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Full Length Research Paper

Effect of nitrogen and phosphorous on Farm Plantations in various agroecological zones of Punjab, Pakistan

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Against a world average of 25% area under forests, Pakistan has around 5% and Punjab has only 2% area under manageable and productive forests. The present deteriorating condition of the forests in Punjab has bleak prospects of improvement and expansion in near future due to ever increasing demand for agriculture produce. In view of the present situation the best possible solution seems to be offered by Farm forestry/agroforestry that models planting trees and agricultural crops together, which unfortunately, has not been utilized to its full potential. Based on physiographic, climate and ecology, Pakistan is divided into nine major ecological or vegetative zones, which are further sub-divided into 18 habitat types – an arrangement for the development of protected areas system in terms of representative ecotypes. During the survey of farm plantations about 400 soil samples were collected and their physical and chemical analysis was conducted for the comparison of the four Agro ecological zones of the Punjab Province of Pakistan with regards to agroforestry. A comparison of the characteristics of soils taken from various farm plantations necessitated a prior evaluation of nitrogen and phosphorous as well as their composition in order to ascertain whether the soils were texturally similar or not. In case of Agroforestry, the type of soil is one of the major factors for the classification of different suitable species of plants. The results of the soil analysis of various Agro ecological zones and the consequent recommendation of the associated suitable species, aids the agrofarmers to pick out the best possible option.

Key words: Soil analysis, agro-ecological zones, agroforestry, nitrogen and phosphorous.

INTRODUCTION

The primary processes held responsible for the formation of high fertility around trees relate to enhanced biological processes associated with the seasonal and long term return of nutrients accumulated in trees to the soil through litter fall, root decay and exudation, and their mineralization, as well as leaching of nutrients stored in canopies (Sangha et al., 2005). Soil texture some times differs according to tree size. Reasons behind these variations related to tree size are not clearly understood. Increases in organic matter and improved microclimatic conditions under trees enhance soil microbial and enzymatic activity, decomposition and physical characteristics (Tian et al., 2001). Compared to open sites, biological activity is two to three times higher. Fine soil lost through wind erosion may be intercepted by trees and deposited by through fall and stem flow. Trees also increase soil nitrogen availability due to nitrogen fixation (N'goran et al., 2002). Increased fertility under trees may also be due to bird droppings and, which integrate livestock's dung deposition by animals which rest and feed under tree shade. The tree effect may be more pronounced where livestock is excluded than in natural agrosilvopastoral systems (Anon, 2000). Small trees induce little fertility change in their soil environment.

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Small trees produce significantly less organic litter and root turnover inputs. Unlike larger trees, small ones also have no dung deposited beneath them (Brown, 2001). Nutrient enrichment by trees increases with tree size. Young trees do not seem to influence the size of the nutrient pool significantly, and that the nutrient concentration of sub canopy soils expands with tree size. More specific information is needed on the dynamics of soil fertility with increasing tree size in relation to the performance of associated crops, and recommendations on size/age and related conditions of tree stands from which increased nutrient availability can potentially generate enhanced crop yields (Sangha et al., 2005). Trees may also increase system productivity by reducing nutrient losses through leaching in deep soil, and reduced soil erosion. Trees may increase overall system productivity by increasing nutrient availability through Nitrogen fixation and deep rooting, and their enlarged absorptive capacity associated with mycorrhizae and fungal infection. However, even though these processes may be important in particular sites with appropriate soil conditions and water availability, there are limitations to these processes (Botha, 2006).

