African Journal of Plant Science Vol. 5(5), pp. 450-459, May 2011
Available online at http://www.academicjournals.org/ajps
ISSN 1996-0824 ©2011 Academic Journals

Full Length Research Paper

Effect of calcium, magnesium, sodium and potassium on farm plantations of various agroeclogical zones of Punjab, Pakistan

Syed Muhammad Akmal Rahim[1]*, Shahida Hasnain[2] and Jabeen Farkhanda[3]

[1]Punjab Forest Department, Pakistan.
[2]Departments of Microbiology and Molecular Genetics, Faculty of Life Sciences, University of Punjab, Pakistan.
[3]Department of Botany, University of the Punjab Lahore, Pakistan.

Accepted 15 April, 2011

The immense impact of trees in the development of a country cannot be denied and over-emphasized. Pakistan has a narrow forest resource base extending over only about 4.8% (4.59% excluding farmland plantations) of its area, which is insufficient to provide the material needs for the growing population, expanding and to retard and arrest the ongoing environmental and ecological degradation process. 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 their calcium magnesium, sodium and potassium in order to ascertain whether the soils were 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, calcium magnesium, sodium, potassium.

INTRODUCTION

The immense impact of trees in the development of a country cannot be denied and over-emphasized. While the productive role does not require much familiarization as indicated by wood and a variety of wood products, the protective function implies much more important features such as impact on climate and physiography of the country; conservation of soil and water (Higgs, 1997); regulation of stream flow (Drury et al., 2000), and prevention of calamities such as floods, landslides, siltation and sedimentation of dams, and river beds and change in the course of rivers (Pallardy et al., 2002). The trees in protecting the croplands and orchards against hot or cold winds is also now well appreciated by the farmers (Craig and Wilkinson, 2004). The recreational and biodiversity value of forests together with the fact that forests are the eternal abode/ habitat where wildlife can live and multiply is now being increasingly realized (Hubbard et al., 1999; Bisseleua et al., 2010). 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

*Corresponding author. E-mail: rahimakmal2@hotmail.com.

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 (Al-Busaidi and Cookson, 2003). Small trees induce little fertility change in their soil environment. 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 and Tonye et al., 1997). 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 (Dove, 2003). 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 as 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, 2002). 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 and Smith, 2006). Generally, higher soil nutrient status under tree cover is reflected in the mineral content of under stored 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 (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 5 million 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 (Benton et al., 2004).

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 for Na^+, K^+, Ca^2, Mg^2 (Margesin and Franz, 2005). There are ten zones of the country which are grouped on the following 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, and 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 thus described.

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 (North East South West) 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 (Rahim et al., 2010).

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℃, while in winter, it goes from 5.5 to 1.3℃. 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, P. cineraria, S. oleoides, T. aphylla* and shrubs like *C. 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 agriculture. The grass cover includes *Eleusine compressa, Lasirus hirsutus, Saccharum benglense* and *Panicum antidotale* (Rahim et al., 2010).

Agro ecological zone IV.A: Northern irrigated plains

The districts of Sahiwal, Lahore, Kasur, Okara Faisalabad, Jhang and part of Multan, Gujarat, 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℃ and the mean monthly maximum temperature is 45℃. In winter, the mean minimum daily temperature is 6.2℃ with occasional cold spells when the mean monthly minimum temperature falls down to 2℃. 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, P. cineraria, T. 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* (Rahim et al., 2010).

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℃ with frequent cold spells. The mean monthly rainfall is approximately 200 mm in summer and 36 to 50 mm in winter (December to February) (Rahim et al., 2010).

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 the 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). 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 subsequently.

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 hectares. 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 - 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: (1) 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 (2) 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: (1) Arid deserts of Thal and Cholistan with 300 mm below annual rainfall; (2) Semi arid areas of southern Punjab and Pothohar with 300 to 600 mm rainfall and (3) 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 million hectare or 58.46% of the total land area.

RESULTS

Every tree needs calcium to grow as an essential element of nutrients available in the soil (Calcium is an essential element of nutrient available in soil and is required by trees for growth). Once fixed, calcium is not mobile in the tree. It is an important constituent of cell walls and can only be supplied in the xylem sap. Thus, if the plant runs out of a supply of calcium, it cannot remobilize calcium from older tissues. Moreover, if transpiration is reduced for any reason, the calcium supply to growing tissues will rapidly become inadequate (Sangha et al., 2005). On the other hand, magnesium is the central core of the chlorophyll molecule in tissues of plants. Thus, if Mg is deficient, the shortage of chlorophyll results in poor and stunted growth of trees. Magnesium also helps to activate specific enzyme systems. Magnesium is abundant in the earth's crust and is found in a wide variety of minerals. It becomes available for tree use as these minerals weather or break down. Magnesium is held on the surface of clay and organic matter particles. Although this exchangeable form of Mg is available to plants, this nutrient will not readily leach from soils. There is an "ideal" ratio of calcium to magnesium in soils (Ahmad et al., 2006). Results for Ca+Mg obtained in the present study are highly variable ($P<0.01$) in different Agro-ecological zones of the Punjab Province (Figure 1). In Zone III.A, Ca + Mg was found to be absent. The results show that maximum and similar values of Ca + Mg ware found in Zones IV.A and V.B but were significantly different from those of Ca + Mg in Zone III.B. The Zone wise graphical presentation for Ca + Mg is given in Figure 3 (Least significant difference test). Depth also affected Ca + Mg values in the soil (Figure 3). Maximum Ca + Mg was found at 13.23 cm followed by all depth levels except >181cm depth. Depths levels 0.12 and 13.23 cm have different value of Ca + Mg from depth level of >161 cm (Comparison of means). Figure 3 reveals cubic trend between Ca + Mg and depth levels with $R^2 = 90.46\%$. It is clear that Ca + Mg decreases with increase in depth till approximately at 60 cm level. After 60 to 150 cm, a slight increase was seen in Ca + Mg values followed by a decrease with increasing depth up to 180 cm.

