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Trend of soil parameters under different spacings of Grewia based agroforestry system in the mid hill zones of Himachal Pradesh

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Abstract
Soil under the 3 spacings (8m×1m, 8m×2m and 8m×3m) of a 14 year old *Grewia optiva* based alley cropping was analysed and compared to that in open condition after successful cultivation of garden pea with organic manures (poultry manure and vermicompost). The available nitrogen, phosphorus, potassium, electrical conductivity and organic carbon were significantly greater under agroforestry system than open condition and under agroforestry system it increased with decrease in spacing. However the trend was inverse for soil pH, which was found to be more acidic under agroforestry system.

Keywords: grewia optiva, organic manures, soil, alley cropping

1. Introduction

Agroforestry is an intensive land-management system that optimizes the benefits from the biological interactions created when trees and/or shrubs are deliberately combined with crops and/or livestock (Garrett *et al*., 1994) [9]. It is one of the best alternative land use system for present and future environmental scenarios. It provides environmental stability, at the same time being economically viable and socially acceptable. Agroforestry systems like agrisilviculture, agrihorticulture, silvopastoral etc provide stability and sustainability to the farming systems. These diversified land use systems not only help the farming community in providing assured income during the events of natural calamities, but also protects the land from degradation and enhance the soil quality. Further, the allocation of the scarce land resource based on its capability class to alternate land uses, checks its degradation and also increases its productivity in terms of food, fuel, fodder, and fruit (Das *et al*., 1993) [8]. As per IPCC, agroforestry systems can provide significant opportunities of creating synergies linking both adaptation and mitigation actions with a technical mitigation potential of 1.1-2.2 Pg C in terrestrial ecosystems in coming 50 years (IPCC, 2007) [12].

In general, trees have been found to improve soil physical and chemical properties by various means (Nair, 1984 and Lal, 1989) [19, 15]. Trees can improve the nutrient balance of soil by reducing unproductive nutrient losses through erosion and leaching, and by increasing nutrient inputs through nitrogen fixation and increase biological activities by providing biomass and suitable microclimate (Schroth and Sinclair, 2003) [22]. Trees act as nutrient pumps *i.e.* uptaking leached nutrients from the deeper zones and making it available in the surface soil in the form of litter fall. (Kellman, 1979 and Yamoah *et al*., 1986) [14, 32]. Out of the several benefits accrued from agroforestry systems in terms of soil quality, nutrient cycling is the most predominant process and it is a key process in tree based ecosystems as it maintains the availability of nutrients for vegetation growth (Xu *et al*., 2003) [31].

Agroforestry is a common practice in the mid hills of Himachal Pradesh where farmers retain certain trees and shrubs in their crop production systems as a means to restore soil fertility exhausted by cropping (Moorman and Greenland, 1980 and Getahun *et al*., 1982) [18, 10]. In hilly regions, the multipurpose trees in the farmland not only provides fodder, fuel, fibre and fruits etc, but also reduces soil erosion, land slide, protects crop to adverse climatic conditions, conserve the moisture, improve the soil quality through nitrogen fixation and organic matter in terms of leaf fall etc. (Atul and Khosla, 1990) [2].

Grewia optiva is an important multipurpose tree species of North-Western Himalayas, distributed throughout the sub-Himalayan tract found upto an altitude of 1800 m (Brandis,

1972) [7] and belonging to family Tiliaceae. It is sparingly found in forest area and is mostly raised along agriculture fields, and is heavily lopped for its nutritious and palatable fodder. It has fairly high protein and nutrients without tannin content, moreover, supplies green fodder during lean period (winter) when generally no other fodders are available in this region. *G. optiva* also support the farm community through its fibre, used for making ropes and the branches of this tree also used for making baskets. The tree is also used for fuelwood purpose in the areas where no other choice of good fuel is available (Sundriyal *et al*., 1994) [27].

In broad sense it is known that agroforestry systems improves the fertility of the soil, however meager research have been made to analyse the effect of tree spacing on the soil parameters under agroforestry system in comparison to open field condition. So this article will be helpful to through some light in this aspect.