Kitalyi et al. (2004) defined as "agroforestry is a deliberate integration of woody components with agricultural and pastoral operation on the same piece of land either in a spatial or temporal sequence in such a way that both ecological and economical interaction occurs between them." The limits of production from particular soils are conditioned by quality and by management practices. Thus the activities which are basic for the promotion of the optimum land use are: land resources inventories, assessment of degradation hazards, evaluation of production capacity, improvement of soil fertility, land reclamation combating `desertification and integrated land use planning (Chandrshekhran, 1987). The potential contribution of trees to soil improvement is one of the major assets of agroforestry in general (Sanchez et al., 1997). The enhancement of soil fertility by trees is conspicuous in studies which compare productivity of crops grown on soils formed under tree canopies and on control soils in open sites (Craig and Wilkinson, 2004). Differences in soil fertility as demonstrated by *in situ* crop productivity differ at varying distances from the tree (Botha, 2006). Generally higher soil nutrient status under tree cover is reflected in the mineral content of under story herbaceous species. Soil infertility is the result of the pressure on the land due to a continuous cycle of crop growing without allowing it to rest (Simons and Leakey, 2004). Therefore, it should be realized that in order to ensure optimum land use, it is important that a country's land resources be assessed in terms of suitability at different levels of inputs for different types of land use such as agriculture, grazing and forestry (Baig et al., 2008). Pfefferkor et al. (2005) suggests that if a large amount of genetic diversity has been removed from the system, a complete replacement of taxa would require a long period of time. Migration in the basin was remarkably rapid and a return to diversity levels took less than 5million years. Regionally restricted environmental changes can also account for different recovery rates in different regions (Jablonski, 2002). Monsoonal climatic conditions favored a more rapid recovery in South Africa.

METHODOLOGY

The soil samples were collected from various ecological zones with the technical help of the staff of Pakistan Soil Survey of the Pakistan (PSSP) and chemical analysis of soil samples were also done in the Laboratory of PSSP. The soil samples were analyzed with regard to nitrogen and phosphorous (Margesin, 2005). There are ten zones of the country which are grouped on the following basis (Figure 1): Climatic and edaphic considerations; physiography and ecology; extent of forest and agricultural resources in each zone; site specificity; water logging; salinity; commanded and uncommanded area and other landforms; the level of biological diversity; socio-economic needs of the communities living in the zone; their agricultural practices, soil fertility; socio-cultural status of the communities and the adequacy or otherwise of irrigation water, including sub soil water. The following five agro-ecological zones of Punjab province are described below:

Agro ecological zone III-A – sandy deserts

This zone covers a part from certain districts of Sindh; and from the province of Punjab, this region covers the districts of Rahim Yar Khan, Bahawalpur, Bahawalnagar and the Cholistan desert, characterized by elongated NESW oriented sand ridges formed by Eolian (pertaining to wind) agencies. The climate is arid (desert) sub-tropical with very hot summer and mild winter, but the winter is practically rainless. The original tree vegetation consists of *Prosopis cineraria, Salvadora oleoides, Tamarix aphylla* and *Tecoma undulate,* whereas, the shrubs include *Calligonum polygonoides, Calotropis procera, Salsola foetida* and *Haloxylon spp*. Major grass species include *Cymbopogon javarancusa* and *Pennisetum divisum*. However, the vegetation is sparse and lopped heavily for fuel, fodder and hutments.

Agro ecological zone III-A and B – Sandy deserts

This region (Thal) covers the districts of Muzaffargarh, Mianwali, Bhakkar, Khushab and Layyah with various forms of sand ridges and dunes including, longitudinal, transverse sand sheets with silty and clayey deposits that occur in narrow strips. The sand ridges are 5 to 15 m high. Between the sand ridges, there are hollows where runoff water is collected after the rain. In the central parts of the desert, large elongated channels and their alignment suggest that they were formerly occupied by the shifting courses of river Indus. The desert is quite profusely dotted with vegetation comprising dwarf trees. The climate is arid to semi-arid sub-tropical continental and the mean monthly highest maximum temperature goes up to 45.6°C, while in winter, it goes from 5.5 to 1.3°C. The region, in general experiences occasional frost with mean annual rainfall of 150 to 350 mm, increasing from south to north. The original vegetation consists of trees such as *Acacia nilotica, Prosopis cineraria, Salvadora oleoides, Tamarix aphylla* and shrubs like *Calligonum polygonoides, Tamarix dioca, Calotropis procera* and *Zizyphus nummularia* which have been heavily damaged due to indiscriminate grazing and on account of conversion of land to

