A Report of the Citriculture on the Coastal Sandy, Windy Land[1]

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Abstract: The first step in building a citrus orchard on the coastal sandy, windy, arid land is planting effective wind-protecting shelter belts. The belts can reduce the critical wind speed, which forms the sand flow, usually 5-6 meters per second to less than 3 meters per second. It effectively avoids the outflow of sand from the orchard. Secondly, the suggested ideal fluctuating range of ground water level under the sandy soil surface during the rainy season is 30-60 cm. Thirdly, a close water source for irrigation should be available. 'Fugie,' 'Ponkan' and satsuma are the citrus cultivars most suitable for planting on the arid land and having high, stable yields. Simultaneously, it is considered that 6625 arrow-tongue pea, Indian compea, Sun flax, Amorpha, etc., are the green manure crop cultivars which are most suitable for planting on the arid land. They improve productivity and play an important role in soil improvement by increasing the fertility and reducing the soil surface temperature by covering it.

Citriculture on the land must include removal of the summer shoots and growth of autumn shoots as fruit-setting branches. This is the basic requirement for canopy control and the key to early bearing and high, stable fruit yield. As an alternative to manual shoot removing, summer shoot growth can be inhibited by applying 1,500 ppm sprays of MH three times a year, namely the middle of May, early or middle of June, and middle of July. The effective period of MH application is 15-30 days. Zinc sulphate (1%) spray may control the zinc deficiency of citrus trees on the sandy, windy land. The plum blossom-shaped diagonal thinning is the best treatment for a crowded, closely planted orchard. Since the citrus trees on the sandy land have shallow roots, producing trees can be easily transplanted to build a new orchard. The transplanted orchard can be put into full production in the third year after transplanting.

The granite coasts in Fujian Province have been marine eroded and cracked by the sea waves. The broken rocks are drifted by strong beachward wind to coastal platforms to form sand dunes with different elevations. Great sand storms destroy everything when the wind blows hard there. It is well known as "coastal sandy, windy arid land." Since the sand has high mobility and low nutrient availability, the strong sea wind and the aridity in those vast areas of sandy, arid land, it is difficult to grow even grass plants. The farmers worry about the poor harvest.

In 1964, Beefwood (*Casuarina equisetifolia*) trees were planted along the coasts on the arid land. This has been a decisive factor for wind prevention and sand arresting and has improved the natural environment. The farmers of Dahe brigade in Changle County in Fujian Province tried to plant citrus trees on the sandy, windy arid land in 1967. They failed twice due to the calamities of wind and waterlogging. However, their efforts were successful when they tried again to plant citrus trees on the sandy soil between the wind-protecting shelter belts in 1968. Successful citriculture on the arid land was a pioneering accomplishment in citrus production in our country. But, there were numerous problems such as, the low yield, fruits were too sour, chlorosis due to lack of micronutrients, etc. There were also other problems, especially the environmental conditions of the soil in large area citrus plantations on the arid land which had to be resolved.

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Since 1972, two research groups have worked in Dahe and Zhanglin brigades in Changle County to develop techniques of utilization of the coastal sandy, windy, arid land and to develop the production of citrus fruits. Research was conducted on citriculture on the land and correcting the problems of citrus production. The results of the research are as follows:

A. Research on the physical-chemical properties, temperature, heat and water content of the arid land, in relation to the growth and development of the citrus trees show that the following factors should be considered.

1. First of all, wind and sand protecting shelter belts should be planted. The main shelter belts are 15 meters in thickness which are kept vertical or just a few degrees angle to the direction of the prevailing wind, the north wind and northeast wind in August till October during the typhoon season. Their effective protecting area is suggested to be 10 times the height of 3-4 year old Beefwood trees, namely 45-55 meters. This is equal to the distance between two main shelter belts and the width of the orchard. The wind reflecting shelter belts (assistant shelter belts) are 5 meters in thickness and vertical with the main shelter belts. Their length is 150-200 meters and it is regarded as the length of the orchard. The wind protecting shelter belts which protect the citrus orchard can reduce the critical wind speed, which can form the sand flow, usually 5-6 meters per second to less than 3 meters per second. This effectively prevents the outflow of sand from the orchard.

2. The sand land which is chosen for the orchard should be open and spacious. It should be near a water source or in a water-rich sand area, and convenient for well drilling or irrigation.

3. The coarse silt (0.1-0.1 mm) should be equal to 80% of the sand content. The general porosity of the soil is high but the space among the sand is small, so the sandy soil is finer and better due to the fact that it preserves the soil moisture and it is easily reformed.

4. Because the distribution of absorbing roots is mostly in the upper 15-45 cm of soil, the fluctuating range of ground water level should be 30-60 cm under the soil surface.

