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THE TECHNOLOGIC SYSTEMS AND THE MODELS OF DEVELOPMENT AND UTILIZATION OF THE PURPLE-SOIL-COVERED HILLS IN THE MIDDLE OF HUNAN PROVINCE

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Abstract In this paper, based on the sustainable development and utilization of the purple-soil-covered hills, together with the harnessing and developing experiments, as well as the application in practice, technologic systems and optimizing utilization models of the purple-soil-covered hills are provided from five aspects: ①The optimizing model of planting arbors, shrubs and grasses, and the technologic system of getting soil, gathering soil, fixing soil and protecting soil; ② The optimizing model of planting fruit trees, crops and grasses , and the technologic system of getting soil and improving soil, fertilizing and tectorial technology; ③ The model of planting rice, Spirodela polyrhiza, and feeding fishes, and technologic system of opening ditch to drain away water, free or less of plowing, planting on ridges, and dispensing prescriptions for fertilizer incorporation; ④ The crop rotation model of waterborne crops and xeromorphic crops , as well as compound planting technology in the rice field; ⑤ The system of constructing the artificial grasslands and growing grasses technology. On this basis, the games of sustainable utilization of the purple-soil-covered hills are advised simply.

Key words The models of development and utilization of the purple-soil-covered hills in the middle of Hunan Province as well as the technologic assembly and supporting measures

1. The characteristics of the purple-soil-covered hills in the middle of Hunan Province

The parent rock in this area is the purple sandstone and purple shale, which were formed during Cretaceous Period and the late Tertiary Period, respectively. The formation of the purple sandstone was the result of calcium agglutination from quartz sands. Its particles are coarse with porous structure, which leads to highly water permeability and the calcareousness can be easily washed away. The distance between horizontal and vertical joints is very far. In general, the erosion from the surface run-off is very weak except the influence of slide caused by gravity. As for the purple shale , the mineral components are very complex, its particles are very small with tight formation structure, making it very difficult for water to penetrate them and the process of washing away the calcareousness is very slow. Although there isn't joint existing in this kind of rock, the cracks are widely found under the influence of thermal expansion and cold shrinkage, the distance between these cracks is very narrow, varying from several millimeters to several centimeters. It is very likely to form particles and clasts which are very small and can be washed away by rain

easily. The rock mass can be divided into three types, that is purple sandstone , purple shale, and the intermediate type which mixed not only purple sandstone layers but also purple shale layers. The characteristics of purple-soil-covered hills are deeply related to the characteristics of their rock mass.

1.1 *The main type of soil is intermediate and calcareous purple soil.* The purple-soil-covered hills in the middle of Hunan province, with an area of $4,67*10^3$ hm^2, are mainly covered by intermediate purple soil, calcareous purple soil and acid purple soil. The area of the first two types is $3,33*10^3$ hm^2, which is more than 70%. The adaptable plantations and the ways to develop and utilize for each kind of soils differ widely. There are four kinds of paddy soils which are originated from the above mentioned kinds of purple soils, that is, purple-muddy paddy soil, purple-sandy-muddy paddy soil, acid-purple-muddy paddy soil and acid-purple-sandy-muddy paddy soil, and their characteristics and utilizing measures are of great difference.

1.2 *The vegetation cover is very low with serious soil erosion.* It had been covered by forest with clean brook flowing away this region in history. But since Dynasty Nansong, because of the explosion of population and the frequent war, as well as the excessive exploiting and denudation and opening up the virgin soil, this has led to the greatly decreasing of the vegetation and the structure of the purple sand-shale rocks are very porous. Under the effect of the thermal expansion and cold shrinkage, they can burst apart into clasts, which are easily washed away when it comes the high temperature and much rain. In many places, the mother rock even can be seen. What's more, because the color of the purple soil is very dark and their absorption of heat is very strong, the temperature of these bare fields is high enough to 73,5℃ in the dry season in Autumn. The evaporation is very huge, and it is very difficult for the vegetation to grow up. Therefore, the soil erosion becomes more and more serious. It is proved by investigation that the erosion area in the hills, where are covered by calcareous purple soil and intermediate purple soil, has reached 95%, while the area in those where are covered by acid purple soil is 59% of the total area. Both of them are mainly groove erosion.