Figure 1. Agro ecological zones of Pakistan.

agriculture. The grass cover includes *Eleusine compressa, Lasirus hirsutus, Saccharum benglense* and *Panicum antidotale.*

Agro ecological zone IV-A – northern irrigated plains

The districts of Sahiwal, Lahore, Kasur, Okara Faisalabad, Jhang and part of Multan, Gujrat, Sheikhupura and Gujranwala are covered by this region. The land is lying between Sutlej and Jhelum Rivers, having a relatively flat surface although there are some remnants of old river channels. This region is canal irrigated. Its climate has been changed from arid to humid through the world's largest canal system. The soils in this zone are sandy loam to clayey loam. Along the rivers, narrow strips of new alluvium are deposited during the rainy season when the rivers are in spate. In the northern part of the region, dominant soils are loam and clay loam with weak structure, while the clayey soils are also quite important, as they cover about 40% of the area. It is the most important area of the country from the agricultural point of view. The climate can be divided into two parts. The northeastern half has semi-arid (steppe) sub-tropical continental type of climate where the mean maximum daily temperature in summer goes up to 39.5°C and the mean monthly maximum temperature is 45°C. In winter, the mean minimum daily temperature is 6.2°C with occasional cold spells when the mean monthly minimum temperature falls down to 2°C. The mean annual rainfall ranges from 300 to 500 mm in the north. The original vegetation consists of trees such as *Acacia modesta, A. nilotica, Prosopis cineraria, Tamarix aphylla, Zizyphus spp.* and shrubs like *Calligonum, Sueda fruticosa, Rhazya stricta, Acacia jacquemontii* etc. These are lopped for fodder, fuel and construction of hutments in the villages. The major grass species are *Eleusine, Lasiurus, Panicum cymbopogan and Saccharum.*

Agro ecological zone V - Barani (rain fed)

The salt range, Pothwar plateau and Himalayan piedmont plains form this region. Climatically, a small narrow belt lying along the mountains is nearly humid, whereas in the southern part, it is semi-arid and hot. The narrow belt has the summer mean maximum daily temperature of about 38°C with frequent cold spells. The mean monthly rainfall is approximately 200 mm in summer and 36 to 50 mm in winter (December to February).

Study area

The Punjab province (Figure 2) is extremely deficient in forest resources with only 2.08% of the total area under productive forest cover. The province happens to be the most populous of all the provinces of Pakistan (Sheikh et al., 2000). With constant increase in demand of food grains for the fast growing population, more areas cannot be spared for raising forest plantations. One of the options is to raise trees along with agricultural crops on the same piece of land called agro forestry. Agro forestry as land use is a collective name for the practices where woody perennials (trees, shrubs, palms, bamboos etc) are deliberately used on the same land management unit as agricultural crops and/or animals or both, either in some form of spatial arrangement or temporal sequence often for maximum net return from this joint production system (Khan, 1989). The farmers in irrigated areas are already practicing agro forestry in some form to supplement fuel wood and timber production of the province thereby increasing their own personal total farm income (Ahmad, 1998 and Ahmad et al. 2006). They have been practicing different models and patterns of agro forestry systems in a haphazard way. So far, these systems have not been properly documented (Sheikh, 2000). The geographical features of the Punjab as a whole, land use pattern, administrative and agro-ecological zones, vegetation types, etc are explained under.

Location and extent

The province of Punjab lies between 27°42' to 34°02 north latitudes and 69°18' to 75°23' east longitudes. Its total geographical area approximates 20.63 million ha. It is surrounded by the provinces of NWFP and Baluchistan on the north and west, the province of Sindh in the south and India on the east. Lengthwise, it extends to about 1,078 km from north to south and widthwise, to 616 km from east to west (Hussain et al., 2003).

