Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 2, 2020

Review Article

MEASURES ON EROSION-PREVENTIVE FOREST MELIORATION IN MOUNTAIN AREAS OF UZBEKISTAN

[1]Gafurova Lazizakhon Akramovna, [2]Djalilova Gulnora Tulkunovna, [3]Ergasheva Olimaxon Xaliqjonovna, [4]Kadirova Dilrabo Abdukarimova

[1]Head Scientific Center of Agro Eco Biotechnology, Doctor of Biological Science, Professor of Department of Soil Science, National University of Uzbekistan, Uzbekistan.
[2]Lecturer, Doctor of Biological Science, Department of Soil Science, National University of Uzbekistan, Uzbekistan.
[3]PhD., Lecturer, Department of Soil Science, National University of Uzbekistan, Uzbekistan.
[4]Lecturer, Doctor of Biological Science, Department of Soil Science of Tashkent State Agrarian University, Uzbekistan.

Received: 11.11.2019 ***Revised: 17.12.2019*** ***Accepted: 18.01.2020***

Abstract
Forest melioration measures in mountainous areas of Uzbekistan are of crucial erosion-preventive importance in medium-high mountains, where exist the conditions for afforestation. Eighty percent or more of the catchment area of mud flow basins are occupied by the slopes that feed the beds with flood of liquid and solid matter. In this regard, the afforestation of slopes takes a huge volume of forest melioration work. The paper deals with the problems of cultivation of productive and sustainable plantation that effectively performs the protective functions. This is primarily related to the selection and mixing of trees and shrubs. Species must conform to the type of growing conditions, which is optimal for their growth.

Keywords: Forest melioration, erosion-prevention, silviculture, protective plantations, hills, ravine afforestation, mixed plantings.

DOI: http://dx.doi.org/10.31838/jcr.07.02.52

INTRODUCTION

Foothill and mountain regions of Central Asia are in need of broad forest melioration works. Silviculture work is carried out on forest-free areas, mainly in the lower and middle parts of the forest zone. The best conditions for afforestation, characterized by rich and relatively deep mountain soils in the conditions of high humidity and relatively even temperatures, are in the northern and north-western slopes, especially in its lower third part, as well as on flat areas of other slopes, where there is a favorable water regime [1,2,3,4,5,6]. However, it is impossible to fulfill the afforestation throughout the territory of the forest even on selected micro-catchment areas, since a significant part of the slopes consists of rocky and stony surfaces not fit to afforestation, and the slopes subjected to landslide processes and ravine-forming. In these areas the floods of liquid and solid matter continue to form; they erode stream beds, supplying washout material to form the mudflows. In this regard, it is necessary to realize the measures to reduce the beds flow rate and the catchment of washout products. In addition, the correct arrangement of mountain areas of forest resources provides the use of the part of land for agricultural purposes such as cattle grazing lands, hayland, orchards, vineyards, etc. These areas also require the implementation of measures to prevent the runoff and washout [8].

MATERIALS AND METHODS

In forest fund the forests are laid out on watersheds and steep slopes, on washed out and eroded areas, landslides and ravines, forest-covered areas and areas without trees, creating woodlands, compacting sparse stands and glades. Further some of the afforestation technologies can be considered in detail.

The main determining factors for a successful growth are the conditions of moisture and temperature, but if the temperature factor in medium-high mountain is favorable for the vast majority of forest species recommended for plantations, they greatly vary in relation to soil moisture.

Concerning the terms of soil moisture content the lower- and medium-high mountain zones of the republic can be divided into: 1 - very dry localities where the soil is wet only in early spring and very dry all of the vegetation period; 2 - dry conditions, the soil is wet all the spring and dry all the rest time; 3 – localities with fresh conditions, when the soil is wet until the middle of summer, and dry all the rest time until the end of vegetation period; 4 - wet localities with soils that have sufficient moisture content for the growth of trees during vegetation period, or a localities with short-term droughts.

Fresh and wet conditions are favorable for the cultivation of almost all tree species used in afforestation of the republic. The only limiting factor is low winter temperature causing the freezing of shoots or fruit-bearing elements.

