Pak. J. Bot., 43(4): 1867-1872, 2011.

INFLUENCE OF PLANTATION TYPE ON GROUND FLORA COMPOSITION AND DIVERSITY IN GATWALA ARTIFICIAL FOREST PLANTATION

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Abstract

Gutwala Artificial Forest Plantation is important due to conservation viewpoint because many endangered species have been planted therein. A survey was conducted to assess the species diversity and ordination as influenced by different plantation types of both native and exotic nature. In the plantation, 58 tree species have been planted, most of these species being exotic. The impact of the Gutwala plantations on ground vegetation of native flora was quite prominent, where some species had resulted in complete elimination of ground flora. This effect may be mainly due to dense canopy cover, resulting into poor sunlight penetration. In addition, some other factors like allelopathic effect of the planted species on ground vegetation as well as a large amount of leaf shedding of the planted species, make harder ground flora to germinate or grow. Mixed type of *Eucalyptus* plantation supported mainly grass species like *Cynodon dactylon* and *Dichanthium annulatum.* Meliaceae (*Azadirachta indica, Melia azedarach* and *Cedrela toona*) restricted the germination and growth of several ground cover species. Papilionaceae (*Butea frondosa*, *Dalbergia sissoo, Pongamia pinnata* and *D. latifolia*) had a single dominant grass species *C. dactylon.* Mimosaceae (*Acacia nilotica, A.modesta* and *A. sanegal*) plantation had a relatively thin ground cover as compared to that in other plantations. In Caesalpiniaceae (*Cassia fistula* and *Bauhinia purpurea*) plantation, *C. dactylon* was the major component of ground vegetation along with two other grasses *D. annulatum* and *Cenchrus pennisetiformis. Dendrocalamus giganteus* had slowly decaying and enormously shedding scaly and foliar leaves, which seemed to have inhibited the germination and growth of ground cover species. On the whole, *Cynodon dactylon* was the most dominant among ground flora, which was followed by *Cenchrus pennisetiformis* and *Dichanthium annulatum.* Among dicots, *Conyza boneriensis, Coronopus didymus, Atriplex crassifolia, Malvastrum coromandelianum, Sisymbrium irio* and *Malva parviflora* were the dominant species.

Introduction

Diversity is one of the major factor that defines stability and efficient functioning of forest ecosystem so as to maintain biodiversity for forest management (Polykov *et al*., 2008). Diversity indices have been computed for various forest types by various workers, but less effort has been devoted to the description of patterns of diversity in these conspicuous strata of vegetation. This may reveal ecological processes responsible for plant community structure.

Habitat loss is considered a major threat to biodiversity (Mac Donald, 2003) with an increased loss of habitat and biodiversity around the world. Thus, there is an urgent need for biodiversity assessment (Agosti *et al*., 2000). Conservation of biological diversity at all levels is essential to maintain the health of forest ecosystem (Hartley, 2002).

Stratification of different vegetation types is the first and foremost feature that one notices while attempting to characterize the vegetation. Different canopy-strata along with under-storey vegetation not only attract a variety of wildlife species (Hameed *et al*., 2002), but this distinction of canopy strata has long been used for the description of vegetation (Rheinhardt, 1992).

In Pakistan, irrigated forest plantations are facing habitat degradation, which is a serious problem for the loss of biodiversity (Javed *et al*., 2006). Vegetation is over-exploited in such plantations, mainly due to extensive tree cutting for the use of timber and firewood. Under-storey shrubs, herbs and grasses are heavily grazed by livestock, which are responsible for destroying not only the breeding sites of ground nesting birds and sub-terrestrial animal species, but also the plant diversity of the area (Maan & Chaudhry, 2001).

Gutwala forest plantation is of immense importance as it has a huge collection of some endangered species of Pakistan and high valued exotic species. It is spread over an area of 5,883 ha (coordinates 10º 09.96E, 29º 48.88N), which has a status of Game Reserve according the Wildlife Act, Government of Pakistan, 1997 (Maan & Chaudhry, 2001). This plantation serves as a conservatory of many important plant species including both native and exotic origin.

A little work has been done to establish a link between biodiversity and forest management in under storey vegetation of plantation forests which had higher species richness, and high proportion of herb or fern species than the natural forests (Igarashi & Kiyon, 2008). The present study was focused on species composition, biodiversity assessment and impact of forest plantation on the under-storey vegetation of the Gutwala plantation, and this is the first step in conservation of both native and exotic species.

Materials and Methods

Study site: Gutwala plantation, Faisalabad is constituted on an area of about 8 ha. The total plantation was sub-divided into 99 blocks and about 58 tree species were planted belonging to 19 families (Fig. 1 and Table 1).

Vegetation sampling: Vegetation was studied by the quadrat method and 29 blocks selected for vegetation studies out of 99 blocks, which were based on the type of tree species (Fig. 1). Five quadrats were laid in each block, four at each corner and one in the center. For the study of

tree and large shrubs, quadrat of 10 m^2, for shrubs of 5 m^2 and for herb, grasses and small shrubs, of 1 m^2 were used. Each smaller quadrat was laid at one fixed corner (eastern corner) of the larger quadrat. Total number of species within each quadrat as well as within each block was recorded (Table 1). The data for density, frequency and percent cover was recorded and relative value of density, frequency and cover and importance value of each species were calculated. Samples of all plant species were photographed and mounted on standard herbarium sheets for permanent floral record.

