Geo-Eco-Trop, 1995, 19(1-4), 83-90

CONSERVATION EFFICIENCY OF TWO COMMON RIVERAIN HERBACEOUS PLANTS ON WATER RUN-OFF AND SOIL EROSION

Efficacité de deux plantes herbacées de rive quant à la limitation du ruissellement et la protection du sol contre l'érosion

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RESUME

Deux plantes herbacées de rive, Gnaphalium indicum *L. et* Grangea maderaspatana *Poir., ont été sélectionnées pour une étude quantitative quant à leur rôle protecteur vis-à-vis des sols et la réduction des effets du ruissellement. Des jeunes pousses collectées sur les bancs du Gange, ont été semées sur des placeaux expérimentaux d'un versant. Trois parcelles de 3 x 1m dont une gardée comme témoin, ont été soumises à des pluies simulées à partir d'un pommeau situé à 1m du sol avec un débit de 20 l min^{-1} pendant une période de 30 minutes.*

Le coefficient de ruissellement est de 17,4 et 21,6 % pour Gnaphalium indicum *et* Grangea maderaspatana, *contre 78 % sur la parcelle restée nue. Le taux de conservation est donc de 77 et 72,4% pour les deux plantes. L'érosion est respectivement de 4,5 et 5,6 % du total érodé sur parcelle nue. La limitation des pertes en substances nutritives a également été évaluée.*

ABSTRACT

Two common riverain herbaceous plants, Gnaphalium indicum *L. and* Grangea maderaspatana *Poir. from the Ganges river bed at Bithoor (Kanpur Dehat) and Kanpur City (India), were selected to assess experimentally their quantitative role in binding the soil and reducing water run-off. Young seedlings from the banks of river Ganges were sown on sloping experimental garden plots. Simulated rainfall (water showers) from a multipore nozzel, at a height of one meter with a constant discharge of 20 l minute^{-1} for*

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30 minutes. Two vegetated and one bare plot size is 3 x 1 m. Run-off water and eroded soil were collected from each experimental plot in artificial reservoir and their quantities measured. The soil and water conservation value of selected herbs were calculated using the formula given by AMBASHT (1970). The values for the riverain herbs ranged between 70% to 95%, while water and soil conservation values ranges between 50% to 75% and 80% to 95% respectively.

Nutrient losses through run-off water and eroded soil from vegetated and bare plots were compared, to assess, the role of these species in maintaining soil quality and fertility.

INTRODUCTION

Accelerated soil erosion by water is the most severe and widespread soil degradation problem in the river bed. It constitutes a serious potential problem in most of agricultural lands where the crop plants are grown in rows.

Riverain ecosystem are delicately balanced and extremely fragile. They experience periodic flooding, erosion, silting and a variety of biotic and abiotic stresses like grazing, scraping, agricultural operations, waste and sewage disposal and discharge of effluents. These lands are important in buffering nutrient flow from upland watersheds to water bodies. Herbaceous species on these sloping can effectively reduce nutrient loss by forming a thick cover. The plants bind the soil mechanically by virtue of their root system. Surface run-off and soil loss are intimately related to landforms, soil type, vegetation and rainfall. The tropical rain, storms result in breaking up of soil aggregates and decrease in filtration by compactness and sealing up of soil surface (KOWAL & KASSAM, 1977), which ultimately result in run-off and soil erosion, surface flow and soil wash from the area depending upon duration and intensity of rainfall. But vegetation cover plays a vital role which protect the soil through erosion action of rain beating and wind effects (HUDSON & JACKSON 1959; ELWELL & STOCKING, 1974). They cut the effect of water run-off, through cushioning effect and soil binding effect by their fine fibrous roots (BAVER, 1956).

The vegetation on riverain ecosystem plays an important role in nutrient and water conservation in binding the soil and in reducing erosion. In the absence, trees may increase erosion by increasing the size of the raindrops. Appropriate management of riverain land can effectively reduce phosphorus input to water bodies from the slopes.

Vegetation sustain the erosion forces and the species growing naturally on eroded areas have capacity of soil binding. Hence the important species growing in the riverain slopes are chosen for conservation study.

The main objectives of this study were to determine the soil and water conservation efficiency of dominant weeds.

MATERIALS AND METHODS

River bed fields are mostly covered with naturally growing weeds, which are dense in the rainy season, moderate in winter and depauperate in summer. In certain regions, cereal crops are grown during March to June.