Population

Of all the provinces, the Punjab is the most populous with 74.32 million people inhabiting it. About 70% of the population lives in villages, mostly dependent upon agriculture for their livelihood.

Literacy rate is less than 30% (Economic Survey of Pakistan, 2006 to 2007).

Topography

The land forms consist of almost leveled alluvial plains except salt range which elevates from 500 to 1000 m and is the dividing line between southern plains and northern plateau of Pothohar which on average has 450 m altitude. The southern alluvial plains of Bahawalpur lie at the minimum altitude of 150 m above sea level, whereas Patriata hills (Murree) are perched at the highest altitude of 2500 m (Hafeez, 1998).

Soils

Two types of soils are encountered in the province: (i) old alluvial soils which are highly fertile plains, irrigated through a world famous canal system as well as gullied, ravined and dissected Barani lands of Pothohar plateau which are deep and relatively fertile and (ii) sandy deserts of Thal and Cholistan covering about 20% of the province's landmass. These are unstable due to wind blown sands and are calcareous and infertile in nature (Soil Survey of Pakistan Report, 2005).

Climate

Climatically, Punjab falls in three zones on the basis of rainfall such as: (i) arid deserts of Thal and Cholistan with 300 mm below annual rainfall, (ii) semi arid areas of southern Punjab and Pothohar with 300 to 600 mm rainfall and (iii) dry subtropical tract of central and north Punjab and salt range with annual rainfall ranging from 600 to 1200 mm. Temperatures in summer may exceed 50°C at certain places. In winter, few areas experience frost for a short period, while rains in monsoon form the bulk, that is, two third of the total rainfall. The rest of the rain falls in winter season. Moreover, the southern part experiences less rainfall (Hussain et al., 2003).

Land use

Agriculture is the major land use in Punjab, with the cultivated area being 12 mha (million hectare) or 58.46% of the total land area.

RESULTS

Nitrogen and phosphorus

Nitrogen is one of the most important factors affecting soil fertility and productivity as well as the growth and development of newly planted trees on farm lands. The major portion of the nitrogen cycle occurs between vegetation especially trees and soil, only minor exchanges generally taking place with the atmosphere and the hydrosphere. All living tree and animals require phosphorus. Phosphorus containing compounds are essential for photosynthesis in trees, for energy transformations and for the activity of some hormones in both plants and animals (Gebrehiwot, 2004). All agro-ecological zones are different ($P<0.05$) for phosphorus contents (Figure 3). The results of the study show that Zone IV A has maximum value (52.58) for phosphorus, followed by Zone V B (18.52) and is considerably

