

Function and Benefit of *Hippophae rhamnoides* L. Improving Eco-Environment of Loess Plateau of China

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Abstract: In loess plateau of China, it is one of mainly restrictive factors of sustainable development of the region to serious erosion of soil and water and fragile ecological environment. Adaptability of *Hippophae rhamnoides* L. is strong and growth is fast, after 4—5 years *Hippophae rhamnoides* L. can form shrubs-grass community of thick forest and lush grass, and keep reasonable community structure and higher net primary productivity by natural thinning. *Hippophae rhamnoides* L. has the ecological function of protecting against wind and preventing sand from drifting, conserving soil and water, improving the soil and adjusting the microclimate, improving the biological diversity and recovering and rebuilding stable ecological system. Meanwhile it is good fodder, fertilizer and fuel also. *Hippophae rhamnoides* L. is pioneer of planting in loess plateau of China, and also is good shrub to mix with grass and shrubs, it has significant place and role in the course of restoring vegetation of loess plateau, and it has the higher comprehensive utilization. These open up a new route for managing loess plateau, improving ecological environmental, fasting the ending poverty and bring about the prosperity in poverty-stricken regions.

Keywords: *hippophae rhamnoides* L, loess plateau, ecology environment, function and benefit

1 Characteristic of ecological environment of loess plateau of China

Loess plateau is located in Yellow-River upper and middle reaches area in northwest China, 34°—41° of north latitude, 100°—114° of east longitude, 800m—1800m above level. It is mainly geomorphologic unit to hilly area, loess hilly, plateau gully and ridge, and loess easily burst apart and run-off when it meets water. Great majority zone in loess plateau belongs to semiarid climatic zone, mean annual precipitation is 250mm—600mm (semiarid zone is 300mm—500mm), yearly and seasonal changes of precipitation is big, more rainstorm, which usually leads to torrents of water rushed down the mountain. Evaporation is 2—4 times as many as precipitation, sunshine time about 2,000—3,100h. Mean annual temperature 7°C—16°C, more fresh gale in winter or spring, and more serious drought in winter or spring. Surviving of natural vegetation in loess plateau is very smaller. It is serious to soil and water losses and wind erosion (area with soil and water losses is about 340 thousand km², of which area of erosion modulus greater than 1,000t/(km² • a) is about 290 thousands km². Ecological balance is dislocation, and ecological environment is very fragile.

2 *Hippophae rhamnoides* L. is a fine species to adapt to the ecological environment of loess plateau

Hippophae rhamnoides L. is perennial Xylophyte of *Hippophae* L. of Elaeagnaceae, ecological amplitude is very wide. It mainly distributes in north, northwest and southwest China. In loess hilly region, there is mono-dominant community or conjunct with shrub-arbor forest in clearance and forest edge of deciduous broad-leaved forest zone, and forest-prairie zone, riverbank and hillside. In the contrast experiment of 29 species of tree or grass, large-scale air-seeding or artificial planting in barren mountain or barren gully of loess plateau, *Hippophae rhamnoides* L. has the characteristics of stronger adaptability,

fast growth, strong productivity of root-system, optimum formational effect, which has relation with itself bio-ecological characteristics to adapt to the ecological environment of loess plateau.

2.1 Seed and seedling character

It is faster to germination and emergence of seedling of *Hippophae rhamnoides* L. In general, if water and heat condition is suitable, after 2—3 days seed begin to imbibe, after 4—5 days germinate, and after 7—12 days emergence of seedling. The lowest soil moisture contents sprouting of seed demanding is 6%—8%, optimum 15%—20%.

2.2 Plant adaptability and resistance

Growth of *Hippophae rhamnoides* is fast, with the ages adding, it gradually strengthens to the capable of cold-resistance, drought-tolerance, saline-alkali-resistance, pour fertility tolerance and resistance to wind and sand. In semiarid loess zone Wuqi, in drought year (annual precipitation about 188mm—277mm) *Hippophae rhamnoides* L. still grows very well, and can vigorous growth in the steep-slope of barren mountain where tree and grass doesn't easily grow because of serious erosion and gull-slope showing Hongjiaotu.

