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# Potential of Silvipastoral System for Increasing the Soil Nutrient in Degraded Land

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**Abstract**

The pressure on land is increasing day by day to grow food and fodder, fuel and wood due to increase in human and livestock population of India. It has been estimated that annually about 6,600 mt top soil and 5.4 to 8.4 mt plant nutrients are washed away to the ocean. Under such situations, multistorey system of vegetation could be of great help in restoring and sustaining health of soils. Physico-chemical properties of soils was compared after 10 years of establishment of pasture and different silvipastoral systems. Organic carbon and available nutrients (NPK and S) increased as compared to pasture alone except K in *H. binata.* The soil samples collected after 15 years in the above said agroforestry systems along with adjoining natural forest of same age and analyzed for different physical properties of soils like mechanical characters, dispersion ratio, pore size distribution, porosity, bulk density. The results revealed that multistoried and silvi-hortipastoral systems of agroforestry appeared to be suitable for sustainable soil and crop productivity and resource conservation.

**Key words : Silvipastoral, Degraded land, Soil microbial biomass, Organic carbon, Nutrients.**

The rains in India are erratic and often come in a few high intensity storms which results in great runoff. This is mainly due to high biotic pressure and the vegetal cover of the land is negligible. It has been estimated that annually about 6,600 mt top soil and 5.4 to 8.4 mt plant nutrients are washed away to the ocean (1). Under such situations, multistorey system of vegetation could be of great help in restoring and sustaining health of soils. Therefore, attempts were made to collect and discuss the improvement in the soils due to silvipastoral systems in the country.

## *Response on Physico-Chemical Properties of Soils*

In semi-arid conditions at Jhansi, Pathak (2) reported that in *A. lebbek-Cenchrus-Stylo* and *A. procera-Cenchrus-Stylo* based systems, significant improvement in soil organic matter and available NPK was possible. Organic matter build up was 38% in former compared with 25% in latter system. Available phosphorus and potash were 22 and 16 and 9.5 and 11.0%, respectively in these systems.

The analysis of soils after 6 years of silvipasture establishment indicated increase in nutrients like N, P, K and organic carbon even when grasses were harvested and removed every year. He also reported improvement in soil physical properties, pH, nitrogen and organic carbon with 4 years silvipasture plantation in calcareous soils.

In another study it has been found that the initial organic matter, available nitrogen and phosphorus and field capacity of 0.32%, 131 kg/ha, 6.2 kg/ha and 11% were changed to 0.78%, 267 kg/ha, 15.5 kg/ha and 15.5%, respectively over a period of 10 years establishment of silvipastoral system (3).

Improvement in some physico-chemical properties of soils was compared after 10 years of establishment of pasture and different silvipastoral systems. It was observed that in all the silvipastoral system organic carbon and available nutrients (NPK and S) increased as compared to pasture alone except K in *H. binata* (4). However, physical properties of soil did not show definite trend in all the silvipastoral systems. Hazra and Singh (4) reported that in a total of about 418.8 ha of highly degraded wastelands of Gaharwara village, an area of 83.75 ha barren hill was treated with appropriate soil and water conservation measures and planted with suitable trees, shrubs, pasture grasses and legumes. The total forage pro-

**Table 1.** Improvement of mechanical, physical and chemical properties of soil after 7.5 years of establishment of silvipasture.

| Attributes | | Barren fields | Silvi-pasture |
|---|---|---|---|
| Sand (%) | | 71.0 | 64.5 |
| Silt (%) | | 20.9 | 18.7 |
| Clay (%) | | 8.1 | 16.8 |
| Bulk density (g/cm$^2$) | | 1.89 | 1.88 |
| Particle density (g/cm$^2$) | | 9.91 | 9.98 |
| Porosity (%) | | 45.10 | 44.50 |
| Field capacity (cm) | | 5.15 | 6.88 |
| Wilting point (cm) | | 8.1 | 9.29 |
| Available water (cm) | | 1.65 | 9.59 |
| pH | | 6.1 | 6.6 |
| Organic carbon (%) | | 0.20 | 0.29 |
| Electrical conductivity (M mho/cm) | | 0.16 | 0.19 |
| Available (kg/ha) | N | 158.2 | 211.9 |
| | P | 2.8 | 5.76 |
| | K | 177.4 | 929.6 |

ductivity from silvipasture on barren hills was 630 tones with average productivity of 7.5 t/ha. The soil and water conservation treatments helped in reducing soil loss from 41 to 9.5 t/ha from barren hillocks and from 20.5 to 5.5 t/ha from wastelands. This has also helped in reducing silt deposition from 0.28 to 0.40 m to 0.05 to 0.1 m and reduced runoff from 70 to 30% with rise in water table from 1—4 m. This leads to increased crop productivity from 0.36 to 2.0 t/ha and increased cropping intensity from bare 80 to 156%. The cost-benefit ratio of the program was 1 : 2.89.