Due to the fact that soil moisture conditions depend not only on the amount of rainfall, but also on the degree of exposure, slope steepness, the degree of stoniness and erosion of slopes, thickness of fine-earth mantle, etc., it is almost impossible to distinguish on this basis the altitudinal limits of each type of conditions [8].

They can overlap each other, and therefore the determination of humidification type should be guided by the data from the nearest weather stations, soil excavation and composition of natural vegetation on each site of forest melioration development.

RESULTS AND DISCUSSION

According to the conditions of growth the following indicative list of species of trees and shrubs is recommended:

- For very dry conditions – pistachios, zygophyllum (bean caper), Atraphaxis (goat's-wheat), ephedra, thorny almonds, jujube, tamarisk, wild rose.
- For dry conditions – pistachios, Bukhara almond, thorny almond, jujube, Siberian elm, Regel pear, Judas-tree, colutea (bladder fern), sumach, fustic, apricot, Semenov maple, frutescent cherry.
- For localities with fresh conditions - in the belt of deciduous natural forests a Crimean pine and Scotch pine, red cedar are recommended of softwood; as for hardwood, besides the species listed for the second type of conditions - ailanthus, white and yellow acacia, hawthorn, honey locust, English oak, hackberry, Turkestan and American maple, osage orange, black walnut (Juglans nigra), staghorn, red ash, Sievers apple, mahaleb, plum, cherry,

eastern and angustifolia oleaster, common pear, black elderberry, barberry, honeysuckle, mahonia, wild rose, verrucous cherry, buckthorn, saskatoon, honeysuckle; in the belt of coniferous forests – Zeravshan, Turkestan and hemispherical juniper, Crimean and common pine, honeysuckle, barberry, wild rose, ephedra, Sievers apple, Turkestan maple, rowan.

- For localities with wet conditions (their area being small in the republic) that correspond to the conditions with over 800 mm of precipitation, on the slopes of northern expositions with non-washed away or weakly washed away thick soils, besides the assortment of species listed above, the walnut, black and white poplar, oriental sycamore are recommended.
- For afforestation of flood-lands, coasts of watercourses and soiling ponds it is recommended to plant tree and shrubby willows, black poplar, eastern oleaster, sea buckthorn, Sogdian ash. For the afforestation of ravines it is recommended to plant on the slopes the creeping-rooted species, such as ailanthus, false acacia (locust), eastern oleaster, amorphous, cherry, etc., and along the bottom - the same species as for soiling ponds.

For afforestation of fresh landslides, which give a very large amount of solid flowing, creating mud flows, it is recommended to plant eastern oleaster, Sogdian ash, jujube on these sites.

In order to create unwatered (non-irrigated) gardens the flat and sloping hillsides of northern exposition with non-washed away or weakly washed away thick layers of soil, melkozem or weak-stony soils in localities of the 3rd and 4th types of conditions, the following selection of fruit trees are used: apple, pear, cherry, plum, apricot, common almond, peach.

It is recommended to create the mixed protective stands on the slopes, as they are the most productive, stable and possess the best protective properties. In mixing the species it should be taken into account whether they have a positive effect on each other (helping to grow better and longer) or a negative one. It is necessary to consider this phenomenon in silviculture and to carry out the mixing of trees and shrubs according to the nature of their mutual influence (see Table 1).

Table 1. Allocation of trees and shrubs according to the character of mutual influence