2.3 Developmental character

After planted, in the first year growth of *Hippophae rhamnoides* L. is more slowly. After two years it begins to grow fast. If stocking percent is over 70 plan t/km², after 4—5 years, *Hippophae rhamnoides* usually closes canopy. Productivity of fruit every square kilometer is about 300kg—1,500kg, seed 75kg—300kg. Distribution of *Hippophae rhamnoides* L. in loess plateau is vast, and seed resources are abundant, which is favorable condition of large-scale constructing *Hippophae rhamnoides* L. plantation.

2.4 Root system character

Hippophae rhamnoides L. has developmentally horizontal and vertical root-system, horizontal root range is about 2m—4m, maximum 6m—10m, length of vertical-root is about 3m—5m. There are a great deal of root nodule and bud of root sprout on the branch root. Principle root and branch root mainly distribute in 20cm—80cm layer of soil, and concentrate root-system net, which makes *Hippophae rhamnoides* L. absorb soil water supplied by precipitation, and create a favorable water ecological environment for itself. Which make *Hippophae rhamnoides* L. has strong adaptability, vast distribution, and higher the benefit of soil and water conservation.

2.5 Character of emergence of tiller

The emergence of root and branch sprout of *Hippophae rhamnoides* L. is strong. 3 years old *Hippophae rhamnoides* L. often can reproduce by stump shoot. A over 3 years plant can spread towards circumference 1m—3m every year, the amount of seedling of stump shoot is over 20. After 5—6 years old *Hippophae rhamnoides* L. stumped, a great deal of stump plant can be germinated from stubble, and ramets sprout from branch root.

3 Function of *Hippophae rhamnoides* L. improving ecological environment of loess plateau

3.1 Adjustment of *Hippophae rhamnoides* L. plantation to microclimate

Hippophae rhamnoides L. plantation intercepts precipitation by lush crown layer and rich undergrowth, and accumulates precipitation by thicker litter layer, which make precipitation redistribute, and make air humidity and soil moisture inside the forest keep higher and more stable.

The measure of Wuqi and Guyuan showed air humidity of *Hippophae rhamnoides* L. plantation is higher 10%—20% than that of outside the forest, and change range is smaller than outside the forest. Soil moisture of *Hippophae rhamnoides* L. plantation is higher 3%—4% than that of outside the forest. Transpiration is the reflection of plant water metabolism, and is mainly way of water moving among soil, plant and air. Soil water absorbed by plant root system transpires to improve air humidity, and reduce heat exhaustion, which continuously change parts of an area ecologically environmental condition. The measure of microclimate of *Hippophae rhamnoides* L. plantation at Guyuan indicated *Hippophae rhamnoides* L. plantation obviously changes the distribution of water and heat of inside the forest and forest microclimate by transpiration.

3.2 Influence of absorbing water of *Hippophae rhamnoides* L. root-system to water ecological environment of woodland

Hippophae rhamnoides L. has fine water ecological adaptability. Developmental root-system can absorb deep soil water to improve water supplement. Meanwhile, with the ages of *Hippophae rhamnoides* L. adding, soil physical characteristic and fertility are gradually improved, soil water-holding capacity has been improved obviously. Restore of soil water of 1m—1.5m layer of woodland is very well in dry season, and soil moisture content suppresses or approaches natural grass-land of barren mountain. So low-wet layer formed by *Hippophae rhamnoides* L. plantation can take in more precipitation because it is improved to permeability and water-holding capacity of soil and improve water ecological environment of woodland.

3.3 Nutrient accumulation of *Hippophae rhamnoides* L. and dynamics of soil nutrient

Root nodule of *Hippophae rhamnoides* L. can fix nitrogen, decomposition of litter, ehevation of plants, and itself penetration, press and cementation of root-system and decomposition of dead-root etc., which improve soil structure, and make nutrient elements return to soil to keep the soil nutrient balance. The measure of 2—13 years old artificial *Hippophae rhamnoides* L. plantation at Wuqi showed mean annual net primary productivity of above ground is 3,820kg/hm², mean annual nitrogen accumulation is 17,475 kg/hm², phosphorus 8.25kg/hm².