Two dominant herbaceous species *Grangea maderaspatana* and *Gnaphalium indicum* found growing luxuriantly on the Ganges river beds, were selected to determine their water and soil conservation values on artificial slopes in a culture experiment. *Grangea maderaspatana* (Asteraceae), is a prostrate, villous herb, with 2 x 1.5 cm, sessile, sinuate pinnatified leaves. *Gnaphalium indicum* L.(Asteraceae), a small white, wooly, erect, annual herb, with 1 x 0.5 cm alternate linear, spatulate leaves attained a stature of 20-30 cm. in the experimental plots.

These riverain species were grown on experimental sloping plots (30% slope) in the Botanic Garden of Forest Research Institute, Kanpur. Cemented collection tanks were prepared at the lower end of each sloping plot to collect the water runoff and eroded soil. Garden soil contained 56.1% sand, 26.4% silt and 17.3% clay. Two plots were planted each with a separate species and a third plot was left bare. The area of each experimental plot was 3 x 1 m. size. At the time of planting, density was kept uniform but later the extent of cover increased to different levels in different plots, depending upon the growth behaviour of the different species. The experiment was performed when the canopy was sufficient to cover the ground surface completely. Weeding of the naturally grown seedlings was done at an early stage. Vegetated and bare plots were watered for 30 minutes using a multipore nozzle with 2 mm perforation from 1 meter height at a constant discharge of 20 l minute^{-1}. This high simulated rain intensity was selected for the experiment to generate sufficient kinetic energy to cause adequate run-off. The rain intensity selected for the treatment was slightly higher than the higher intensity storm events, that occur in nature. The experiment was repeated three times and in order to restore, so for as possible, the plot characteristics, an interval of 10 days was allowed between successive watering treatments. Results of the three treatments were averaged and then the soil and water conservation efficiency percentage for each of the studied species was calculated. The volume of water showered on each plot, the volume that run-off and the weight of soil eroded from each plot were measured from the collections in the reservoirs. Samples were taken immediately after the watering treatments to avoid evaporating loses. Soil samples were oven-dried for 36 hours. at 80°C and sifted through a 0.5 mm sieve before analysis. Soil particles concentration and nutrient concentration were analysed selecting appropriate methods for deposited soils as described by JACKSON (1967). The conservation value of each of the two species for soil and water was calculated using the procedure given by AMBASHT (1970).

$$\text{Conservation value} = 100\ (1 - Sp/So)$$

where Sp and So are the quantities removed from vegetated and bare plots respectively of soil and water under identical erosive stresses.

RESULTS AND DISCUSSION

Experimental Plot Characteristics :

Herbaceous plant species grown in monoculture on artificial slopes varied considerably in their canopy cover, standing crop biomass and growth performance. Among the two stands studied (two vegetative and one bare), *Grangea maderaspatana* had the maximum canopy cover in comparison to other species. Minimum canopy cover observed in the *Gnaphalium indicum,* while the highest standing crop biomass were observed in *Grangea madespatana,* while minimum in *Gnaphalium indicum.* The bare plot showed the maximum (1.4) soil bulk density.

Water and soil conservation

Ground cover protected the soil against erosion. Simulated rain on vegetated and bare plots depleted the soil quantities differently. Minimum water run-off (105 litres) and soil loss (0.750 kg) and maximum water conservation value (77%) and soil conservation value (95%) were observed in the *Grangea maderaspatana* stand, while in the bare plot, the soil loss was 16.60 kg, infiltration 20.7% and water run-off was 470 litres. The infiltration of water was also maximum in *Grangea maderaspatana* plot compared to other plots (Tab.I).

Low water run-off and low soil loss from the *Grangea* sp. stand may largely be attributed to reduction in raindrop energy by the multilayered (2-4 leaf layers), canopy cover (YOUNG & WIERSMA; 1973), whose cushioning effect was further increased when the plants became lodged under the impact of the initial application of simulated rain and protected the ground more closely. Reduction in the shear stress of run-off by the small diversion and detention reservoir formed by plant residues (FOSTER & MEYER, 1977) further help to reduce raindrop energy. This led to increase depth of flow on the plot surface, which acted as a protective cushion against raindrop impact and in turn caused high infiltration, low water run-off and low soil loss.

Tab.I.- Quantities and percentage of water and soil run-off from different experimental plots and conservation values. (Cv)

Experimental Plots	Water run-off (liters)	Water run-off %	Cv for water	Soil loss (kg)	Cv for soil
Plot 1. *Grangea* sp.	105	17.41	77	0.750	95.49
Plot 2. *Gnaphalium* sp.	130	21.57	72.34	0.935	94.37
Plot 3. Bare plot	470	77.94		16.6	

The cover of vegetation reacts favourably upon soil, not only protecting it from wastage, but under natural conditions also improving its fertility and texture. The primary effect of cover is to retard the movement of water or wind over the surface of the soil by means of stems and leaves and to filter water into the soil along the roots and old root channels, a process in which litter and leaf mold also play leading roles (BATES & ZEASMAN, 1930; FORSLING *et al.*, 1931; PEARSE & WOOLEY, 1936). In the bare plot, in the absence of vegetation intense splashing and beating effects on the surface soil by high energy rain drops caused finer particles to come to the surface, resulting in clogging and sealing of the pore spaces. This changed the matrix structure and textural composition of the surface soil layer leading to maximum loss of water and soil through run-off (ROMKENS *et al.*, 1986)

Tab.II.- Mechanical composition of soil from different experimental plots.