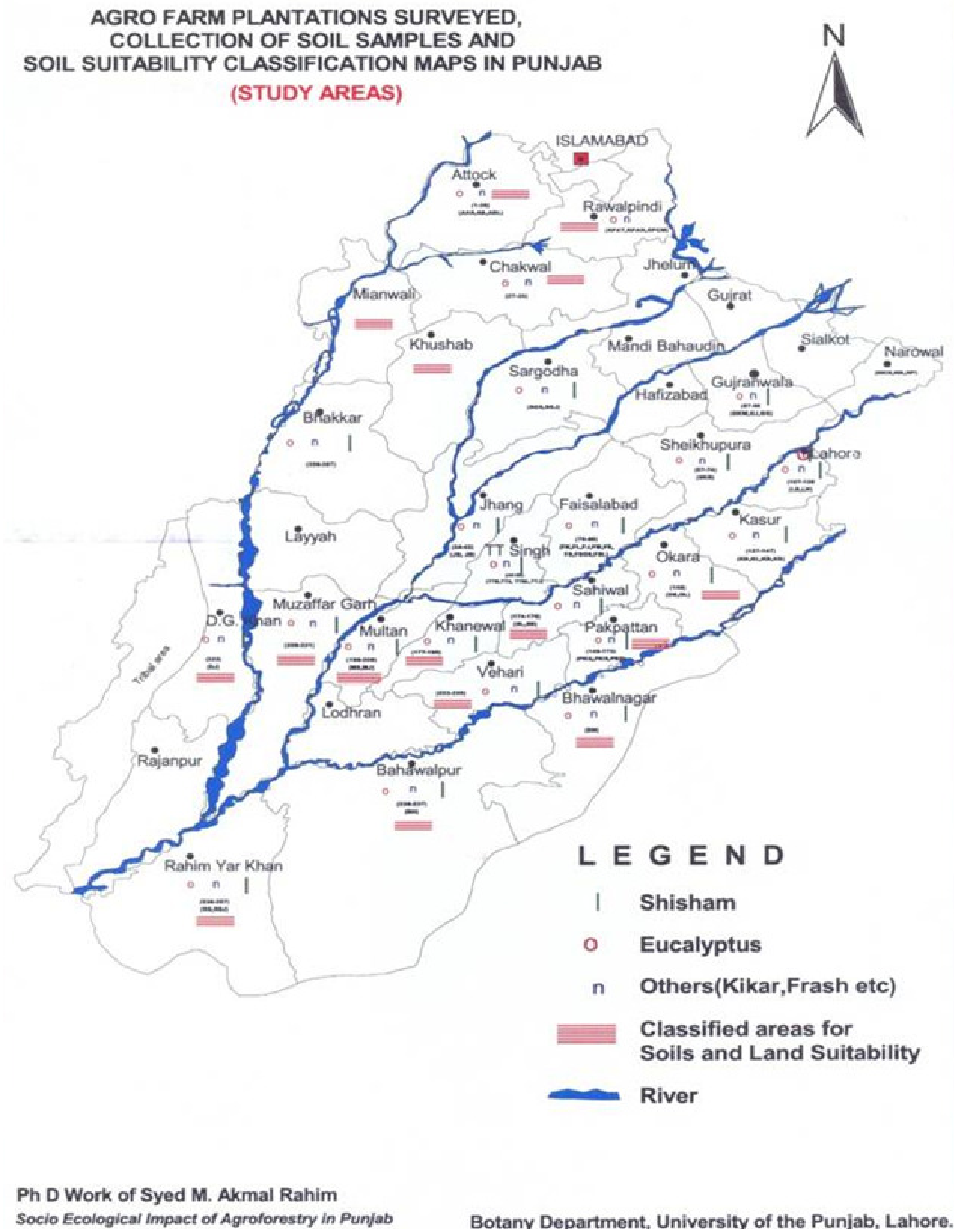

Figure 2. Collection of soil samples.

different from that of Zone III B (15.40). It is also shown that Zone III B and Zone V B have nearly no difference (P>0.05) regarding phosphorus value. For Zone III A, phosphorus was not detected (comparison of means). It