2. Materials and Methods

2.1 Site description: The experiment was conducted in a 14 year old existing agroforestry model of *Grewia optiva* in the department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). Located at 30º 51' N latitude and 76º 11' E longitude, the area has an elevation of 1200 m above MSL and slope of 7-8 percent. It comes under sub-tropical, sub-humid agro-climatic zone of Himachal Pradesh, India and receives rainfall of 1000-1400 mm annually. The soil of the area belongs to Typic Eutrochrept subgroup as per the soil taxonomy of USDA. The soil is gravelly sandy loam in texture and the pH of the top layer of the soil (15 cm) is neutral and containing high organic matter.

2.2 Details of structural components: *Grewia optiva* tree rows runs in East-West orientation and was established in three different spacings (8m×1m, 8m×2m and 8m×3m), since July, 2004. Average tree height, diameter at breast height and crown spread of trees under different spacings are presented in the Table no. 1. Garden pea (*Pisum sativum* L.), variety Azad P1 was grown under Grewia trees and in open condition. Pea was grown in plots of size 3m×1m, adopting spacing of 60cm×10cm, thus accommodating 50 plants per plot. Plots were irrigated daily for two weeks and after that, at interval of 3-4 days. Organic manures such as Poultry manure and Vermicompost was used as a source of fertilisation.

Table 1: Average tree height, diameter at breast height and crown spread of trees under different spacings

Tree Spacing	Tree height (m)	D.B.H (cm)	Crown spread (m)
S_1 (8m×1m)	5.45	10.15	1.50
S_2 (8m×2m)	5.39	11.58	1.96
S_3 (8m×3m)	5.17	12.52	2.31

2.3 Design of the experiment: The experiment was established as per split-plot design, in which the main plot treatment was tree spacing and sub plot treatment was the manure doses. The total number of treatment combination was 32 and it was replicated thrice. The aim of the experiment was to know the mean effect of main plot treatment (tree spacing) on the soil parameters, keeping the effect of manure treatment (sub plot treatment) a constant for all the main plots. The comparison of soil parameters was made between the different spacings and open condition.

Table 2: Detail of the treatments (*i.e.* Main plot treatments)-

Treatment	Spacing (S)
S_1:	8m × 1m
S_2:	8m × 2m
S_3:	8m × 3m
S_0:	open condition

2.4 Parameters recorded: Random soil samples were collected with the help of soil auger, from 0-15 cm depth before sowing and at the time of harvesting of garden pea. Samples were air dried, crushed thoroughly and passed through 2 mm sieve and thereafter analyzed for soil available N, P, K, pH, EC and OC. Available nitrogen (kg ha^{-1}) was estimated by following Subbiah and Asija (1956) [26] method, available Phosphorus (kg ha^{-1}) by Olsen *et al.* (1954) [20] method and available potassium (kg ha^{-1}) by Merwin and Peech *et al*. (1951) [17] method. Soil pH was measured with the help of digital pH meter by making 1:2 soil water suspensions following Jackson (1958) method. EC was estimated using the Electrical conductivity meter by making 1:2 soil water suspensions following Jackson (1973) [13] method. Soil organic carbon (%) was determined with help of rapid titration method (Walkley and Black, 1934) [30].