In another trial at Jhansi, Yadav and Varshney (5) reported on the basis of five years that a 3 tier silvipastoral system (*L. leucocephala*) as top canopy, *D. cinerea* as middle and *C. ciliaris* + *S. hamata* as lower canopy reduced the runoff and soil loss about 6 and 11 times, respectively against a bare land. Similarly loss of total soluble salts, dissolved nitrogen and potassium was reduced at the tune of 69, 67 and 43%, respectively as compared to above land. While improvement in organic carbon and available nitrogen and phosphorus in silvipastoral system was 53, 23 and 8%, respectively compared to the initial status of the nutrients of this area. The potassium status in the system was almost maintained. However, in bare land all the nutrients were decreased after 4 years as compared to initial status.

In Shiwaliks where mean annual rainfall receives between 800—1,500 mm is situated below the Himalayas and above the Indo-Gangetic alluvial plains. Due to different agroforestry system in this region, it was observed that average soil, water and nutrients losses with runoff water were less as compared to agricultural systems (6). Similarly, improvement in soil nutrients (NPK) in four silvipastoral systems were higher as compared to pure grass except for P in two silvipastoral systems.

Srivastava et al. (7) reported that silvipasture along with staggered contour trenching in Kangra watersheds reduced the soil erosion and improved productivity, survival of plants and out put from silvipastoral system. Treatment with staggered con-

**Table 2.** Effect of different MPTS based silvipastoral systems on soil fertility. BC = Below canopy, OPC = Open canopy, EC = Electric conductivity, OC = Organic carbon, SMBC = Soil microbial biomass carbon.

| Constituents | | *A. nilotica* var *cupressiformis* | | *D. sissoo* | | *H. binata* | | Pasture alone |
|---|---|---|---|---|---|---|---|---|
| Soil pH | BC | 7.11 | 7.35 | 6.91 | 7.04 | 7.21 | 7.05 | 7.43 |
| | OPC | 7.30 | 7.30 | 6.88 | 7.05 | 7.35 | 7.23 | |
| EC (ds/m) | BC | 0.111 | 0.097 | 0.087 | 0.112 | 0.107 | 0.129 | 1.07 |
| | OPC | 0.0135 | 0.111 | 0.065 | 0.098 | 0.082 | 0.089 | |
| OC (kg/ha) | BC | 7.0 | 7.6 | 8.3 | 8.6 | 8.6 | 9.4 | 6.4 |
| | OPC | 7.4 | 8.4 | 4.8 | 6.3 | 7.2 | 6.6 | |
| Available K (kg/ha) | BC | 224 | 207 | 220 | 242 | 193 | 210 | 186 |
| | OPC | 179 | 290 | 188 | 248 | 167 | 198 | |
| SMBC (μg/g soil) | BC | 479 | 503 | 540 | 518 | 631 | 661 | 303 |
| | OPC | 433 | 527 | 505 | 495 | 545 | 509 | |
| Dehydrogenase activity | BC | 149 | 290 | 149 | 151 | 304 | 158 | 98 |
| (μg TPF/day/g soil) | OPC | 259 | 164 | 109 | 130 | 158 | 188 | |

tour trenching at 1 m vertical interval could create 227 to 424 $m^2$/ha runoff retention and trapped 37 t/ha per year silt in watersheds in Kangra.

In north-east region of the country in the Meghalaya, Prasad (8) studied the nutrient management in hill agriculture and found that exchangeable Al and Mg decreased while, Ca, K and Bray's P content increased in silvipastoral system. Similarly in north-west Himalaya, Rao (9) studied the dynamics of herbage in *A. catechu* and *Pinus roxburghii* based natural silvipastoral systems and noticed that as distance increased from tree trunk pH and Ec enhanced while organic carbon, N, P., K, Ca and Mg decreased.

Evaluation of different agroforestry systems viz., *citrus reticulata* + annual crops, *Citrus lemon* + annual crops, arboretum (mixed multipurpose tree species) + annual crops, silvihortipastoral (*Alnus nepalensis*) (pineapple + fodder grasses ) and *A. nepalensis* + tea + black pepper + annual crops was done up to 15 years under hilly ecosystem of Meghalaya. The soil samples collected after 15 years in these agroforestry systems along with adjoining natural forest of same age and analyzed for different physical properties of soils like mechanical characters, dispersion ratio, pore size distribution, porosity, bulk density. The results revealed that multistoried and silvi-hortipastoral systems of agroforestry appeared to be suitable for sustainable soil and crop productivity and resource conservation in hilly agroecosystems of Meghalaya (10).

Studies on soil fertility improvement in *Greveilla robusta, Gmelina arborea* and *Tectona grands* based silvipastoral systems under semi-arid condition at Mettupalayam, Tamil Nadu revealed that due to inclusion of either trees alone or tree + grass the organic carbon, available N, P, and K in the soils increased appreciably as compared to open (barren) land and pure grass except N in *G. robusta* + grass, P with pure trees of *G. arborea* and *T. grandis* + grass and K with *T. grandis* (11).