Main species	Character of mutual influence	
	Positive (species-activators)	Negative (species-inhibitors)
Zerafshan juniper	Acacia (locust), common pine, Semenov maple, red cedar, Sievers apple, Korolkov honeysuckle, wild rose, plum	Red ash, walnut, Schrenk fir-tree, common apricot, eastern biota, white poplar, weeping birch, Crimean pine, Siberian elm, oblong barberry
Walnut	Red ash, plum, Sievers apple, red cedar, wild rose	English oak, acacia (locust), Siberian elm, common apricot, Crimean pine, common pine, Zeravshan juniper, white poplar, black poplar, pistachio, Bukhara almond, sea buckthorn
English oak	Red ash, Norway maple, small-leaved lime-tree, Siberian elm, three-thorned acacia, Semenov maple, Korolkov honeysuckle, red cedar	Walnut, locust, weeping birch, common pine, Crimean pine, Schrenk fir-tree, pistachio-tree, almond, wild rose
False acacia (locust)	Red ash, common apricot, Silver birch, red cedar	Walnut, English oak, black poplar, Crimean pine, pistachio, almond
Siberian elm	False acacia (locust), common pine, wild rose, h Korolkov honeysuckle, juniper	Common apricot, white poplar, red ash, Zeravshan juniper, Schrenk fir-tree, Turkestan hawthorn
Common pine	Weeping birch, red ash, common apricot, Zeravshan juniper, Siberian elm	Red cedar, buckthorn, barberry, common oak, walnut, Korolkov honeysuckle
Red cedar	Field maple, white poplar, red ash, Zeravshan juniper, common apricot	Weeping birch, sea buckthorn, Scots pine, Korolkov honeysuckle, Sievers apple
Red ash	Crimean pine, red cedar, Sivers apple, Korolkov honeysuckle, wild rose	Siberian elm, common apricot, Acacia, Zeravshan juniper, Schrenk fir-tree, Turkestan hawthorn
Common pistachio	Not stated	Bukhara almond, walnut
Common almond	Not stated	Pistachio, common pine
Sea buckthorn	Not stated	Birch, walnut, barberry

When creating the mixed stands for forest melioration purpose it is important not only to know which species can be mixed with each other, since woody species take mineral nutrition elements differently from soil. In mixed planting it is necessary to avoid the disturbance of their balance and to observe a certain ratio of the main and associating species, recommended in the Table 2.

Table 2.Optimum ratio (%) of trees and shrubs to create the mixed stands on the slopes

Main forest-forming species	Associating species	Ratio	
		Main species	Associating species
Zeravshan juniper	Common pine, Korolkov honeysuckle, wild rose	50	50
Zeravshan juniper	Sievers apple, Semenov maple	60	40
Zeravshan juniper	Acacia, plum,	70	30
Zeravshan juniper	Red cedar	80	20
Walnut	Sievers apple, plum, wild rose	50	50
Walnut	Red cedar	60	40
Walnut	Red ash	70	30

English oak	Semenov maple, Norway maple, Siberian elm, Korolkov honeysuckle.	50	50
English oak	Red cedar	60	40
English oak	Red ash	70	30
False acacia	Weeping birth, Common apricot	50	50
False acacia	Red ash	80	20
False acacia	Red cedar	60	40
Siberian elm	Common pine, Sievers apple, Korolkov honeysuckle, wild rose	50	50
Siberian elm	False acacia	60	40
Siberian elm	Red cedar	70	30
Common pine	Common apricot	50	50
Common pine	Zeravshan juniper	60	40
Common pine	Weeping birth, Siberian elm	70	30
Common pine	Red ash	80	20
Red cedar	Zeravshan juniper, common apricot	50	50
Red cedar	Red ash	70	30
Common apricot	Sievers apple	70	30

Now the methods of afforestation can be considered. Plantations on the slopes may be created both by sowing and by planting on a permanent site. In the area of silviculture the sowing may be cultivated of species with large seeds - walnut and English walnut, almond, pistachio, apricot, oak, chestnut. When sowing these seeds it is necessary to take measures to protect them from birds and rodents. Because of the danger caused to the seeds by animals it is better to sow incipiently germinating seeds in early spring for early germination. The best quality seeds approved in seed-control stations are used for the sowing. The seeds can be sown by mountain seeding-machine SKG designed for line-hole dibbling of large seeds [6, 11,13] or manually.

Willow, poplar, sometimes oleaster and sea buckthorn are planted by the seedlings from rooted cuttings, willow in moist sites can be dibbled. For other forest species the planting of annual (fast-growing) and biennial (slow-growing) species is recommended to do by standard seedlings with well-developed root system. Birches and pines are better to be planted of 2-3years old seedlings, and spruce and fir-tree - of 3-4-5years old seedlings. Plantations of juniper, pistachio and other species are better to lay by planting material with closed root system that increases up to 90% the survival rate (establishment) of cultures.