3.4 Influence of *Hippophae rhamnoides* L. plantation to bio-diversity

After planted 7—8 years, *Hippophae rhamnoides* L. can form shrub-grass community of thick forest and lush grass and coverage over 80%. After 13 years forest natural shrubs and grass species is more 40 species than that of pre-experiment, introduction species as arbor, shrub and pasture and crop suppress 20. Because natural vegetation restores under the environmental condition of suitable itself growths and artificial vegetation is planted by the principle of geophile, dendrophile, grassphile and agri-phile, the structure of new ecological system. *Hippophae rhamnoides* L. plantation formed by artificial construction and natural restore is more stable and relation is more harmonious. Environmental reconstruction and restore make wilding add gradually, there are on over 3 snake-species, much more birds (includes pheasant), rats, rabbits and badger etc.. According to incomplete statistics, 10—30 wilding species perch in the *Hippophae rhamnoides* L. plantation, which form stable ecological system and improve biological diversity, stable and harmony.

4 Ecological and economical benefit of *Hippophae rhamnoides* L.

4.1 Protection against wind and prevent sand from drifting and conservation of soil and water

After planted 4—5 years *Hippophae rhamnoides* L. can be crown contact, weeds is lush under the forest, species is about 10—20. Thickness of litter layer of over 5 years old *Hippophae rhamnoides* L. plantation is about 2cm—6cm, water-holding capacity is over two times as many as itself weight. Root-system of *Hippophae rhamnoides* L. is very developed, it mainly concentrates in 20cm—80cm soil

layer and form root-system-net. So *Hippophae rhamnoides* L. forms thick crown layer, lush undergrowth and developed root-system layer, which create fine water eco-environment and forest ecological structure to strengthen protection to soil. *Hippophae rhamnoides* L. growing barren-mountain and barren-gully can intercept precipitation to keep soil surface out of raindrop directly hitting, reducing rainstorm intensity, alleviating runoff velocity and intercepting silt. Because *Hippophae rhamnoides* L. has stronger function of improving the soil, it improves soil permeability, soil anti-erodibility, and soil anti-scouribility. The measure showed at Ansai station, a test station of institute of soil and water conservation, Chinese Academy of sciences and Ministry of water resources, the runoffs of 2—4 years old *Hippophae rhamnoides* L. were 66.2%, 65% and 78.0% of natural barren-slope respectively. Soil erosive amounts were 39%, 37% and 47% of natural barren-slope respectively. There isn't often erosive gully and landslide under over 5 years old *Hippophae rhamnoides* L. The experiment planted *Hippophae rhamnoides* L. in wind-sand zone of Inner Mongolia and shanxi province showed *Hippophae rhamnoides* L. plantation can effectively control disaster of sand of storm, fixing drift-sand and improving sand land.

4.2 Fine forage, fertilizer and fuel

Browse and young leaves of *Hippophae rhamnoides* L. are high-quality forage, which contains very abundant such nutrient matter as protein, amino acid and miner etc., and has better immunity. Taste of *Hippophae rhamnoides* L. leaves is fine, after domestic animals of sheep, cow etc. eating it, it will often fat, hair blight, leaves of *Hippophae rhamnoides* L. are fine forage ill and weak livestock of dispelling ill and helping health to. According to the experiments, the capacity of *Hippophae rhamnoides* L. plantation is over 10 times as many as barren mountain.

The nitrogen contents of soil surface of 5—9 years old *Hippophae rhamnoides* L. plantation are 2.8, 1.2, and 3.1 times as many as that of barren vegetation respectively, effect of improving soil is obvious. If crop is planted in land planted *Hippophae rhamnoides* L., it will have obvious effect of increasing produce.