Potassium is an essential nutrient for tree growth. As large amounts are absorbed from the root zone and utilized for the production of most of the agronomic crops, it is classified as a macronutrient. Soil commonly contains over 20000 parts per million (ppm) of total potassium (K). Nearly all of this is structural component of soil minerals and is unavailable to the plants. The trees use only exchangeable K present on the surface of the soil particles and the potassium that is dissolved in the soil water. This often amounts to less than 100 ppm (Benton et al., 2004). Potassium is involved in many plant metabolism reactions, ranging from lignin and cellulose used for formation of cellular structural components, to regulation of photosynthesis and production of plant sugars that are used for various plant metabolic needs. It controls water loss from trees and is involved in overall tree health. Soils that have adequate potassium allow trees to develop rapidly and outgrow tree disease, insect damage and protect against winter freeze damage (Harper, 2000). The results indicate that there is no significant difference among the values of the K in all agro-ecological zone ($P>0.05$). There was not much variation in the potassium values found in different zones e. g. Zone IV.A (13.68±2.23) and Zone V.B (14.25±4.83) have similar values ($P>0.05$) for potassium and Zone III.A (0.02±0.001) and Zone III.B (1.52±0.40) have also similar values and not differ from each other ($P>0.05$). But Zone IV.A and Zone V.B with maximum values are notably different from Zone III.A and Zone III.B. Similar results are shown in Figures 5 and 6 where both sodium and Sodium adsorption ratio (SAR) are similar in all zones and not much variation was observed ($P>0.05$). In Zone III.A, sodium and SAR were not recorded. Figures 5 and 6 show zone wise mean ± standard error values regarding Na and SAR. The result shows mark difference ($P<0.01$) among the depth levels for potassium value. The maximum K was found at 13.23 cm depth and minimum at 81.160 cm. Potassium at 0.12 cm depth was considerably ($P<0.05$) decreasing from K at 81 to 140 cm level of depth. Depth levels from 0.12 to >161 cm have same value of K except at 81.140 cm depth and from 13.23 to >161 cm levels of depth have almost similar values and ($P>0.05$) differ with one another. The graph between depth and amount of potassium shows exponential trend (Figure 4). This means that K is found up to level of 30 to 60 cm and then its concentration considerably decreases and finally becomes almost negligible. The zone V B has no sign of the K because this zone is almost located in hilly / scrub areas. The data indicates that the K has least effective role in Zone V B as majority of the plantations comprise of eucalyptus plants.

A soil high in sodium, also known as a “sodic” soil, is one in which sodium occupies an excess amount of space on soil exchange sites. As soil sodium levels