1.3 The surface soil coverage is very thin and it is very dry for most of the slopes in the middle of Hunan province. The surface soil coverage has become thinner and thinner because of the serious soil erosion. For the hills which are covered by calcareous and intermediate purple soil, the thickness of the soil layer is below 10 centimeters in the upper slopes, while in the lower position, it is 10 to 15 centimeters. But for the acid-purple-soil-covered hills, the thickness of the soil layers on the slope is no more than 30 centimeters. The purple-soil-covered hills in the middle of Hunan province are situated in the corridor of Hengyang and Shaoyang basin, the rainfall of which is very small during July to September with an temperature of 38℃ or so. The artificial vegetations, such as forests and grasses, can hardly survive in this region. These factors can greatly influence on the dry farming.

1.4 The mother rock can easily be efflorescent, and the organic substance is very low, but is abundant of phosphor and kalium. The purple-sandy rock is called " the substance which is vanish- away as soon as the wind blows". It will be efflorescent into soil after one year if being crashed, and can grow mung bean, horsebean, and rape. In the area which was suffered from serious water and soil erosion, the organic substance in the soil is extremely scarce, only 3,1% to 7,3%. However, for those where the vegetation coverage is very good, their organic substances are much higher, ranging from 11,7 to 26,2 g/kg. The amount of phosphor and kalium in the soil, which is 0,59 to 1,2 g/kg and 21,5 to 28,8 g/kg separately, is much more than that of those where the vegetation coverage is very bad. This has improved the utilization value of the purple soil. On condition that the winter crops are planted, good harvest can be got if only the thickness of the soil layers are no less than 10 centimeters on condition that the winter crops are planted.

2. The existing problems on the utilization of lands

2.1 The quality of the cultivated lands has decreased a lot and the area percentage of land with secondary and poor productivity is very large. Among the purple-soil-covered hills in the middle of Hunan province, the area of cultivated lands is $1,4*10^5$ hm^2, including $1,2*10^5$ hm^2 paddy field and $2*10^4$ hm^2 dry land. In recent ten years, because the investment to the construction of the farm lands is very small, and the area of the green manure planting has decreased, together with the labor forces' immigrating to the other regions to work, the quality of the cultivated fields has reduced a lot. In the middle of the 80s, winter Astragalus sinicus planting was 80% of the paddy field in this region, and the area of lying land in winter was less than 10%. While in the middle of 90s, the area of green manure planting was less than 5%, and the fallow paddy fields were more than 40%, which has made the improved fields change into less productivity fields again. Most of the dry farm lands are still plough along the direction of the slopes, the cultivated layers are getting thinner and thinner, and the fertility of the soil has decreased. It is shown by investigation that the less productivity fields in this region with an area of about $8,7*10^4$ hm^2 is more than 60%.

2.2 The forest coverage rate is very low together with low productivity efficiency of forest industry. The forest coverage rate is about 5% in this area, being the last one in Hunan province. At the same time, the forest species structure is not very proper, too. Acacia dominated this area except that there are a few other species growing on the acid-purple soil such as *Phyllostachys pubescens* - forest, *Cunninghamia lanceolata*, and *Pinus massoniana*. Especially in the areas where are covered by calcareous purple soil and intermediate soil , arbors are almost consist of acacias. There are few economic forests and fruit trees, such as *Castanea mollissima*, *Vernicia fordii*, *Ziziphus jujuba*, *Citrus* sp., plum trees, *Friobotrya* and so on. The economic value of the acacias is very low, only 750 Yuan RMB per hm^2. While in the villages, where farmers use coal as the main fuel, the function of acacias is ecological.

