-35.3%. These suggested green manure mulching could improve soil fertility, relieve soil acidification and reduce soil nutrients loss.

Effects of mulching on the surface soil nutrients in citrus garden (2013, Jinxian)

Treatment	pH	OM (g/kg)	A.P (mg/kg)	A.K (mg/kg)	A.N (mg/kg)	T.N (g/kg)	T.P (g/kg)	T.K (g/kg)
CK	4.63	16.022	15.54	99.17	78.91	0.831	0.479	11.79
Villose vetch	4.88	18.594	20.48	125.00	94.06	0.852	0.510	12.09
chamaecrista	4.78	17.599	15.89	105.83	87.20	0.858	0.488	11.97
White clover	4.80	18.971	16.43	134.17	90.88	0.862	0.487	11.83

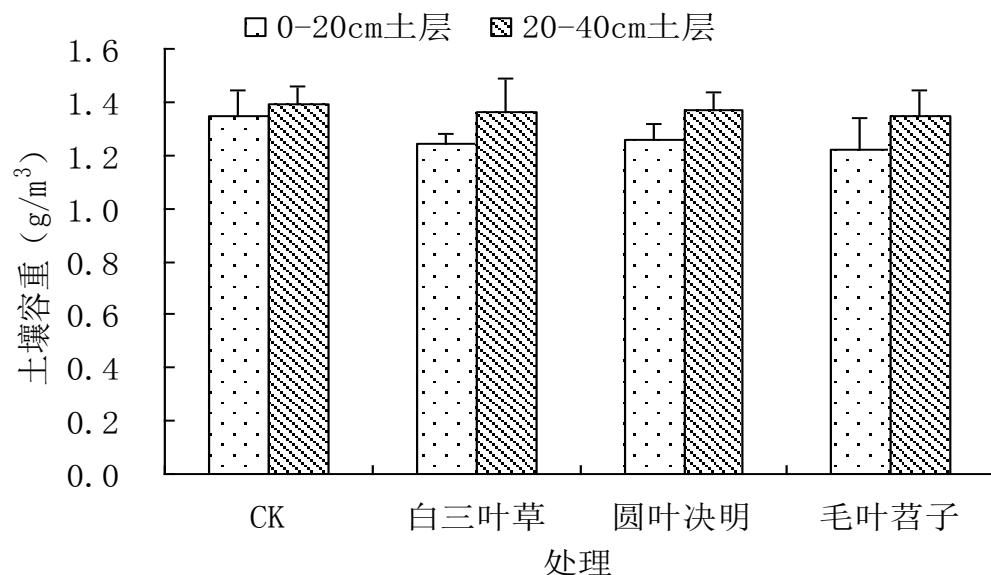
III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(3) Effect on the soil quality

Effect on the soil structure

mulching green manure decreased the soil bulk density of 0~20cm layer by about 0.09~0.13g/m³, and 20~40cm layer by about 0.02~0.04, which suggested the green manure mulching could improve the soil bulk density though there was no significant difference among treatments.



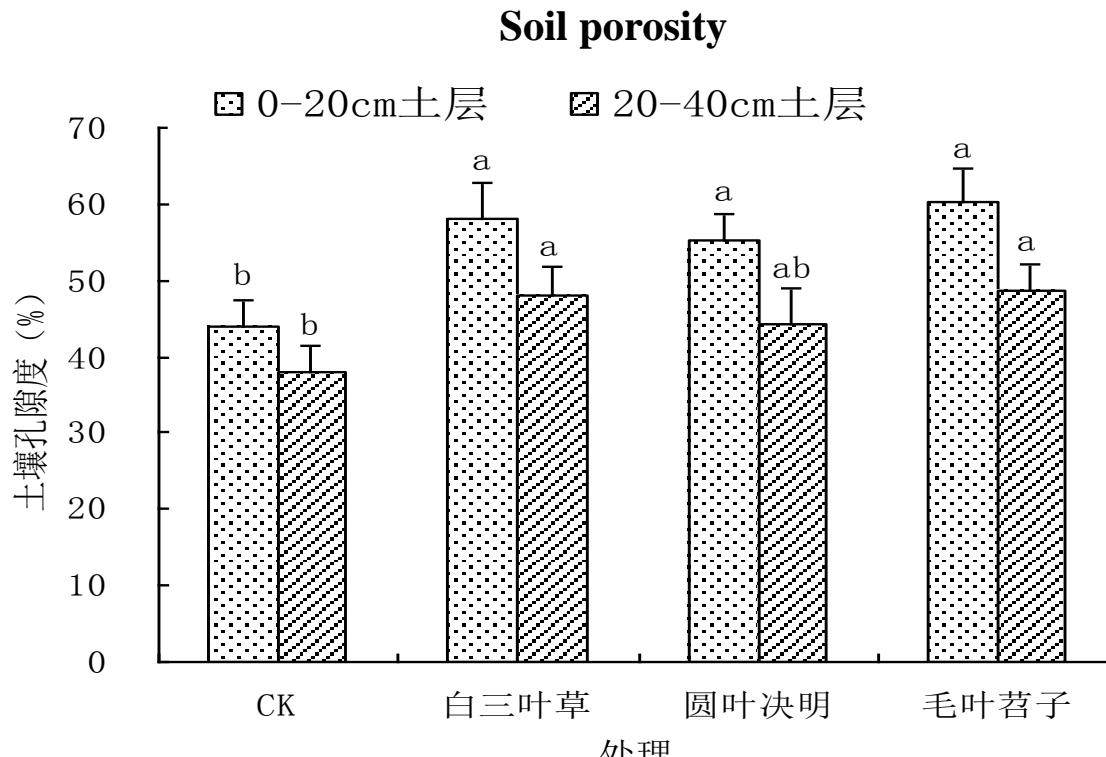
effect of green manure mulching on soil bulk density of citrus garden (Jiangxi Jinxian, 2014)