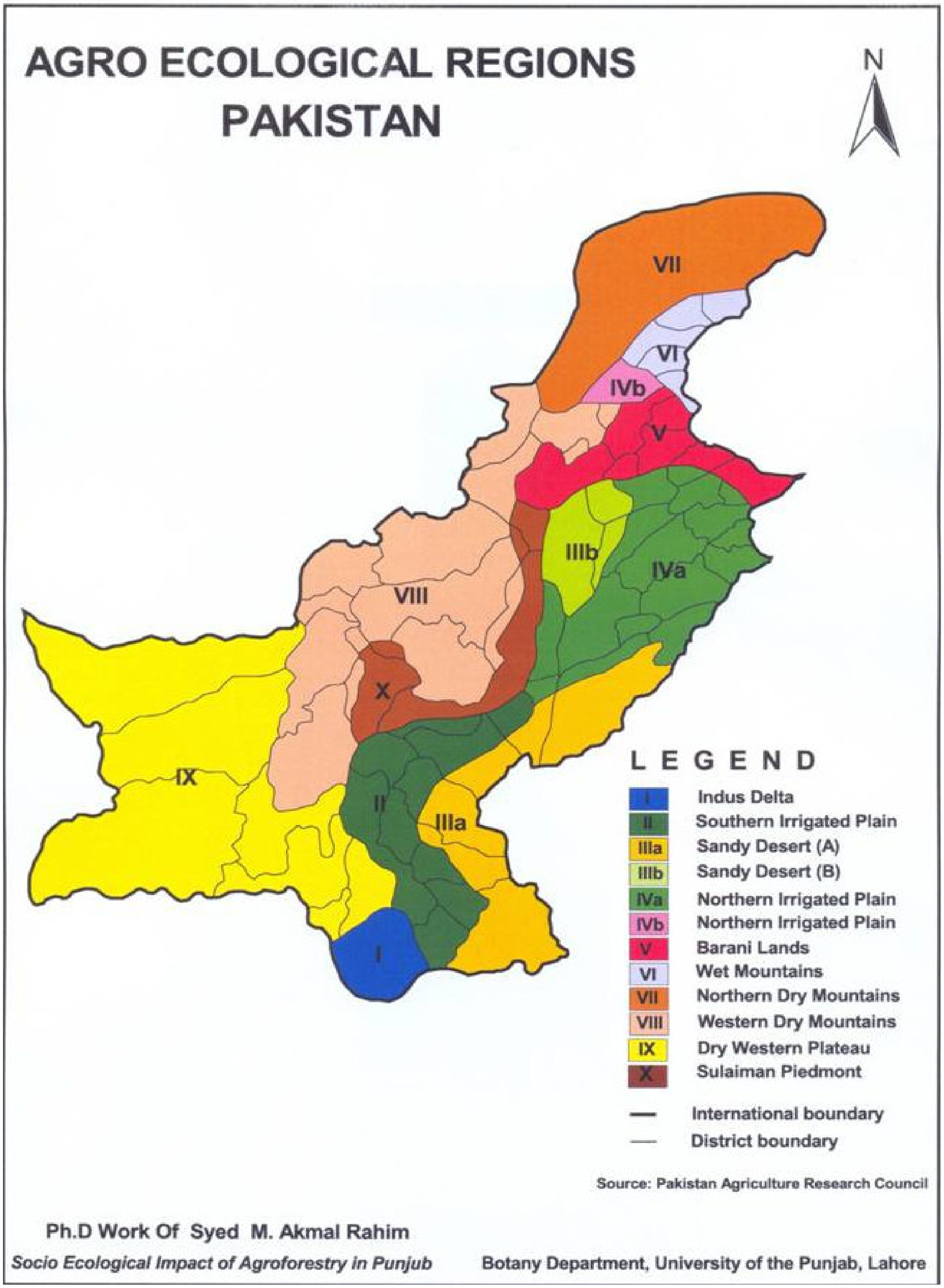

Figure 1. Agro ecological zones of Pakistan.

increases, soluble calcium levels decreases and it is calcium solubility that gives friable, loamy, and permeable structure to the soil. A continued decline in soluble calcium brought on by ever increasing soil sodium causes the soil to lose these favorable structural properties, resulting in impaired drainage and increased