2.3 The quality of pasture is very low together with serious over depasture. Because it is very dry during Autumn and the soil layers of the sandy shale is very thin, the herbaceous vegetation coverage, which can adapt to the dry land environment, is very sparse. One can often meet *Setaria, Eleusine indica, Digitaria, Kummerowia Striata.* Theses kinds of grasses become ageing in a short period, and the utilization efficiency of pasture is not very economic. At the same time, the natural grasslands are getting worse and worse near the residential area as a result of over depasture. The herd in this region is mainly feed on the stalks and agriculture products.

2.4 The rice is the main crops and the area proportion of economic crops is very small. For a long time the agriculture in this area was characterized by so called "rice plus straw". Since 1980s, the agriculture structure was adjusted, and the economic crops, which had been grown in large areas before, were paid much attention again, such as *Desmodium*, Green broad bean, Soybean crop, *Gossypium herbaceum* , earthnut, *Sagittaia trifolia*, and so on, but their planting area was still a very small proportion of the total crop seeding area, only 21% - 28%. Among these crops, only the cotton became the main cash crop.

3. The optimizing models and technologic systems of reasonable development and utilization for the purple-soil-covered hills

The main purpose of reasonable development and utilization to purple-soil-covered hills is to realize the sustainable development of the soil resources by ways of optimizing models and technologic systems, aiming at pursuing the best benefit, economically, ecologically, and socially. After ten years scientific experiments and practice, the following optimizing models and technologic systems are summarized:

3.1 The optimizing models of planting arbors, shrubs and grasses, and the technologic systems of getting soil, gathering soil, fixing soil and protecting soil. In the intermediate and calcareous purple-soil-covered area, we adapted the model of planting arbors, combined with planting shrubs and grasses, for most of them are calcareousness-liking plants. The main arbor species are *Acacia, Korlreuteria mionr, Firmiana simplex, Dalbergia rimosa, Asparagus* sp., *Kalopanax septemlobus, Gleditslia, Quercus chenii, Alnus trabeculosa, Liquidambar formosona hance, Quercus glauca, Pistacia chinensis* ; The shrub species are *Coriaria sinica, Lespedeza, Amorpha fruticosa*, and *Vitex*; the main grass genus are *Melilotus, Paspalum, Digitaria, Kummerowia* and so on. As for the acid purple-soil-covered hills, the main species differs a lot, most of them are acid-liking plants. The main arbor species are *Phyllostachys edulis, Cunninghamia lanceolata, Pinus, Cinnamomum, Sassafras tzumu*, and so on. The main shrubs are *Eurya, Lespedeza, Barleria cristata, Vitex* and so on. The grass species are *Imperata cylindrical, Arundinella anomala, Arundinella nepalensis, Artermisia japonica* and so on. In general, it is organized in such a way that plants of nitrogen-fixed and nitrogen-unfixed, conifer and

broadleaf can be planted together. As for the exposed and half-exposed rock hills, contour demolition technology was used to blow up the trenches in order to get soil. Based on this, grasses are planted at first, and then trees, thus vegetation can be recovered artificially. As for the purple-soil-covered hills where are covered by thin soil, the mixture of plants and fense are used to collect and fix the soil, by this way, terrace can be formed in the slope, which can provide the habitant conditions for many species of plants and speedup the recovery of the vegetation cover. As for those purple-soil –covered hills where are scarce of irrigative water and those with a steep slope, it is more fit for the optimizing models of planting arbors, shrubs and grasses, as well as technologic systems of getting soil, collecting soil and fixing soil. Forestation by explosion resulted little soil erosion. The method of mixing plants with fence can hold up 80% of mud and sands. Therefore, the species of plants can increase from 30 to 71.