B. Experiments were necessary for gaining early-bearing, high yield, and good fruit quality in the citrus orchard on the coastal sandy, windy, arid land. The results from the experiments are as follows:

1. **Introduction of superior citrus cultivars (1967-1975):**

For the observation of drought resistance and productivity of citrus trees, more than 20 cultivars were planted, and the performance of these cultivars showed that 'Fujie' (*Citrus tangerina*), 'Ponkan' (*C. reticulata*), and satsuma (*C. unshiu*) are the best cultivars for planting on the sandy land and having good productivity.

2. **Interplanting of green manure crops in the citrus orchards and the utilization of the green manure fertilizers (1973-1974):**

During the summer and autumn, the temperature of the surface of the sandy soil (to 25 cm deep) is up to 67°C and there is a great disparity between the diurnal temperatures. Green manure crops are advantageous to the growth of the new roots and planting must be done in the citrus orchard. The branches and leaves of the green manure crops can be used to shield the sandy soil from the sunshine and they can also be buried under the surface around the trees in order to lower the temperature of the surface of the sandy soil (0-30 cm). This can also reduce the evaporation of moisture and raise the moisture content of the sandy soil.

More than 20 types of green manure crops were introduced during 1973-74. As a result of the experiment, the

types of green manure crops which are suitable for planting on the sandy land and have good productivity are as follows: For winter green manure crops: Red flower pea (*Pisum sativum*), 6625 arrowtongue pea (*Vicia sativa*), etc.; for summer green manure crops: Indian cowpea (*Vigna* sp.), August white cowpea (*Vigna sinensis*), Sun flax (*Crotalaria juncea*), Black green bean (*Phaseolus aureus*), etc. For perennial green manure crops: Golden light chrysanthemum (*Titonia diversifolia*), Amorpha, etc. The area for the interplanting of the annual green manure crops is about 50-60% of the area of the young orchard.

Around the orchard next to the wind-protecting shelter belt, Amorpha should be planted. It can prevent the blowing of the sandy soil in the orchard by the wind near the ground and improve the wind-protecting efficiency of the shelter belts. The Amorpha plant branches can be reaped three times per year. They can be used as compost and wet compost and used as dressing in the furrows during the winter. It increases the fertility of the sandy soil very well. Since the composition of the soil is mostly sand (93.33-95.33% of size larger than 0.01 mm), has no cohesiveness, and all in separate particles, the organic content is low (0.01-0.16%).

The effective nutrient content such as total nitrogen (0.011-0.02%), total phosphorus (P_2O_5 0.016-0.05%), and total potassium (K_2O 0.7-1.2%) is also rather low. In addition, it has high perviousness and low ability to preserve fertility. Therefore, besides a heavy base manure and several topdressings every year in the young orchard, care must be taken to improve the physical-chemical conditions and increase the use of nitrogenous fertilizer. The results from the experiment during 1975-77 have shown that the average yield of 3 years in young bearing satsuma orchards on sandy soil where the fresh green manure dressing was applied twice a year is 1.6-2.7 times that of the orchard where only nitrogenous fertilizer was applied. The productivity of citrus was much higher in the orchard where the green manures were mixed with a small amount of pig manure. The quality of the fruits was improved as well. The quality of the fruits following the application of green manures with a small amount of chemical fertilizer was much better. Its sugar content was 8.07%, acid content was 0.69%, sugar/acid was 11.7, TSS/acid was 14.2. The quality of fruits from trees without green manure was sugar content of 7.88%, acid content of 0.75%, sugar, sugar/acid at 10.5, TSS/acid at 12.9.

3. **Topdressing and shoot control in the closely planted citrus orchard on the sandy land:**

The coastal sandy, windy, arid land has high air-filled porosity. The air-filled porosity in the sand layer of 0-30 cm from the ground is up to 34.35%. Most of the citrus roots extended out smoothly and easily, so that they were long and well branched. The upper part of the plants above the ground grew fast, were well branched, had big leaves and big fruits. The rate of fruit setting of those trees was high, for 'Fujie' (15.48%), 'Ponkan' (29.11%), and satsuma (5.83%).

Under the conditions of close planting, the canopy of the tree must be strictly controlled. However, it is necessary to allow some summer and autumn shoots to grow evenly to increase the effective fruit-setting branches. Extensive area tests showed that the summer shoots of the 1-2 year old citrus trees should be removed in the Beginning of Summer (the 7th solar term). Before the Grain in Ear (the 9th solar term), apply a quick acting fertilizer. Then, let summer shoots sprout evenly during the Grain in Ear season. When the summer shoots are mature, remove new shoots during the period between the Slight Heat (the

11th solar term) and Great Heat (12th solar term) in order to grow autumn shoots evenly during the period between the Beginning of Autumn (the 13th solar term) and the Limit of Heat (the 14th solar term). For trees with more than 3 years of growth, the summer shoots should be removed only between the Beginning of Summer and the Beginning of Autumn. While the autumn shoots grow out on 80% of the trees in the orchard, a heavy dressing of fertilizer should be applied and the autumn shoots allowed to grow out for next year's fruitsetting branches. That is the effective measure for getting high and stable yields of fruit.