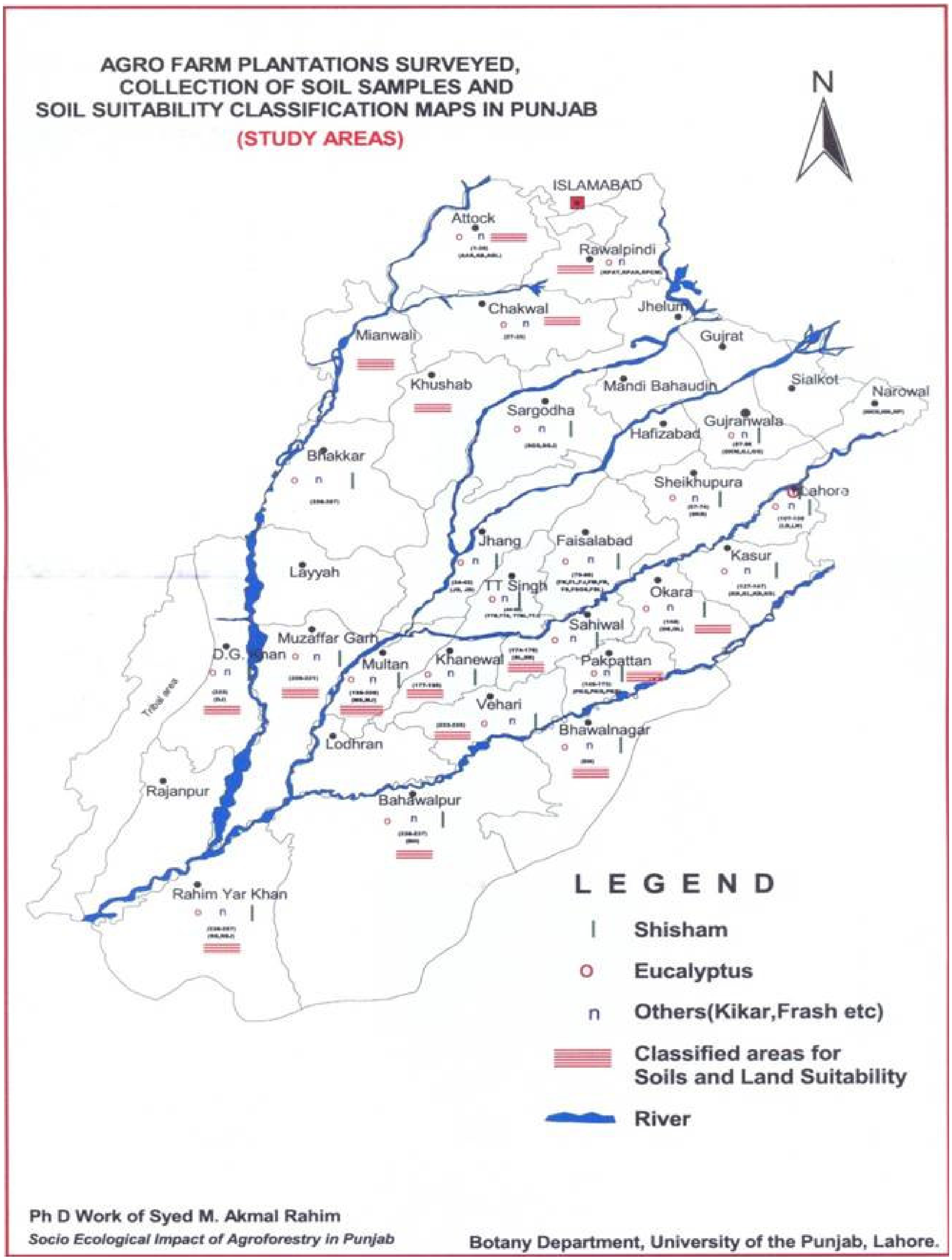

Figure 2. Collection of soil samples.

compaction. Toxicity arising from the sodium ion itself is rare, due to the fact that problems with soil structure usually arise well before sodium can build to toxic levels (Ahmed et al., 2006).

A soil high in salt, also known as a “saline” soil, is one in which soluble salt levels impair turf health by making it

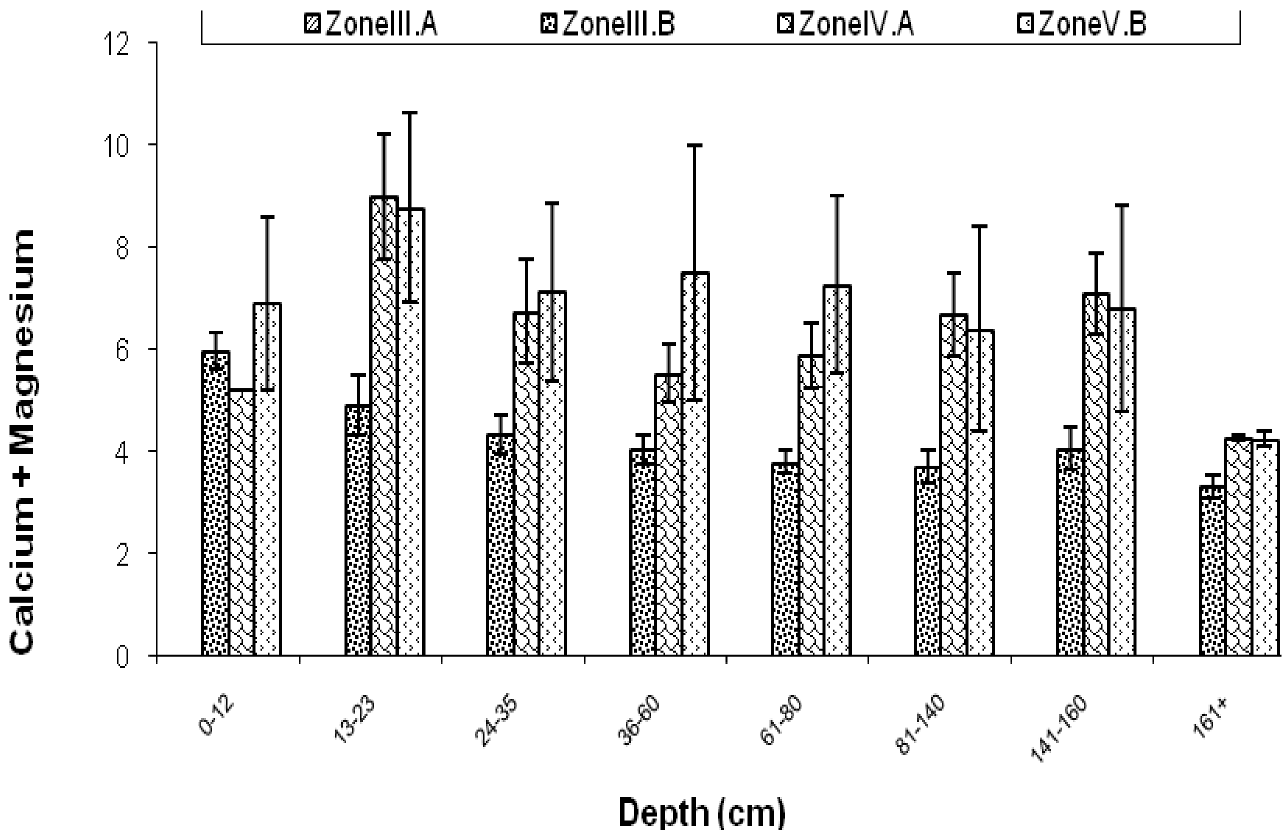

Figure 3. Effect of depth (cm) on Ca + Mg in the soil of different agroeclogical zones.