3.2 The optimizing model of planting fruit trees, crops and grasses, and the technologic system of getting soil and improving soil, fertilizing and tectorial technology. In this model, the main economic trees are as followings: *Citrus reticulalta, Brown plum, Prunus salicina, Peach, Punica granatum, Castanea mollissima, Ziziphus jujuba, Vernicia montana, Sapium rotundifolium*, etc. The main crops are earthnut, mung bean, soybean, rape, radish, pachyrhizus, watermelon and so on. The grass vegetation is fabaceous green manure plants, such as *Astragalus sinicus, Coronilla varia, Trifolium pratense, Trifolium repens*. In order to make full use of nutrient and space, and to improve the multiple effect, this model should be organized in such a way which crops and grass vegetation are planted between fruit trees and economic forests. Meanwhile, a highly efficient arrangement should be put into practice, such as crops which would cost the organic substance of soil are planted together with those which could nourish the soil, crops with deep roots are arranged to be grown together with shallow-root ones, forage grass and forage crops, economic crops and grain crops, upstanding crops and creepers are grown together. But in the exposed and half exposed wild lands, it would be better to plant the fruit trees and economic forest if the technologic systems of getting soil by opening trenches from explosion, fertilizing by layers, and covering the soil with tectorial materials are put into uses. What's more, the irrigation model should be water-economic. As for those wild land areas with a ticker layer of soils, measurements should be taken to improve the original fruit gardens. In order to exploit these regions, the following technologic systems should be adopted: to dig deep trenches to get soil, to fertilize the soil by layers, to resist drought by water-economic irrigation etc. Fruit trees should be planted on the region with much water resources, while for those with little water resources, dry fruits and economic forest can grow well. Followed by the above mentioned optimizing models and technologic systems, little soil erosion will be resulted, and the production efficiency of economic forest can increase over 50%, and the net profit per unit area will increase over 70%.

3.3 The model of planting rice, Spirodela polyrhiza, and feeding fishes, and technologic system of opening ditch to drain away water, free or less of plow-

ing, planting on ridges, and dispensing prescriptions for fertilizer incorporation. This is a very important way to improve the glei paddy soil. After digging ditches to drain away water, the groundwater level decreased. Followed by this, free or less plowing, and planting on ridges were practiced. In the paddy fields, *Spirodela polyrhiza, crucian, cyprinoid,* and loach were fed. By this way, the production of paddy rice can increase 5%. The net income of the farmers can increase over 600 yuan RMB, among which include the value of more than 100 kg fresh fishes within an area of 667km^2.

3.4 The crop rotation model of water-borne crops and xeromorphic crops , as well as compound planting technology in the rice field. The crop rotation model can adapt for all types of paddy fields in this region. For example, one type of rotation model is the rotation of paddy rice with the cotton, at the same time, when it comes the turn of growing cotton, watermelon, muskmelon and capsicum can be planted in the cotton fields. Both of cotton and watermelon planting are adopted to the technology of transplantation from growing seedlings and covering the youngest seedlings with plastic films. Another kind of rotation model is the rotation of paddy rice with tobacco, which can last 3 years' turn continuously. This kind of model not only can improve the soil by promoting the formation of crumb structure, but also can increase the net income of farmers. As for the rotation of paddy rice with tobacco, the income of farmers can increase over 600-800 yuan RMB every year per 667 km^2; while for the rotation of paddy rice with cotton, companied with the planting of vegetables and melons, the income of the farmers can increase over 600-3000 yuan RMB every year per 667 km^2.