Studies on soil erodibility characteristics under different land uses viz. agriculture, pastoral, silvipastoral and forest (Kardhai dominated) was conducted at CSWCR & TI, Research Center, Datia (MP). The soil pH varied from 6.79 to 8.91 and minimum of 7.60 was in forest. While bulk density was highest in forest (1.71 $Mg/M^3$ ) and minimum of 1.58 $Mg/M^3$ was in silvipastoral plot. The organic carbon was highest in pastoral land use (0.55%) followed by silvipasture (0.51%) and minimum of 0.45% was agriculture land use (12). Mean clay content varied from 12.0% in forest to 17.5% under pastoral land use. Suspension percentage varied from 7.15 to 14.30 with highest value under forest land use indicating the highly erodible nature of the soils. Minimum erosion ratio was recorded under pastoral land use (33.5) followed by silvipastoral (36.7), agriculture (38.2) and forest (92.4) which again confirmed the high erodibility of soil. This showed that Kardhai forest in this region are prone to erosion owing to coarse, texture, low organic matter coupled with low soil depth.

Rana et al. (13) reported the fertility improvement in *Dalbergia sissoo* based silvipastoral system after three years of establishment. On an average, improvement in available N, P and K was 10.7, 13.2 and 6.8%, respectively over initial value. While, increase in organic carbon was 0.05 unit. The decrease in pH value was also observed (0.03—0.06 unit).

In arid condition, Singh and Lal (14) investigated profile characteristics and level of fertility under khejri (*P. cineraria*) and babul (*A. nilotica*) canopies. Parallel observations were made on soil under open field condition. It was concluded that comparatively high organic matter, total nitrogen, available phosphorus, soluble calcium, low pH and better mechanical composition of soil upto 120 cm depth in khejri promoted the growth and yield of crops grown in its vicinity. Agarwal et al. (15) concluded that status of available micro-nutrients generally improved under plantation specially under khejri. Comparative study on the soil moisture status in 120 cm soil profile under five tree plantations (16) indicated that the soil moisture regime remained generally higher below khejri (*P. cineraria*), rohida (*T. undulate*) than that in Vilayati babul (*P. juliflora*), siris (*A. lebbek*), and kumut (*A. Senegal*). The soil moisture under khejri ranged from 27 to 50 mm during the dry period from November to June and 115 to 140 mm from July to September.

Studies on soil moisture regime under khejri (17) revealed that khejri being a phreatophyte, moisture fluctuations in the upper soil layers has hardly any influence on its internal water balance and that the water balance of upper soil layers is largely regulated by evapotranspiration of the shallow rooted

herbaceous ground flora. It was suggested that herbaceous plants with limited root growth can be grown during short rainy season only and if grown during dry period (November to June) stand very little chance of survival because of the soil moisture content (2%) hardly exceeds wilting point (2 to 2.5%).

Soil profile analysis under tree canopy of *P. cineraria* and open field condition was done (14). Results indicate that better nutrient status in 0—20 and 20—60 cm soil depth under tree canopy. Analysis of organic carbon, nitrogen and potassium in these profile depth was 0.15%, 512 kg/ha and 309 kg/ha and 0.13%, 521.9 kg/ha and 241.9 kg/ha respectively in *P. cineraria* plots. In open plots the vale of organic carbon N and K were 0.13%, 449 kg/ha and 290 kg/ha and 0.13%, 506.2 kg/ha and 295 kg/ha respectively.

Beniwal (18) reported that natural grassland of Rajasthan, maintain a constant level of organic carbon and available nutrients in soil. Cultivation of improved pastures, mixed pasture with legume and silvipasture systems, improves soil fertility. While cultivation of annual crops like pearlmillet, oats, mothbean and cowpea decreased organic carbon and available nutrients in soil. Soil pH, micronutrients (Zn, Cu, Mn) status remained unaffected by cropping systems both under arid and semi-arid conditions.

Naugariya and Puri (19) reported improvement in soil fertility after 7.5 years of silvipasture compared to barren fields (Table 1) in sub-humid region of Chhatisgarh.

Yadav et al. (20) studied the soil fertility in a 13 years old different MPTS (*Acacia nilotica* var *Cupressiformis, Dalbergia sissoo* and *Hardwickia binata*) based silvipastoral systems and reported that irrespective of MPTS and pruning up to 50% of height of the trees or unpruned trees, the soil pH decreased by 0.27 unit and increased organic carbon by 28% in silvipastoral system compared to pasture alone. Similarly, available K, soil microbial biomass carbon and dehydrogenage activity increased by 16, 83 and 104% in silvipastoral system, respectively, over pasture alone (Table 2).

In different agro-climatic condition under various land use systems it has been reported by various workers that reduction in runoff and soil loss, and improvement in soil nutrients due to silvipasture, silviculture and pasture was observed as compared agriculture or cultivated fallow land use systems (21—28).

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