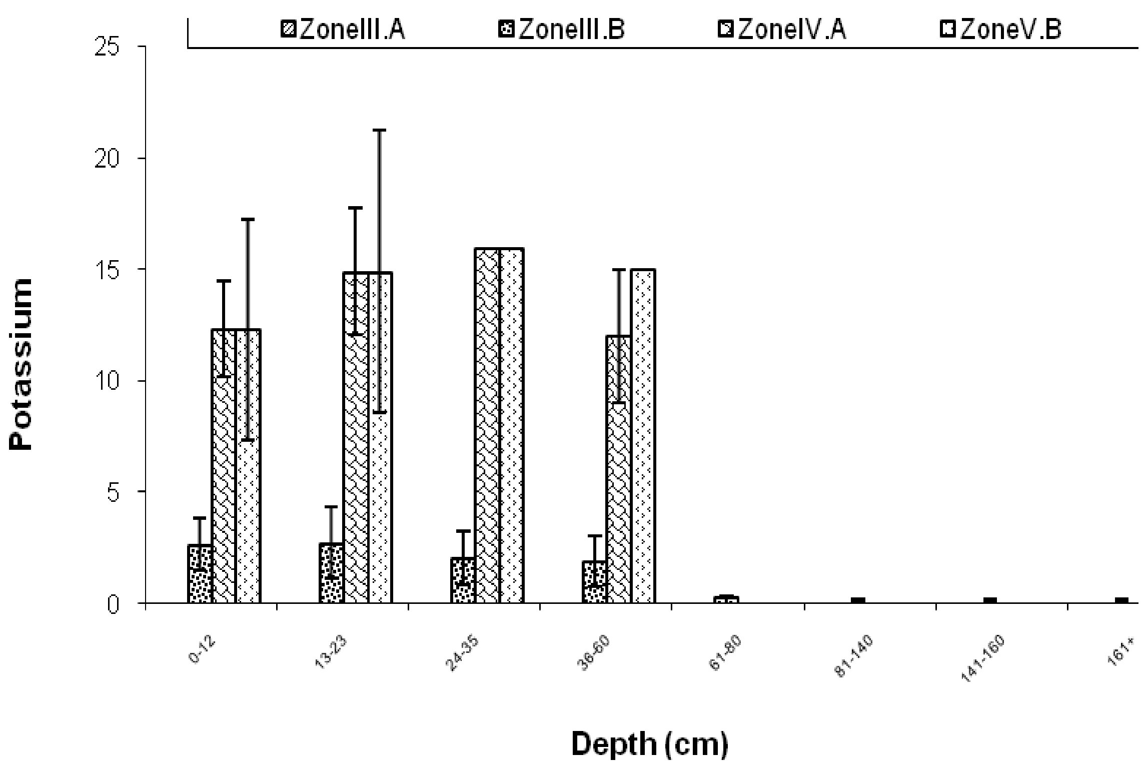

Figure 4. Effect of depth (cm) on potassium (K) in the soil of different agroeclogical zones.

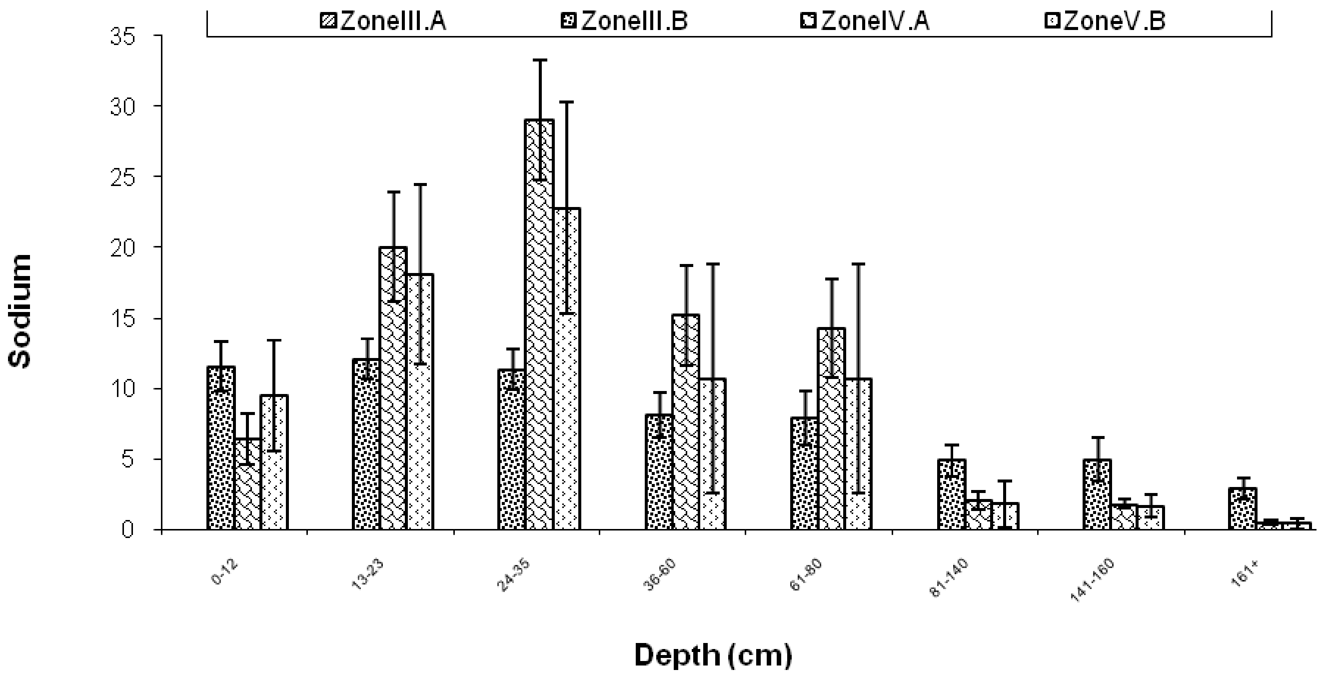

Figure 5. Effect of depth (cm) on sodium (Na).