The laying of unwatered (not-irrigated) gardens of fruit and nut species (other than pistachios) is better to do by one or two year old seedlings of zoned varieties. Pistachios are bred by sowing the seeds or planting the seedlings with closed root system on a permanent site with further budding of plants by zoned forms.

The planting of seedlings and saplings can be carried out in autumn and spring, but spring planting is more preferred. Fall planting can be accepted only after wetting the soil to a planting depth. Spring sowing and planting must be finished no later than two weeks after snow melting. To improve the survival rate (establishment) and the growth of young cultures the root systems of planting material are recommended to be soaked for a day in the 0.1-0.2% solution of growth substances - sodium gumate or SAG-1, or dip them before the planting into soil mash of cream density, prepared with the solution of sodium gumate of the same concentration.

The planting of saplings and seedlings is carried out on continuous and strip tillage and on the terraces by mountain forest-planting machine LMG-2, if the height of surface part is no more than 50 cm, or by tree-planting machine LPA-1, which beds the plants 0.4 - 2, 0 m high on terraces and slopes (up to 12°) with simultaneous loosening of removed portion of terrace bed. When creating the protective afforestation with large planting material and additional cultures it is recommended on the terraces and flat slope areas to prepare the holes by tractor hole-borer KYaU-100; or by KRK-60, which is handy to use when the bedded plants rows are shifted from longitudinal axis of the tractor. When planting the cultures on sites the digging of holes is done manually.

Species location on silvicultural area is conducted under the schemes adopted by technical project. At rational distribution of the main species at continuous plowing the width between the rows should provide the cultivation process. Therefore, the distance between the rows in this case should be a multiple of 2.5-3.0 m. When growing the walnuts according to garden scheme, between the rows of the main species there are 3-4 row-spacings of 3 m wide, with associated species in each row; when growing the almonds and pistachios the row-spacings are 6-8 m (7,5) with one row of associated species, and the apples - 7.5 - 9.0 m with two rows of associated species. This arrangement provides cross processing (fertilization (allogamy)) of the gardens.

At afforestation according to forest scheme the row-spacings are 2.5-3.0 m, the main species are located on the same distance. Shrubs and associated species are located between the main species in the row. If to locate them in rows the distance between the main species is two times wider.

At strip tillage the sowing and planting is carried out on the wide strips - as in continuous plowing, and on the narrow strips - at a distance of 50-70 cm from the bottom edge of the plowed strip. On the terraces, with single-row cultures, the plants are located as far as 0.5-0.8 m from the outer border of earth-filled part of the terraces; with double-row cultures – the second row is located as far as 0.5-0.8 m from the base of borderland slope. 1-2 plantings are located on the sites. Fast-growing species are bedded by a single plant, and slow-growing – by 2 at a site. At strip plowing and on the terraces the distances between the trees in the row are the same as in continuous plowing. Under the best conditions of moisture the distance between the trees is established as a maximum one from recommended ones.

On the slopes of ravines the seedlings are bedded on micro-terraces 40-50 cm wide with the distance between them of 2.0 m. The distance between the plants in a row is 1 m. Near-ravine strips are created by sites of 3-4 rows with the distance between the sites of 2,0 m. Along the river-beds a line planting of trees to protect the coasts from erosion (washing away), is performed with location of trees and shrubs 1.5-2.0 m apart. Soiling ponds are bedded with plants located at 2.0 x 2.0 (1.5) m. Along the bottom of the ravines in every 7-10 m the willow

stakes are bedded in cross rows 0.5 m apart to build the fence (screen) barriers regulating the surface and river-bed flows.

To improve the survival rate (establishment) and the growth of culture on terraces during the first year it is recommended in the vicinity of bedded plants to dig on the side of borderland the ditches 20 cm deep and 1m long making the rolls of excavated earth at the edge of the ditches on the side of borderland with diverging runners to collect the rainwater that falls on the filled part of the terrace bed. Otherwise, the water slides into the borderland part of terraces and young plantings turn out to be in very dry conditions due to reverse gradient of the terrace bed. This purpose can be achieved by plowing the furrows at 0.4-0.5 m from planting rows, but the effect of this approach is reduced since the moisture is not concentrated near the plant. In the rows of plant bedding, where soil loosening is impossible to do with mechanisms, it must be carried out manually; it is recommended to water the soil in spring with structure-formers K-25 or I-1 (synthesized in the Institute of Plant Chemistry of the Academy of Sciences of Uzbekistan), in concentration of 0.1% at irrigation norm 2 l/m2. This technique allows soil to keep the moisture and to reduce the weed growth [7,12].