3. Results and Discussion

3.1 Available nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}) and potassium (kg ha^{-1}): Among the four spacings, maximum available nitrogen (388.72 kg ha^{-1}) was recorded in S_1 (8m×1m) and minimum (372.63 kg ha^{-1}) was recorded in S_0 (open) spacing. Maximum available phosphorus (50.89 kg ha^{-1}) was recorded in S_1 (8m×1m) spacing and minimum (46.85 kg ha^{-1}) in S_0 (open) spacing. Maximum available potassium (296.51 kg ha^{-1}) was recorded in S_1 (8m×1m) spacing and minimum (279.84 kg ha^{-1}) in S_0 (open) spacing. The available N, P and K was recorded higher in the agroforestry system as compare to the open condition, due to organic matter accumulation in the form of leaf litter, followed by decomposition and mineralisation. In the agroforestry system, available N, P and K was found more under the closer spacing *i.e.* at 1 m spacing as compared to wider tree spacing, might be due to the possible reason that due to close canopy, more litter was added at 1m spacing as compare to wider tree spacing. Stunted growth of crops under the closer spacing of the trees results in lesser utilisation of nutrients in the soil and as a result more nutrients are accumulated in the soil. The results of the present findings are in line with the findings of Bhat (2015) [4] in *Melia composita* based agroforestry system and Prem (2015) in *Grewia optiva* based agroforestry system, where they both reported that available N, P, K and organic carbon was higher in agroforestry system, than in open condition, and in agroforestry system, the values increased with decrease in spacing between the trees. Tripathi (2012) [12] and Atta *et al.* (2013) [1] reported similar results under Peach and *Acacia* species respectively. Sileshi (2016) [25] and Tanga *et al.* (2014) [28] reported higher available nitrogen and potassium under tree canopy to that of outside the tree canopy and decreased with increase in distance from tree crown. Hailu *et al.* (2000) [11] also reported higher available phosphorus under *Millettia ferruginea* as compared to outside the tree. Manjur *et al.* (2014) [16] also reported that available phosphorus was higher under the canopies of the scattered *Faidherbia albida* and *Croton macrostachyus* tree species and all showed a decreasing trend with increasing distance from tree base which was attributed to high accumulation of organic matter under tree canopies.

3.2 Soil pH: Among the four spacings, maximum soil pH (6.92) was recorded in S_0 (open) spacing, whereas, minimum (6.80) was recorded in S_1 (8m×1m) spacing. Present investigation revealed that, pH was recorded lower in the agroforestry system as compare to the open condition; and with decrease in spacing between the trees, pH also decreased. This was attributed to several mechanisms that releases H^+ ions such as soil base cation uptake, decomposition of organic matter to organic acids and CO_2, root respiration and nitrification. Berhe *et al.* (2013) [3] also reported higher soil pH outside the tree canopy of *Ficus thonningii* as compared with that of soil pH under tree canopy and also reported increasing trend of soil pH with increase in distance from tree trunk. Manjur *et al.* (2014) [16] also reported increase in soil pH with increase in distance from tree trunk of *Faidherbia albida* and *Croton macrostachyus.* Results of the present investigation are in line with the findings of Bhuyan (2017) [5] in Morus based agrisilviculture system and Sharma (2017) [23] in Grewia based agrisilviculture system, who recorded lower pH in the agroforestry system as compared to the open condition.

3.3 Electrical conductivity (dS m^{-1}): Soil electrical conductivity was recorded highest (0.229 dS m^{-1}) in S_1 (8m×1m) spacing, which was statistically at par with the electrical conductivity (0.222 dS m^{-1}) registered under S_2 (8m×2m) spacing, whereas lowest (0.195 dS m^{-1}) was recorded in S_0 (open) spacing. Results of the investigation revealed that, EC was recorded higher in the agroforestry system as compare to the open condition, and with decrease in spacing between the trees, the EC increased. These findings are in line to the results achieved by Shivani (2017) [24] and Bhat (2015) [4], who reported that soil electrical conductivity was higher under agroforestry system than open condition. However, Tanga *et al.* (2014) [28] also reported that values of electrical conductivity at different distance from *Acacia tortilis* and *Acacia seyal* were significantly at par with values of electrical conductivity outside the tree canopy.

3.4 Soil organic carbon (%): Among the four spacings, maximum organic carbon (1.30%) was recorded in S_1 (8m×1m) spacing, while minimum (1.17%) was recorded in S_0 (open) spacing, which was statistically at par with S_3 (8m×3m) spacing i.e. 1.21%. Organic carbon content was found maximum under *Grewia optiva* compared to open area. Litter fall and fine-root turnover may have increased soil organic matter concentration in the agroforestry system. Bowen *et al.* (1988) [6] also reported that plant residues or litter has multi-beneficial effects like increase in soil organic matter, provision of nutrients and stimulation of biological activity as well as maintaining moderately acidity in soil.