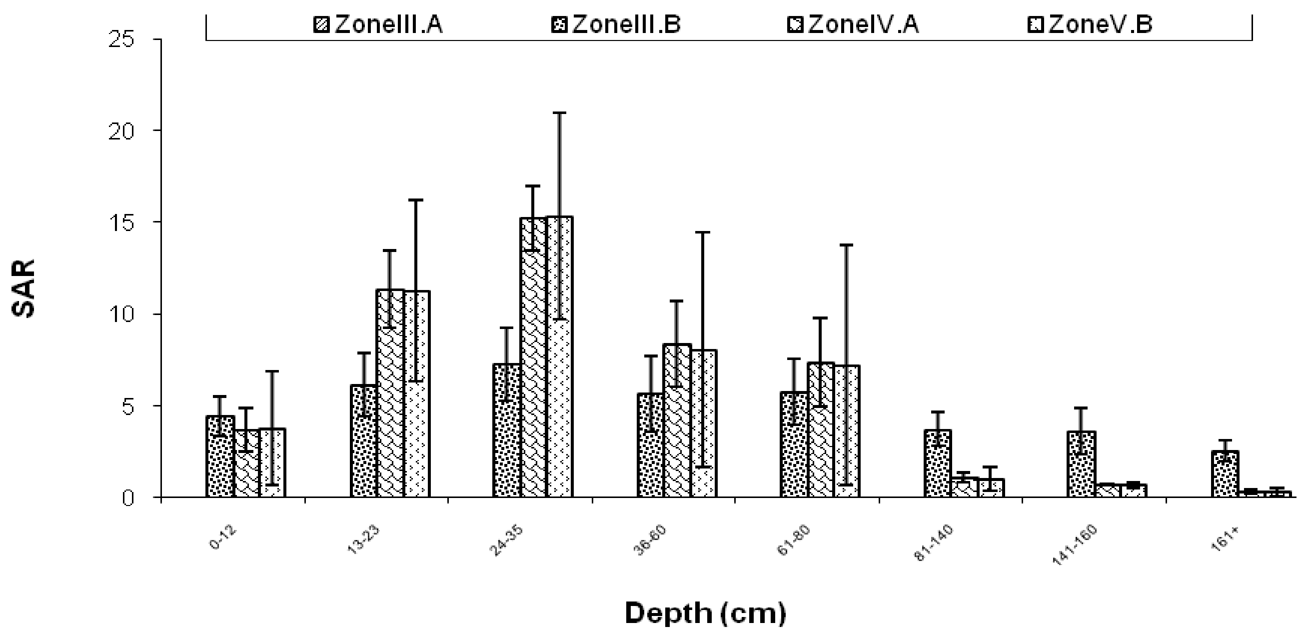

Figure 6. Effect of depth (cm) on SAR in the soil of different agroeclogical zones.

difficult for the plant to extract water from the soil. Sodium salts are critically important because they have the potential to impair soil structure. Though sodium can be involved in each condition, it is important to note that a saline soil quite often contains very little sodium. Moreover, soils high in sodium are often low in soluble salts (Dove, 2003). The results of the study reveal that sodium varies ($P<0.01$) in different levels of depth (Figure 3). Sodium was found at 24.35 cm depth followed by 0.12, 13.23, 36.60 and 61.80 cm. Minimum value of Na was recorded at depth >161 cm. Figure 5 reveals almost linear trend between different depth levels and sodium value. As depth increases, sodium decreases (Comparison of means, maximum). The value of SAR at different levels of depth is not similar and varies (Figure 6). Maximum SAR was found at 24 to 35 cm depth level which is almost similar (P>0.05) but higher from 13 to 23, 36.60 and 61.80 cm depth levels and significantly (P<0.05) lower from 0 to 12, 81 to 140, 141 to 160 and >161 cm depth levels. The relationship between SAR and depth is cubic like. SAR value increased from 0 to 40 cm depth level then decreased up to 150 cm and then showed some increasing trend (Figure 6).

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 (Chaudhry, 2000 and Andrew, 1999). 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 (Vanwilgen et al., 2004). The suitability classification of soil based on several parameters, can help in predicting the best growing field crops, horticultural crops, forest species and other plantation crops once the suitability criteria is established (Nel et al., 2004).