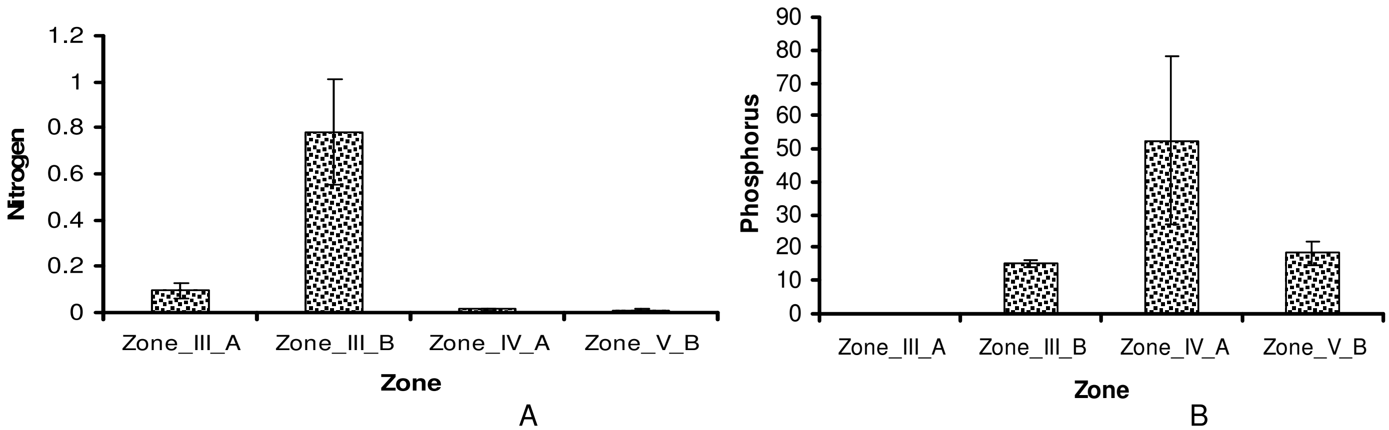

Figure 3. Zone wise variation in nitrogen and phosphorus.

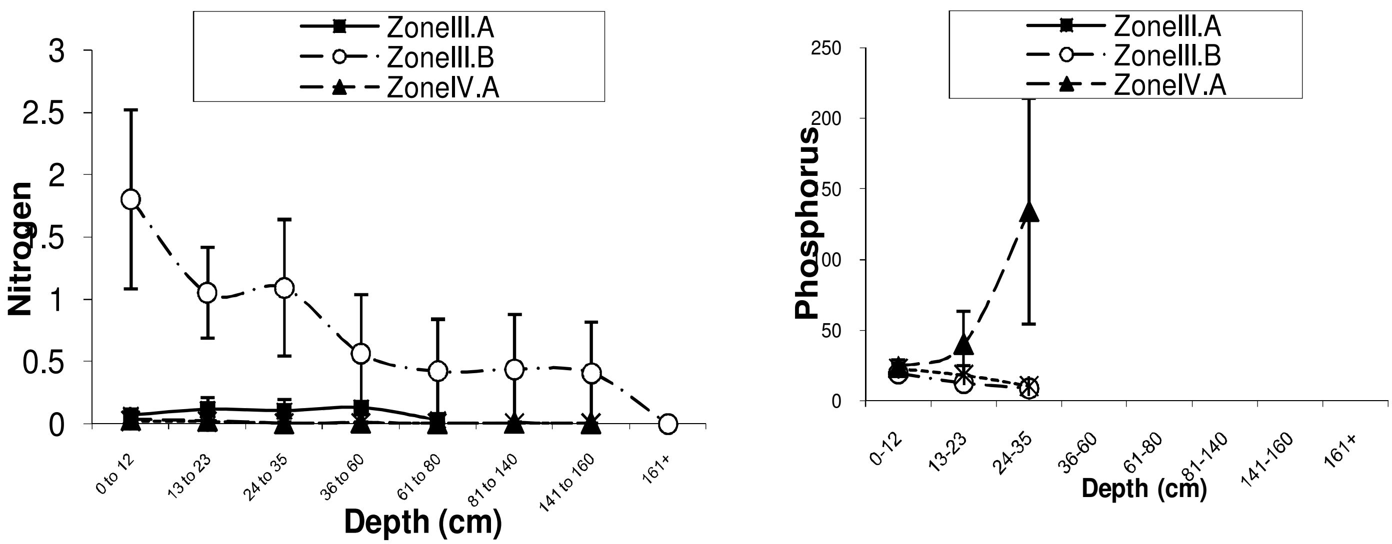

Figure 4. Effect of depth (cm) on nitrogen and phosphorus.