3.5 The system of constructing the artificial grasslands and growing grasses technology. The pasture grasses in the purple-soil-covered hills in the middle of Hunan province are very scattered with bad quality, which not only affects the farm cattle's raising, but also the ecologic environments. Therefore, the construction of the artificial grasslands plays a very important role in improving the ecologic environment, controlling the water and soil erosion, as well as promoting the development of the agriculture and stockbreeding. But it is very difficult to survive the bad weather for the grasses in this area because the summer is very hot with little rain. Disadvantage can be overcome if the technologic systems of selecting grass species and seeding can be realized. The concrete method is to arrange the pasture species in pairs, for example, planting the bird's-foot with the gramineous species, deep-root species with the shallow-root species, pasture species which are needed to be seeded in winter with those which are needed to seeded in spring, combining broadcast sowing with dibble seeding and so on. By these methods, the grasses can make full use of the nutrient of the soil, and the pasture species which are easily germinated can protect those with weak germination ability in order to resist the bad natural conditions. As for intermediate and calcareous purple-soil-covered hills, if their soil profile is very thin (<10 cm), we planted *Adsurgen* S. Pall, *Melilotus albus*, in January or February by broadcast sowing or dibble seeding, and *Kummerowia striata, Coronilla varia,* (immerge in water with the temperature

20°C for several hours before seeding) in March and April by dibble seeding. But if the soil profile is very thick, we selected *Melilotus albus*, *Adsurgen* S. Pall, *Medicago sativa* by dibble seeding in January or February, and *Paspalum*, *Coronilla varia, Kummerowia striata* in March and April. As for acid purple-soil-covered hills, because the thickness of their soil layers is no less than 3,3cm, we planted *Astragalus sinicus* by dibble seeding in January and February, and *Paspalum*, *Roegneria ciliaris* Nevski in March and April. As a result of selecting these pasture species and technologic systems, not only the relative stability of the excellent pasture structure can be kept, but also can provide a good habitat for the local pasture species, which can improve the quality of the artificial grasslands as a whole. *Roegneria ciliaris* Nevski, being green all the year , is a kind of ideally local pasture at present because of its high quality.

4. Strategy

In order to carry out the above-mentioned models and technologic systems and realize the intention of sustainable development of the soil resources, the following strategies should be performed in the future. As a result of a request for developed science and technology in realizing the crop rotation and the compound planting of rice paddy, *Spirodela polyrhiza,* and fishes, as well as the high cost of farm materials such as fertilizer, pesticide and plastic film etc., it is necessary to increase the supplies of these farm materials, and to help the farmers to grasp these critical technologies by technologic training.

4.1 To increase the investment to the cultivated fields. The crop rotation model of water-borne crops and xeromorphic crops and the model of planting rice, *Spirodela polyrhiza*, and feeding fishes requires high technology, and the investment to the farm materials such as fertilizer, pesticide, and plastic films is also very much, so it is necessary to increase the investment to the agriculture, and to train the local farmers to grasp these critical technologies.

4.2 To resolve the energy problems in the countryside by all kinds of means. For a long time, one of the main reasons why the area of wild lands is increasing in this region is that the farms burn firewood, which has resulted of the damage of the forest. This had led to the situation that the forests were destroyed as soon as they grew up and you couldn't met any pieces of forest even though they were planted all the year. The following ways can be used to resolve the energy problems in the countryside: □To spread the miasma pools, which can provide marsh gases to cook and get warm in winter; □ To encourage the farmers to burn coal as the fuel for those villages where the traffic conditions are very convenient; □ To spread the kitchen range which will use less coal and firewood in order to save the fuels.

4.3 To pasture cattle rationally and take effective measures to protect the grassland resources. On one hand, the propaganda should be strengthened to

change the habit of pasturing the herd near the countryside and to prevent serious depasture, which can be realized by way of planting *Melilotus albus* Desr because the herd don't feed on this kind of pasture.

4.4 *To encourage the peasants to exploit the wild lands and protect the current forests.* To formulate a special policy to stimulate their excitation of utilizing the purple-soil-covered hills, consciously.