Table 3: Soil parameters under different spacings before starting of the experiment

Spacings \ Parameters	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})	pH	Electrical Conductivity (dS m^{-1})	Organic Carbon (%)
S_1 (8m×1m)	357.47	38.56	258.16	6.98	0.19	1.12
S_2 (8m×2m)	351.26	37.34	255.73	7.03	0.17	1.09
S_3 (8m×3m)	346.94	35.79	250.26	7.07	0.15	1.07
S_0 (Open Condition)	340.53	32.59	247.11	7.11	0.13	1.04

Table 4: Green pea pod yield and soil parameters under different spacings analysed after the harvesting of garden pea

Spacings \ Parameters	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})	pH	Electrical Conductivity (dS m^{-1})	Organic Carbon (%)	Yield of pea pods (q/ha)
S_1(8m×1m)	388.72	50.89	296.51	6.80	0.229	1.30	44.87
S_2(8m×2m)	384.96	49.67	290.99	6.85	0.222	1.24	68.18
S_3(8m×3m)	380.57	48.36	285.19	6.89	0.208	1.21	89.09
S_4 (Open Condition)	372.63	46.85	279.84	6.92	0.195	1.17	103.20
$CD_{0.05}$	1.29	1.08	2.83	0.02	0.007	0.05	4.27

4. Conclusions

Trees not only improve the physical properties of soil, soil fertility, but also maintain adequate moisture and soil biota. They check unproductive nutrient losses through erosion and leaching, and help in nutrient pumping from the sub soil. In the agroforestry system tree also sequester carbon dioxide and also acts as a separate source of income in the form of timber, fuel, fodder, fibres, fruits etc.

5. References

1. Atta HE, Aref I, Ahmed A. Effect of *Acacia spp*. on soil properties in the highlands of Saudi Arabia. Life Science Journal. 2013; 10(4):100-105.
2. Atul P, Khosla PK. Classification of traditional agroforestry system. In: Proceeding IUFRO, 19th World Forestry Congress, Montreal, 1990, 24-27.
3. Berhe DH, Anjulo A, Abdelkadir A, Edwards S. Evaluation of the effect of *Ficus thonningii* (blume) on soil physico-chemical properties in Ahferom district of Tigray, Ethiopia. Journal of Soil Science and Environmental Management. 2013; 4:35-45.
4. Bhat SA. Effect of Tree Spacing and Organic Manures on Growth and Yield of Vegetable Crops under *Melia composita* Willd. Based Agroforestry System. Ph.D. Thesis. Department of Silviculture and Agroforestry, Dr. YS Parmer University of Horticulture and Forestry, Solan, 2015, 251.
5. Bhuyan BK. Effect of Morus alba on Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) *Under Rainfed Conditions.* M.Sc. Thesis. Department of Silviculture and Agroforestry, Dr. YS Parmar University of Horticulture and Forestry, Solan, 2017, 66.
6. Bowen WT, Quitena JQ, Pereira J, Bouldin DR, Reid WS, Lathwell DJ. Screening green manures as nitrogen sources to successing non-legume crops. Plant Soil. 1988; 111:75-89.
7. Brandis D. Indian trees. Bishen Singh Mahendra Paul Singh, Dehradun, UK, India, 1972, 767.
8. Das SK, Sharma S, Shanna KL, Saharan N, Nimbole NN, Reddy YVR. Land use options in a semi arid alfisols. American Journal of Alternative Agriculture. 1993; 8:34-39.