III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(3) effect on soil quality

compared with ck, green manure mulching increased the soil porosity of 0-20cm layer by 11.3-16.2 percentage points, reaching the significant difference level, and 20-40cm layer by 6.0-10.6 percentage points, also reaching the significant difference level. However there was no difference among different green manure treatments.



Effect of green manure mulching on soil porosity of citrus garden (Jiangxi Jinxian, 2014)



III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(4) Effect on the growth development and yield of citrus

Compared to the ck, green manure mulching remarkably enlarged the crown of citrus tree, increased the height of citrus tree. In addition, it also could improve the content of chlorophyll of citrus leaves

Effects of green manure mulching on the growth development of citrus (cm)

Treatment	November of 2011			November of 2015			SPAD value
	Diameter S to N	Diameter E to W	Height of tree	Diameter S to N	Diameter E to W	Height of tree	
CK	178.7	198.5	192.9	192.8	215.2	203.4	80.08b
Villose vetch	175.5	194.6	190.1	220.2	240.8	217.5	83.00a
chamaecrista	175.3	192.2	189.6	212.1	222.5	210.2	81.54ab
White clover	176.3	196.5	191.3	218.9	237.6	215.6	81.61ab



III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

(4) Effect on the growth development and yield of citrus

compared with CK, green manure mulching could significantly increase the citrus yield

Effect of green manure mulching on citrus yield (Jinxian, 2012-2015)

treatment	2012		2013		2014		2015		average	
	yield (kg/hm ²)	increase (± %)								
CK	18253.5a	-	16060.0c	-	21100.0c	-	19700.0c	-	18471.2d	-
T2	18488.5a	1.29	18452.5a	14.90	26590.0a	26.02	24239.5a	23.04	21177.0 a	16.85
T3	18408.2a	0.85	16472.5bc	2.57	22260.0c	5.50	21885.4c	11.09	19046.9 c	5.21
T4	18482.6a	1.26	17682.5ab	10.10	24510.0b	16.16	22647.5b	14.96	20225.0 b	10.93

NOTE: T2 is villose vetch, T3 is chamaecrista, and T4 is white clover



III. Management technology of fertilizer-saving and efficiency-improving on citrus

2. Mulching technology of green manure

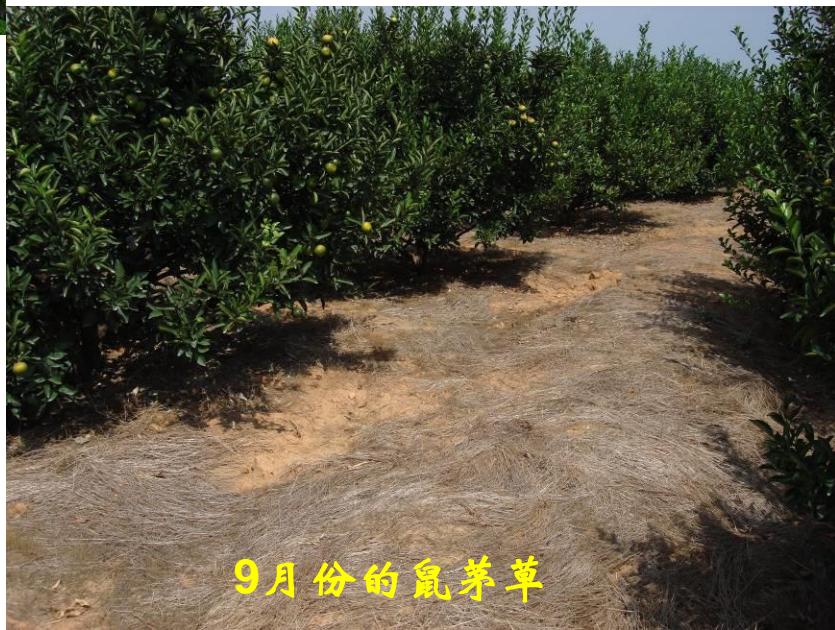
(4) Effect on the growth development and yield of citrus