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МОДЕЛЬ СЕЛЬСКОХОЗЯЙСТВЕННОГО ИСПОЛЬЗОВАНИЯ ФИОЛЕТОВОЙ ПОЧВЫ (МЕЛКОСОПОЧНИКА) И ТЕХНОЛОГИЧЕСКИЕ СХЕМЫ ИХ ОСВОЕНИЯ В ХЕНЬЯНСКОЙ ДОЛИНЕ

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Хеньянская долина находится на юге провинции Хунань Китая. Весна здесь наступает рано. Часто идут дожди. Температура воздуха летом иногда повышается до сорока (40^0) и выше, а зимой редко понижается до нуля. Сельскохозяйственные культуры дают здесь два-три урожая в год. У нас выращивают рис и пшеницу, горох и сою, цитрусовые и табак, хлопок и масличные культуры. Все это является существенным сельскохозяйственным базисом провинции Хунань Китая.

Хеньянская долина занимает территорию 20000 кв. км, сложена пластами фиолетовых песчаников и мелкосопочника, которые занимают почти половину всей территории долины. Фиолетовые почвы представляют собой каменистый субстрат скального происхождения, покрытый редкой растительностью. В профиле такой почвы практически не прослеживаются генетические горизонты. Вследствие недостатка гумуса и влаги, растительность на этих почвах развита слабо. Такие почвы у нас называют «красным открытым грунтом».

Однако фиолетовый песчаник – рыхлый грунт. В нем мало органического вещества и азота, зато много фосфора, калия и кальция.

Для изучения возможностей использования фиолетового мелкосопочника в Хеньянской долине мы в 1988 г. опытную полевую базу. Здесь разрабатывались технологические схемы рационального использования фиолетовых почв и охраны их от эрозии.

Нами разработаны и внедрены некоторые технологические схемы рационального использования фиолетовых почв.

Первая модель – взаимодействие древесного, кустарникового и травяного ярусов экосистемы с целью образования почвенного профиля, кумуляции почв.

Вторая модель – модель последовательного согласования и чередования сельскохозяйственных культур (севооборот) и технологическая схема улучшения фиолетовых почв.

Третья модель – технологическая цепочка взаимополезного выращивания риса, пресноводной рыбы и технологическая схема вспашки, бороздования и внесения удобрений.

Четвертая модель – севооборот риса и технических культур с технологической схемой обработки почвы.

Эти модели уже апробированы на площади 190 га в провинции Хунань и показали хороший экономический эффект. В результате использования моделей прибыль от продажи сельскохозяйственной продукции возросла более, чем на 400 млн. юаней. В 2000 году годовой доход крестьянина в этом регионе увеличился до 78 юаней по сравнению с 50 юаней в 1987 году.

На площади 500 га ликвидирован очаг эрозии, т.е. остановлены эрозионные процессы и получена полезная продукция. Более 8 тысяч крестьян разрешили свои экономические проблемы, перейдя на современное горючее вместо дров и хвороста.

Так полезно взаимодействуют между собой теоретические и практические результаты научных исследований нашего Института.

СРЕДНЕВЕКОВЫЙ СОЦИАЛЬНО-ЭКОЛОГИЧЕСКИЙ КРИЗИС В СТЕПЯХ ВОСТОЧНОЙ ЕВРОПЫ*

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Социально-экологический кризис, т.е. кризис одновременно природы и общества – явление характерное не только для наших дней. Локальные потрясения такого рода бывали и раньше. Механизм их впервые был раскрыт на примере земледельческих цивилизаций - Китая [Кульпин, 1990], России [Кульпин, 1995], Древнего Египта [Прусаков, 1999], а для аридных и семиаридных областей в общих чертах для малых (локальных) ландшафтов [Иванов, Васильев, 1995]. В них Человек Хозяйствующий, как правило, был, образно говоря, одноликим – кочевником-скотоводом, хозяйствующим экстенсивно.

При экстенсивном скотоводстве человек замещает крупных хищников на вершине биологической трофической пирамиды и вследствие этого вынужден подчиняться законам природного гомеостазиса, который влия-

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