Optimal organization of the territory of mud-flow ponds in mountain forest fund provides the arrangement on the slopes of not only protective forest plantations, but also the introduction of other spheres of economy, including the hayfields and pastures. The vegetation with projective covering of more than 80% efficiently transfers the surface water runoff into subsurface flow, stopping soil erosion and washout; the annual growth and die-off of huge amounts of biomass helps to create high-humus structure of soil [9].

In this regard, in medium and highly-eroded slopes in the areas that do not fall under the establishment of forest plantations, it is recommended to sow the perennial grass, forming a turf that gives the greater biomass and not dies off for a long time without seed reproduction. For the complete stoppage of water flow during heavy rains on the slopes with grass cultivation, the water-absorbing protective strips are created with 2-3 rows of wood-shrub belts located on the slopes on the terrain contours at a distance of 40-50 m from each other. Preparing the soil for planting the belts is carried out depending on the steepness of the slopes - on the glacis (up to 8°) the continuous moldboard plowing to a depth of 20-25 cm is done, on a gentle downhill slopes (up to 15°) - the moldboard strip plowing is done to locate the belts leaving inter-strip spaces of 40-50 m to plant the grass. On steep slopes (more than 15°) the soil for the belts is prepared by terraces and on very steep slopes by sites of 2-3 rows also leaving the free space to plant the grass.

Planting of trees and bushes in a row is 1.0 m apart and between the rows – 3-2 m. The technique of trees and shrubs planting is the same as when creating the protective forest cultures. The assortment of recommended species includes, in descending order according to requirements of soil fertility: the trees – red ash, American maple, acacia (locust), apricot, Russian olive, Kalmikov plum, common almonds, Siberian elm; the shrubs - Fedchenko and scutella wild roses. The mixing of species is done by the rows. In the row the planting of trees is alternated with shrubs. The treatment is the same as for protective forest cultures.

Soil tillage to sow the grass on the glacis of up to 8-10° is carried out in the form of continuous moldboard plowing, sowing the seeds and embedding them by harrowing. On the gentle slopes the soil is loosened by cultivators and further the seeds are embedded after sowing by harrows. On the steep and very steep slopes the sowing of grass seeds is carried out without embedding, just manually scattering about. Grass seeds are better to sow in pellets, if possible, in order to prevent being eaten by ants, birds and others. Sowing time is late autumn or early spring.

For a quick cessation of erosion, soil recovery and increase in forage capacity it is recommended to sow grass mixtures; 50% of kochia and 50% of wheatgrass, 60% of lucerne and 40% of ryegrass , 40% of fescue and 60% of lucerne. The rate of application of ryegrass seed is 10 kg/ha, kochia -20, lucerne - 14, wheatgrass – 10 and fescue - 9 kg/ha. These grasses differ in characteristics of drought-resistance, frost-resistance, macrobiosis, low requirements to soil fertility [7,12].

CONCLUSION

Afforestation of foothills and mountain areas should be based on several principles:

- any area should be considered as an element of small catchment area;
- preparation of soil to plant the trees and shrubs is designed in such a way as to capture and accumulate the precipitation for better water supply to vegetation and termination of surface runoff;
- forest vegetation should occupy the part of soil surface of slopes so as accumulated moisture was spared not only on transpiration, but also on uniform feeding of mountain water sources during the summer season;
- to establish such plantations it is necessary to use an approved assortment of trees and shrubs, depending on the growing conditions of the site;
- the layout of tree species should be chosen depending on soil moisture content;
- mixed stands are more resistant, but when planning the mixing schemes of species one should take into account their mutual influence and correlation of main and secondary (associated) species.

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