9. Garrett HE, Buck LE, Gold MH, Hardesty LH, Kurtz WB, Lassoie JP *et al*. Agroforestry: An Integrated Land-Use Management System for Production and Farmland Conservation. Resource Conservation Act (RCA) Appraisal of U.S. Agroforestry, USDA Natural Resources Conservation Service, 1994, 58.
10. Getahun A, Wilson GF, Kang BT. The role of trees in farming systems in the humid tropics. In: Agroforestry in the African Humid Tropics (Donald LHM ed). UNU, Tokyo, Japan, 1982, 28-35.
11. Hailu T, Negash L, Olsson M. *Millettia ferruginea* from southern Ethiopia: impacts on soil fertility and growth of maize. Agroforestry Systems. 2000; 48:9-24.
12. Intergovernmental Panel on Climate Change (IPCC). Assessment Report. 2007, 73.
13. Jackson ML. Soil Chemical Analysis. Prentice Hall of Indian Pvt. Ltd., New Delhi, 1973, 498.
14. Kellman M. Soil enrichment by neotropical savanna trees. Journal of Ecology. 1979; 67:565-577.
15. Lal R. Agroforestry systems and soil surface management of tropical alfisol parts i-iv. Agroforestry Systems. 1989; 8:192-242.
16. Manjur B, Abebe T, Abdulkadir A. Effects of scattered *F. albida* (Del) and *C. macrostachyus* (Lam) tree species on key soil physico-chemical properties and grain yield of maize (*Zea mays*): a case study at Umbulo Wacho watershed, Southern Ethiopia. Wudpecker Journal of Agricultural Research 2014; 3:63-73.
17. Merwin HD, Peech M. Exchangeable of soil potassium in the sand, silt and clay fractions, as influenced by the nature of the complementary exchangeable cations. Soil Science American Proceedings. 1951; 15:125-128.
18. Moorman RR, Greenland DJ. Major production systems related to soil properties in humid tropical Africa. In: Soil Related Constraints to Food Production in the tropics. IRRI, Loss Banos, Philippines, 1980, 55-77.
19. Nair PKR. Role of trees in soil productivity and conservation: soil productivity aspects of agro-forestry. The International Council for Research in Agroforestry, Nairobi, 1984, 85p.
20. Olsen R, Cole CV, Wantanable FS, Dean LA. Estimation of available P in soil by extraction with sodium bicarbonate. U S Department Agricultural Circular. 1954; 939:19.
21. Prakash P. Effect of Tree Spacing and Organic Manures on Growth, Flower and Seed Production of Floriculture Crops Under Grewia optiva Drummond. based Agroforestry System. Ph.D Thesis. Department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, India, 2015, 250.
22. Schroth G, Sinclair FL. Trees, crops and soil fertility concepts and research methods. CABI Publishing, Wallingfold, 2003, 122.
23. Sharma H. Crop Production and Soil Physico-Chemical Properties of *Grewia optiva* Drummond. Based Agroforestry System in Mid Hill Zone of Himachal Pradesh. M.Sc. Thesis. Department of Silviculture and Agroforestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, 2017, 94.
24. Shivani S. Studies on Bioeconomic Appraisal and Effect of Organic Manure on Biomass Production of Ocimum sanctum Under Stone Fruit Based Agroforestry System. M.Sc. Thesis. Department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan. India, 2017, 91.
25. Sileshi GW. The magnitude and spatial extent of influence of *Faidherbia albida* trees on soil properties and primary productivity in drylands. Journal of Arid Environments. 2016; 132:1-14.
26. Subbiah BV, Asija GL. Rapid method for estimation of available nitrogen in soils. Current Science 1956; 25:259-260.
27. Sundriyal RC, Rai SC, Sharma E, Rai YK. Hill agroforestry systems in south Sikkim, India. Agroforestry Systems. 1994; 26:215-235.
28. Tanga AA, Erenso TF, Lemma B. Effect of three tree species on microclimate and soil amelioration in the central rift valley of Ethiopia. Journal of Science and Environment Management. 2014; 5:62-71.
29. Tripathi P. Effect of Organic Manures on Yield and Biomass Production of Medicinal and Aromatic Plants under Peach Based Agroforestry System. Ph.D. Thesis. Dr. Y S Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, India, 2012, 209.
30. Walkley AJ, Black IA. Estimation of soil organic carbon by chromic acid titration method. Soil Science. 1934; 37:29-38.
31. Xu X, Enoki T, Hirata E, Tokashiki Y. Basic application of agroforestry principles. Ecology. 2003; 4:229-237.
32. Yamoah CF, Agboola AA, Wilson GF. Nutrient contribution and maize performance in alley cropping systems. Agroforestry Systems. 1986; 4:247-254.