The result for Ca + Mg varies in different zones with respect to Ca + Mg. In Zone III A, Ca + Mg was absent. Almost similar values of Ca + Mg ware found in Zone IV.A and Zone V.B but different from value of Ca + Mg occurred in zone III.B also found by Ben-and Epena (1999). Potassium value was slightly different for Zones III.A and III.B but Zones IV, V.A and V.B show maximum values. Both sodium and SAR were not different regarding zones (Krogh et al., 2000). Sodium and SAR were not recorded in zone III.A. Depth has a huge effect on Ca + Mg values and maximum Ca + Mg was found at 13.23 cm followed by all depth levels except >160 cm depth. Depths levels 0.12 and 13.23 cm have different value of Ca + Mg from depth level of >161 cm. After 60 to 150 cm, slight increase was seen in Ca + Mg values followed by a decrease with increase in depth up to 180 cm. Differences among depth levels for potassium value show that maximum k was found at 13.23 cm depth and minimum at 81.160 cm. Potassium at 0.12 cm depth was different from k at 81.140 cm level of depth. Similarly, sodium value was radically different at different levels of depth. Maximum value of sodium was found at 24.35 cm depth and minimum value of NA was at depth >161 cm, as depth increases sodium decreases (Ahmad et al., 2006). The value of SAR at different levels of depth is also varied. Maximum SAR was found at 24.35 cm depth level which was not significantly different from 13.23, 36.60 and 61.80 cm depth levels.

RECOMMENDATIONS

The best combinations of agricultural crops and trees should be identified by calculating the cost benefit ratio including tangible and intangible benefits resulting in poverty 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. If harvested at the same time with the rest of the field, the grain gets shriveled leading to lesser yields. Further, it is recommended that shallow rooted and shade tolerant crops such as *Trifolium* (berseem) or other fodder crops should be grown near tree rows as a direct competition would not develop, resulting in better yield e.g Leguminous trees such as A*lbizzia procera*, *Leucaena leucocephala* (Iple – Iple) and *Pithecolobrium dulce* (jungle jaleba) etc (Calegari and Alexander 1998). This study represents a pilot study with regards to the development of Soil and Land Suitability maps, as the work was restricted to 17 districts of the Punjab. The undoubted utility of such maps based on the valuable land resource information being generated, makes it imperative that the same may be extended to the rest of the districts of Punjab as the next step and later for other provinces too, for it not only assists the agrofarmers but also alleviates poverty, consequently enhancing the gross economy at the national level (Isbell 2002). The soil texture 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. Keeping in view the vast area of the county affected by salinity, producing low yields, it is highly recommended that this study should be carried out for such salinity hit areas, so as to utilize the potential of the land maximally. Furthermore, stress should be laid on the fodder grasses and nitrogen fixing plant species that are not only economically viable but also provide fertility to the land.

ACKNOWLEDGEMENTS

The authors are grateful to M. Akram Khan, Director Soil Survey of Pakistan and his staff for their technical assistance in soil analysis. They are also thankful to Mr. M. I. Sheikh, farmer Chief Conservator of the Forests, Punjab and former DG, Pakistan Forest Institute, Peshawar, Syed Muhammad Ajmal Rahim, Conservator of Forests Sargodha, and Dr. Seemal Vehra Ejaz for their valuable suggestions.

REFERENCES

Ahmad S, Ghafoor A, Qadir M, Aziz MA (2006). Amelioration of a calcareous saline-sodic soil by gypsum application and different crop rotations. Int. J. Agric. Biol., 8: 142-146.

Ahmad J (1998).Changing perspectives on forest policy. IUCN p. 12.

Anon (1991). A guide to a global environment. World FAO Resources p. 383.

Al-Busaidi AS, Cookson P (2003). Salinity-pH relationships in calcareous soils. Agric. Mar. Sci., 8: 41-46.

Andrew NR (1999). Remote Sensing for Earth Sciences: Manual of Remote Sensing, 3 ed., Vol. 3, John Wiley and Sons Inc, USA, pp. 3-52: 111-188.

Baig MB, Shabbir A, Nowshad K (2008). Germ plasm Conservation of Multipurpose Trees and their Role in Agroforestry for Sustainable Agricultural Production in Pakistan. Int. J. Agric. Biol., 10: 2.

Bisseleua DHB, Missoup AS (2010). Biodiversity Conservation, Ecosystem Functioning, and Economic Incentives under Cocoa Agroforestry Intensification Conservation Biology, October 2009, 23(5): 1176-1184(9).

Botha J (2006). The viability of conservation and social forestry nurseries in South Africa. PhD Thesis, University of the Witwatersrand, Johannesburg, South Africa.

Brown G (2001). Center for Forestry and Ecology. Available by Alabama A&M University, School of Agricultural and Environmental Sciences, Department of Plant and Soil Science, pp. 1131-1149.

Calegari A, Alexander I (1998). The effects of tillage and cover crops on some chemical properties of an Oxisol and summer crop yields in south-western Paraná, Brazil. Adv. Geo.Ecol., 31: 1239-1246.

Chandrshekhran C (1987). Expert Consultation on Inter sectoral linkages Forests and food security FAO, Bangkok, pp. 53-67.

Craig E, Wilkinson K (2004). Nitrogen Fixing Trees-A Brief Introduction. The Over story is distributed by Agroforestry Net, Inc., Holualoa, Hawaii 96725 USA, pp. 167-178.

Dixon HJ, Doores JW, Joshi L, Sinclair FL (2001). Agroecological Knowledge Toolkit for Windows: Methodological Guidelines, Computer Software and Manual for AKT5. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK, pp. 171.

Dixon HJ, Doores JW, Joshi L and Sinclair FL (2001). Agroecological Knowledge Toolkit for Windows: Methodological Guidelines, Computer Software and Manual for AKT5. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK, p. 171.