Since manual shoot removal requires a lot of labor, the use of growth inhibitors is suggested. An experiment with MH for controlling summer shoots was carried out during 1978-80. The results showed that the concentration of the MH should not exceed 1,500 ppm. It should be sprayed three times per year, namely in the middle of May, early or middle of June, and middle of July. The effective period of application of MH for inhibiting summer sprouts is 15-30 days. And, the MH also has an obvious inhibition to the growth of the seeds inside the fruits.

4. **Prevention and control of chlorosis by micronutrients.**

The soil on the sandy, arid land lacks nitrogen and some trace elements. The analytical data show that in the sandy soil, the content of available boron is only 0.007-0.12 ppm; zinc, 2.40-10.89 ppm; and copper, 0.67-5.76 ppm. The leaves of satsuma grown on the arid land show deficiencies of trace elements. Analytical data show that the content of total zinc in the leaves is 12.5-21.5 ppm; and total boron, 19-53 ppm. Therefore, the leaves from summer and autumn shoots show chlorosis. The symptom is similar to zinc deficiency. During 1976-77, spraying with 0.1% zinc sulphate corrected the chlorosis and its effectiveness was much better than those receiving 0.1% boric acid, 0.2% manganese sulphate, or 0.05% ammonium molybdate.

C. Management of closely planted citrus trees on the sandy, windy arid land:

Citrus grown on the arid land has the advantage of fast growth and early harvest. However, under the condition of close planting of the trees, decline in growth and productivity is also fast. In the 'Fujie' orchard in Dahe brigade, which is the first closely planted 'Fujie' orchard in Fujian Province, the planting space is 3 × 2.5 m. The rows in the orchard were crowded in the 10th year after planting, and many problems appeared after the crowding. In view of the situation, transplanting of producing trees was used to thin out the trees. Experience showed that care must be taken to avoid the decline of total fruit yield which was affected by thinning and the reduction of gross income. Also, care must be taken to maintain a high percentage of surviving trees and to encourage abundant new fluhses to maintain fruiting branches. It is suggested that transplanting proceed in early spring in an off-year. The total yield of the thinned orchard declines in the first year, but it will be recovered by next year and maintains a high and stable yield.

Citrus trees planted on the coastal sandy, windy arid land have the character of shallow rooting making them easy to transplant and high rate of survival. The mature trees can be skeletonized and transplanted to build another new orchard. The survival rate of transplanted trees may be up to 100%. In the first year after transplanting, two summer growth flushes and one autumn growth flush should be developed. In the second year, one summer flush of growth and one autumn flush of growth should be forced to develop good fruit-setting

canopy. Over 50% of the transplanted trees can set fruit in the second year. The transplanted orchard can be in full production in the third year after transplanting.

During the period 1972-82, further research was carried out on citriculture on the coastal sandy, windy arid land. It showed that citriculture on the arid sandy, windy land is possible. About 275 hectares of citrus orchards have been established in the coastal sandy area. Citrus trees growing in these highly porosis, sandy soils had vigorous growth, early fruit setting, and high productivity. In an area of 3.3 mu (about 0.22 hectares) of the 'Fujie' 8-year-old test orchard in the Dahe brigade in Changle County, an average yield of 10,506 jin (5,253 kg) per mu has been obtained. The wind-protecting and sand-arresting shelter belts have been constructed on vast areas along the coast. This area is more suitable for planting prolific and high quality cultivars, i.e., 'Ponkan,' satusma, 'Fujie,' 'Tankan' (*Citrus tankan*), 'Sekkan' (*C. sinensis*), 'Anliucheng' (*C. sinensis*), navel orange (*C. sinensis*), etc.

In summary, it is possible to develop citriculture on the coastal sandy, windy, arid land if suitable irrigation and good management are provided and the expansion of citrus in this area is expected.

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Studies on Citrus Rootstocks for Sweet Orange

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Abstract: The results of a citrus rootstock experiment with sweet orange tops from 1952 to 1977 are reported in this paper. The effects of 19 rootstocks on the growth, fruit production, yield, fruit quality, cold and drought resistance of the cultivar, 'Xianfeng,' are given. Experimental results showed that for 'Xianfeng' orange grown in the Sichuan hilly lands, trifoliate orange is an excellent rootstock. Tugan, Xianggan and Jiangan mandarins are suitable stocks; Tangcheng is a semi-dwarfing stock, and Ichang papeda is a dwarfing stock.

Introduction

Studies on the selection of the rootstock are of great importance for the production of citrus. In order to find suitable rootstocks for sweet orange in the hilly land of Sichuan, a citrus rootstock test was planted in 1952 and evaluated for 24 years.

Materials and Methods

The tests were conducted on the experimental farm of the Fruit Insti-

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