It is high to *Hippophae rhamnoides* L. produce firewood. 5—6 years old *Hippophae rhamnoides* L. plantation can produce dry-firewood of $7,500 \text{ kg/hm}^2$ — $15,000 \text{ kg/hm}^2$, its calorific value is 77% of coal. *Hippophae rhamnoides* L. can be stumped every 3—5 years, it is fine firewood.

4.3 *Hippophae rhamnoides* L. is pioneer of forestation and fine shrub mixed with grass and shrub

Hippophae rhamnoides L. plantation not only improves soil, but also ecologically environmental and microclimatic condition, which create suitable habitat to growth of arbor. For example, at test zone of Wuqi, inside the *Hippophae rhamnoides* L. plantation, Ansu Apricot *Prunus armeniaca* and Simon poplar *Populus simonii* is doing well, and growth is faster than that of outside the forest. Chinese pine *Pinus tabulae formis*, Cathay poplar *Populus cathayana* and Simon poplar *Populus simonii* planted in natural *Hippophae rhamnoides* L. plantation have fast-growing superiority to that of outside forest.

After 4—5 years *Hippophae rhamnoides* L. crowns closure, it is fine to intercrop *Hippophae rhamnoides* L. and *Astragalus adsurgens* in strip at Wuqi test zone. After planted 2—3 years *Astragalus adsurgens* can form thick and lush grass-strip. During 4 years, *Hippophae rhamnoides* L. and *Astragalus adsurgens* give play to higher ecological and economical benefit. Output value reaches 6,000 Yuan/hm². After 8—9 years, with *Astragalus adsurgens* declining, *Hippophae rhamnoides* L. expands towards *Astragalus adsurgens* strip by reproducing of stump shoot, at last it forms more stable *Hippophae rhamnoides* L. shrubbery. So *Hippophae rhamnoides* L. has an important sites and function in the course of vegetation succession.

4.4 Big value of comprehensive exploitation and utilization

Hippophae rhamnoides L. not only has fine the function of soil and water conservation and improving eco-environment, but also higher the value of economical exploitation and utilization. Fruit, seed oil, leaves and stem etc. of *Hippophae rhamnoides* L. contain over 100 biologically active substance, which have an important property of a medicine and health protecting of fatigue-resistance,

anti-senescence, anti-sclerosis, radiation-resistance, anti-cancer and anti-tumor. For example, vitamin E content of fruit is 5.2mg/100g, carotinoid 9.3 $\mu\text{g}/100\text{g}$, ascorbic acid 412 $\mu\text{g}/100\text{g}$, flavonol 7.7 mg/100g, fruit sugar 0.59%, sebaceous 1.5%, carbohydrate 5.92%. SOD contents of fresh berry and leaves are 3,451.00 $\mu\text{g}/\text{g}$ and 450.00 $\mu\text{g}/\text{g}$ respectively (fresh leaves of ginseng is about 695.5 $\mu\text{g}/\text{g}$). Vitamin C contents of fruit is especially rich, it is thus nicknamed as the “king of Vc”, vitamin C content is 850mg per 100g of berry juices from analysis, higher than in the kiwi fruit (*Actinida sinensis*)(70 mg/100g ~ 400mg/100g). *Hippophae rhamnoides* L. is an important raw material of food, medicine and chemical industry and “green energy resources”. Recently years, Many produces of *Hippophae rhamnoides* L. were exploited and produced in loess plateau. For example, Zhonghua Hippophae oil, Hippophae oral liquid, Hippophae oil oral liquid, Hippophae flavone, Hippophae anti-cough syrup, Liyuan oral liquid, Hippophae powder etc., which effectively promote economic development of poverty zone in loess plateau.

By fostering and managing, it can be large-scale constructed to soil and water conservation forest, fuel forest, fruit forest, grazing forest, and common forest of grazing and fuel, which give full play to ecological, economic and social benefit of *Hippophae rhamnoides* L. improving eco-environment of loess plateau. These open a new route to accelerate management of loess plateau and ending poverty and bring about the prosperity in poverty-stricken regions.

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