Green manure mulching obviously increased the orange quality such as the weight of single fruit, the soluble solids, the vitamin C and so on. The probable reason was that mulching improve the soil quality and the status of soil nutrient.

Effect of green manure mulching on the fruit quality

Treatment	Weight of single fruit (g)	Soluble solids (%)	Total sugar (g/100ml)	Measurable acid (%)	Rate of sugar to acid	Vc (mg/g)	Fruit shape index
CK	36.7c	11.0b	9.4a	1.69a	5.6a	0.389b	0.71a
Villose vetch	41.3a	12.2a	10.2a	1.43b	7.1b	0.489a	0.74a
Chamaecrista	37.9bc	11.9a	9.7a	1.57ab	6.2bc	0.450a	0.72a
White clover	40.6ab	12.2a	9.6a	1.60a	6.0a	0.475a	0.73a





III. Management technology of fertilizer-saving and efficiency-improving on citrus



3. technology of integration management of water and fertilizer

Drip irrigation fertilization system: consisting of reservoir, water supply pipe, field pool (fertilizer distribution pool), water level controller, field branch pipe, and micro-run water pipe

The Drip irrigation fertilization system irrigate through the self-pressure flow by making full use of the water potential gradient caused by the altitude difference. When fertilization, it didn't need the external force, just only to dissolve the chemical fertilizer into the field pool (fertilizer distribution pool), then the dissolved nutrients were sent to the citrus rhizine with the water flow through the water level controller, field branch pipe and micro-run water pipe. The micro-run water pipe was made of nanomaterial. It can self-regulate the irrigation according the soil moisture. Additionally, this system can also regulate the concentration and the component of nutrients in the irrigation water according to the nutrients demand of citrus in different growth stages, thereby timely and effectively coordinating the water physiology of citrus and ensuring the best supply of water and fertilizer.

III. Management technology of fertilizer-saving and efficiency-improving on citrus



3. technology of integration management of water and fertilizer

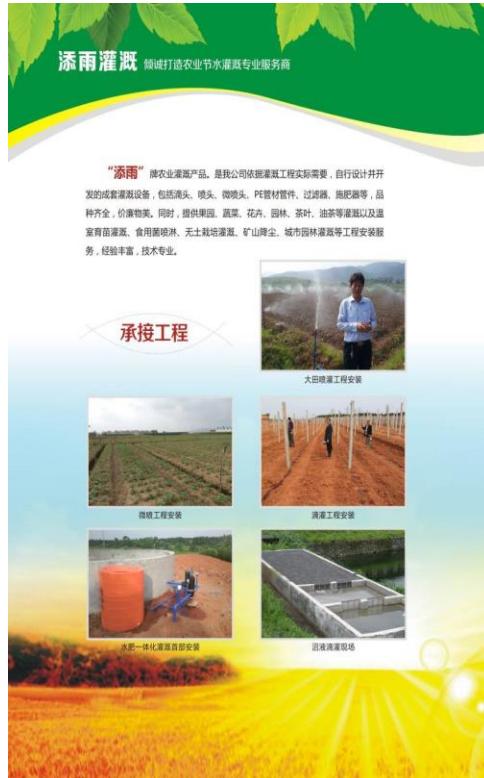
Because this technology could significantly improve the supply of water and nutrients to citrus tree. It could markedly increase the yield per plant. Compared with the control, it increased yield 39.4%, and decreased labor input 96.7% though the fertilizer input was reduced 80%. The reduction of fertilizer input resulted into decrease of nutrients loss, thus greatly reducing the risk of environmental pollution.



III. Management technology of fertilizer-saving and efficiency-improving on citrus

3. technology of integration management of water and fertilizer

Now the technology of integration management of water and fertilizer is mainly applied on navel orange, the application area is about 3,300 hectare. The increased investment in drip irrigation system is about 9,000-10,500 RMB per hectare.



III. Management technology of fertilizer-saving and efficiency-improving on citrus



3. technology of integration management of water and fertilizer



Thanks