Drury CF, Ng HYF, Serem VK, Tan CS, Gaynor JD (2000). Modeling and testing of the effect of tillage, cropping and water management practices on nitrate leaching in clay loam soil. Agric. Water Manage., 43: 111-131.

Economic Survey of Pakistan (2006-2007). Ministry of Finance. Economic Division, Islamabad.

Chaudhry KA (2007). Effect of spacing and plant density on the growth of poplar (Populus deltoides) trees under agro-forestry system. Pak. J. Agri. Sci., 44(2).

Hafeez M (1998). Agro forestry series: volume I to VI, handbooks, Punjab For. Res. Inst. Faisalabad Pakistan.

Higgs ES (1997). What is good ecological restoration?. Conserv. Biol., 11(2): 338-348.

Hubbard BD, Faircloth B, Long A (1999). Recreation options for your forestland. Fact sheet SS FOR 4. School of Forest Resources and Conservation, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, pp. 181-1 95.

Hussain SS, Arshad MK, Shahzad AM (2003). Mountains of Pakistan: Protection, Potential and Prospects. Islamabad: Global Change Impact Studies Centre, pp. 133-232.

Isbell RF (2002). The Australian Soil Classification, CSIRO Publishing, Collingwood, Victoria, Australia, pp. 244-255.

Jablonski LM, Wang XZ, Curtis PS (2002). Plant reproduction under elevated CO2conditions: A meta-analysis of reports on 79 crop and wild species. New Phytol., 156: 9-26.

Khan MM (1989). Economic analysis of agroforestry options for small irrigated farms in Punjab. Professional paper in partial fulfillment of the requirements for the degree of master of science Colorado state university fort Collins, Colorado, pp. 16-21.

Kitalyi A, Nyadzi G, Oduol PA (2004). The Ngitili System as a platform for agroforestry in the dry lands. Annual Review of Agroforestry Science and Innovation Planning Forum: The World Agro forestry Centre (ICRAF) Nairobi, 20-25th September 2004. Nairobi: World Agro Forestry Centre (ICRAF).

Krogh L, Breuning H, Greve MH (2000). Cation exchange capacity pedotransfer function for Danish soils. Soil Plant Sci., 50: 1-12.

Lavelle P, Spain A (2001). Soil ecology. Dordrecht, The Netherlands, Kluwer Academic Publishers, pp. 49-53.

Margesin RF, Schinner I (2005). Manual for soil Analysis - Monitoring and assessing Soil Bioremediation. Springer, 1,2&3: 67-233.

N'Goran A, Gnahoua GM, Oualou K, Balle P (2002). Evolution of maize yield after tree fallow in a humid forest zone of Cote d'Ivoire. Cahiers d'Etudes et de Recherches Francophones/Agricultures (France), 11: 145-149.

Nel JL, Richardson DM, Rouget M, Mgidi T, Mdzeke NP, Le Maitre DC,van Wilgen BW, Schonegevel L, Henderson L, Neser S (2004). A proposed classification of invasive alien plant species in South Africa: towardsprioritising species and areas for management action. S. Afr. J. Sci., 100: 53-64.

Pallardy S, Gibbins D, Rhoads J (2002). Above and below-ground biomass production by two-year-old poplar clones on floodplain sites in the lower Midwest, U.S.A. In; W. Schrodder and J. Kort (eds.) Proceedings of the Seventh Biennial Conference on Agroforestry in North America. Regina, Sask., Canada, pp. 34-39.

Pfefferkor SS, Rizki PP, Noviana K, Laxman J (2005). Land tenure, agroforestry adoption, and reduction of fire hazard in a forest zone: A case study from Lampung, Sumatra, Indonesia World Agroforestry Centre, Southeast Asia Regional Office, Indonesia; Agrofor. Syst., 65: 1-11.

Sanchez PA (2002). Soil fertility and hunger in Africa. Science, 295: 2019-2020.

Sangha KK, Jalota RK, Midmore DJ (2005). Impact of tree clearing on soil pH and nutrient availability in grazing systems of central, pp. 267-280.

Sheikh MI, Bukhari AS, Khan AQ (2000). Baseline survey of three irrigated plantations viz Changa Manga, Lal Sohanra and Kundian. For. Sector Dev. Project, p. 152.

Simons AJ, Leakey RRB (2004). Tree domestication in tropical agroforestry. Agrofor. Syst. 61: 167-181.

Soil Survey of Pakistan Report (2005). Soil Survey of Pakistan Government of Pakistan, Multan Road, Lahore, pp. 12-140.

Tian FK, Salako IR, Ishida F (2001). Replenishment of C, N, and P in a degraded Alfisol under humid tropical conditions: Effect of fallow species and litter polyphenols. Soil Sci., 166: 614-621.

Tonye J, Ibewiro B, Duguma B (1997). Residue management of a planted fallow on an acid soil in Cameroon: Crop yields and organic matter fractions. Agrofor. Syst., 37: 199-207.

VanWilgen BW, deWit MP, Anderson HJ, Le Maitre DC, Kotze IM, NdalaS, Brown B, Rapholo MB (2004). Costs and benefits of biological, p. 456.