is, therefore, concluded that there are similarities regarding the Nitrogen and Phosphorous values (P>0.05) among different depth intervals as shown by Figure 4. Nitrogen values were found to be 1.283, 0.749, 0.772, 0.414, 0.293, 0.334, 0.300 and 0.001 at 0.12, 13.23, 24.35, 36.60, 61.80, 81.140, and 141.160cm and >161cm depth intervals, respectively. Phosphorus values were found as 20.86, 20.60 and 42.51 at intervals 0.12, 13.23 and 24.35cm depth, respectively. Phosphorus values were not traced from.36.60cm depth interval to more than 161cm depth interval. Figure 4 showed that zone III B has maximum value (0.782) for nitrogen but zone III A, zone IV A and zone V B have very low values (0.095, 0.013 and 0.011 respectively) for nitrogen as compared to zone.III B. Zone wise comparison for nitrogen have almost no variation (P>0.05). This contradiction is due to huge variation among nitrogen values within the zones. There is an exponential relationship between nitrogen and depth with R^2 Value of 61.81% (Figure 4). There is no apparent relationship between phosphorus and depth of the soil. From Figure 4 it is clear that at the depth ranging from 50 to 200 cm, the value of phosphorus is almost equal to zero.

DISCUSSION

Ecological effects include the environmental condition at which living organism can easily survive. In case of agroforestry, a type of soil is one of the major factors for the classification of different suitable species of plants (Khan and Chaudhry, 2007). A comparison of the characteristics of soils under various farm plantations necessitates a prior evaluation of their particle size composition in order to ascertain whether the soils were texturally similar (Dixon et al., 2001). Mostly the plant species required well drained, medium texture soils, with average physical environment in which salinity problem is neglected (Calegari and Alexander, 1998; Vanwilgen et al., 2004).

Results showed that zone III.B has maximum value for nitrogen but zone III.A, zone IV.A and zone V.B have very low values for nitrogen as compared to zone III.B. Zone-wise comparison for nitrogen has no considerable variation. Maximum phosphorus value was observed in zone IV.A. It was shown that zone III.B and zone V. A have almost similar value regarding phosphorus. Phosphorus was not detected in zone III. No obvious relationship between phosphorus and depth was observed while an exponential relationship between nitrogen and depth existed. Maximum nitrogen values at 0 to 12 cm depth and minimum at 161 cm depth interval were observed. Maximum value for phosphorus was found at 24 to 35 cm depth, showing considerable difference between different depth intervals regarding nitrogen and phosphorus values which were not traced from.36.60 cm depth interval to more than 161 cm depth interval. In four zones, both CEC and EC are appreciably different. ZONE V.B showed maximum value as compared to others. Regarding depth zone IV.A and zone V.B showed zero value from 36 to 60cm depth interval to 161+ cm depth, while zone III.B showed maximum EC value and it decreased in zone III.A. These results are in conformity with those of Krogh et al. (2000). Not much variation regarding pH values was observed in the zones studied. Zone III.A has extensively lower value for ph of 6.57 as compared to all other three zones. Zone.III B, zone. IV B, and zone. IV B have higher value than zone. IIIA but do not differ from one another. The effect of different tree species on soil pH is most varied in the first ten centimeters of the topsoil. The pH difference between zones could be as much as 1 pH unit in the topsoil. Nevertheless, the mean pH difference in soil was between 0.2 and 0.4 ph unit. Similar findings have been recorded by Krogh et al. (2000). Results revealed that CEC and pH have no significant effect regarding depth that is, CEC and pH values at different depths have the same pH values. There is highly considerable effect of different depths on EC value.

RECOMMENDATIONS

The best combinations of agricultural crops and trees should be identified by calculating cost benefit ratio including tangible and intangible benefits resulting in poverity allevation programme like development of infrastructure and other facilities. North-South orientation of the tree rows will cause less crop depression and delay harvesting of grain crops such as wheat, maize, barley, etc in close vicinity of the tree belt as crop closer to the belt takes a few more days to mature and ripen.

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