Parent stock		Clay (%) 17.3	Silt (%) 26.4	Sand (%) 56.1
Plot.1. *Grangea* sp.				
	Before showering	15.57	24.24	60.00
	After showering	14.50	24.01	61.25
	Loss / Gain	- 1.05	0.13	1.25
	Deposited soil	28.25	34.01	35.75
Plot.2. *Gnephalium* sp.				
	Before showering	15.46	24.00	60.47
	After showering	14.19	23.08	62.82
	Loss / Gain	- 1.27	- 0.92	- 2.35
	Deposited soil	30.45	36.10	33.42
Plot.3. Bare plot				
	Before showering	14.72	22.79	62.69
	After showering	11.51	20.62	68.58
	Loss / Gain	- 3.21	- 2.17	5.89
	Deposited Soil	41.35	43.44	15.06

The shallow topsoil and dense subsoil combine to promote soil erosion by water especially under rolling topographic conditions (PEARSE & WOOLLEY, 1936). After simulated rainfall, the sediment and run-off washed from the plots were delivered to a reservoir contained a greater proportion of finer particles of soil like clay and silt. Maximum gain, sand percentage was in bare plot (15.89%) and least in *Grangea* sp. plot (1.25%). Rest plot also showed loss in percentage of clay and silt particles (Tab. II).

The soil condition is maintained and improved under cover of the plants. According to JEJE (1978), there will be little or no run-off on coarse textured soil covered with good vegetation in humid areas as the rainfall falling on the surface will ordinarily penetrate down. BAVER (1956) reported that grass cover limits soil loss.

The organic carbon, organic matter, total nitrogen and C/N ratio have been recorded 0.26%, 0.45 %, 0.022 % and 11.82% respectively in bare plots after showering. The highest were 0.44%, 0.77%, 0.035% and 0.57% for organic carbon, organic matter, total nitrogen and C/N ratio respectively in *Grangea maderaspatana* plot. This must have been due to greater leaching and wash off from senescing and decomposing herbaceous plant parts and to their subsequent suspension in run-off (TIMMONS *et al.*, 1970; Mc DOWELL *et al.* 1984) (Tab. III).

Tab.III.- Chemical properties of soil at different stages of the experiment

	Organic Carbon %	Organic Matter %	Total N (%)	C/N Ratio
Parent Stock	0.73	1.27	0.053	13.77
Before Showering				
Plot 1	1.02	1.75	0.064	15.93
Plot 2	1.00	1.67	0.059	15.50
Plot 3	0.51	0.88	0.039	13.08
Deposited soil				
Plot 1	0.44	0.77	0.035	12.57
Plot 2	0.42	0.70	0.025	12.50
Plot 3	0.26	0.45	0.022	11.82

WHITE & WILLIAMS (1977) have reported that nutrient transport in surface run-off was significantly related to the amounts of water and soil loss and that 50-70% of data variation was attributable to these factors alone. An unexplained variation was partially attributed to cover, growth and stage of decomposition resulting in difference in the leachate from different stands.

Reduction in run-off volume and the amount of eroded soil from different vegetated stands may be due largely to reduced mechanical disturbance and mixing of the soil, resulting from greater protection provided to the soil surface by ground cover conditions. High run-off losses from the bare plot were due to the high run-off volume caused by the intense impact of rain drops on the soil surface and low infiltration due to the absence of vegetation.

It can be concluded from the above study that, canopy cover was the single most important factor in overall nutrients, soil and water conservation value.

The conservation value of soil and water for the two dominant plants were found maximum for *Grangea maderaspatana* in comparison to *Gnaphalium indicum*, which is due to the cushion shaped, prostrate nature.

Both the prostrate and erect above ground vegetation lower the run-off velocity as well as it provides a check to the forces of raindrop from splashing effect and low infiltration due to the absence of vegetation.

ACKNOWLEDGEMENT

Thanks are due to Dr. ASHWANI KUMAR, Director, Forest Research Institute,Kanpur (Uttar Pradesh) for providing necessary facilities to accomplish present endeavour.

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