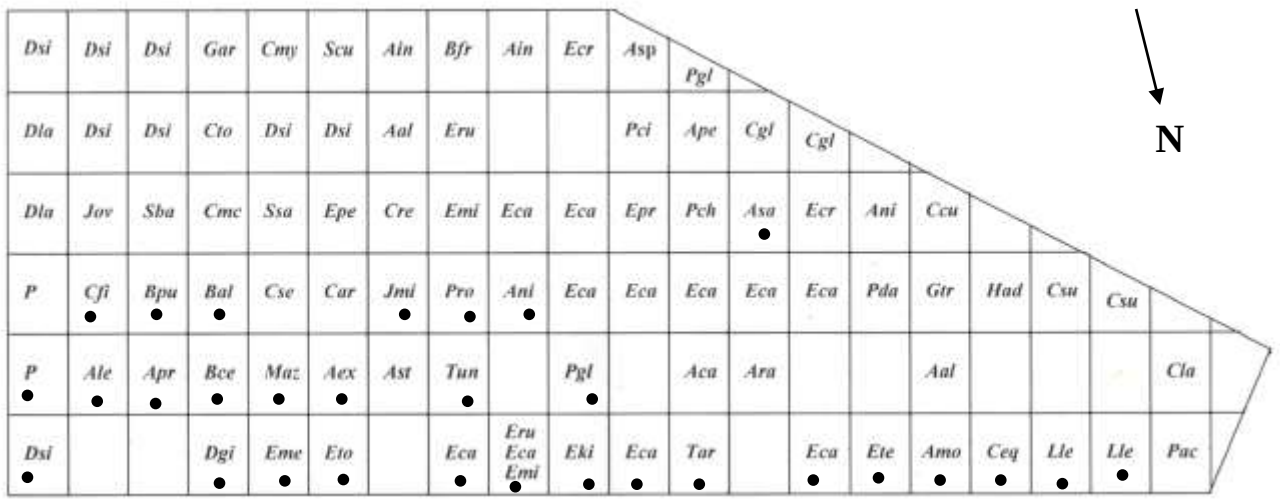

Fig. 1. Layout plan of Gatwala Artificial Forest Plantation showing the vegetation study sites (●)

Aal: Acacia albida
Aca: Acacia catechu
Ain: Azadirachta indica
Ale: Albizia lebbeck
Amo: Acacia modesta
Ani: Acacia nilotica
Ape: Acacia pendula
Apr: Albizia procera
Ara: Acacia raddiana
Asc: Alstonia scholaris
Ase: Acacia senagal
Ast: Acacia stenophylla.
Bce: Bombax ceiba
Bfr: Butea frondosa
Bpu: Bauhinia purpurea.
Bva: Bauhinia variegata 'Alba'
Car: Cupressus arizonica
Ccu: Casuarina cunninghamiana
Ceq: Casuarina equisetifolia
Cfi: Cassia fistula
Cgl: Casuarina glauca
Cla: Callistemon lanceolatus
Cmo: Casuarina montana
Cmy: Cordia myxa
Cre: Crataeva religiosa
Cse: Cupressus sempervirens
Csu: Casuarina suberosa
Cto: Cedrela toona
Dgi: Dendrocalamus giganteus
Dla: Dalbergia. latifolia
Dsi: Dalbergia sissoo.
Eca: Eucalyptus camaldulensis.
Ecr: Eucalyptus crebra
Egl: Eucalyptus glabulus
Eki: Eucalyptus kitsoniana
Eme: Eucalyptus melanophloia.
Emi: Eucalyptus microtheca.
Epe: Eucalyptus pellita
Epr: Eucalyptus. pruinosa
Eru: Eucalyptus rudis
Ete: Eucalyptus. tereticornis
Eto: Eucalyptus torelliana
Gar: Gmelina arborea
Gtr: Gleditsia triacanthos
Had: Heterophragma adenophylla
Jmi: Jacaranda mimosifolia
Jov: Jacaranda ovalifolia
Maz: Melia azedarach
Pac: Parkinsonia aculeat
Pda: Phoenix. dactylifera
Ppi: Pongomia .pinnata
P: Paulownia tomentosa.
Sba: Salix babylonica.
Scu: Syzygium cumini
Sse: Sapium sebiferum
Tar: Terminalia arjuna
Tro: Putranjiva roxburghii
Tun: Tecomalla undulata

Table 1. Plantation types in the Gutwala forest.

Plantation type	Planted species
Bignoniaceae	*Paulownia tomentosa, Jacaranda mimosaefolia, Tecomella undulata*
Bombacaceae	*Bombax ceiba*
Caesalpiniaceae	*Bauhinia purpuria, Bauhinia veriegata*
Meliaceae	*Azadirachta indica, Melia azedarach*
Mimosaceae	*Acacia modesta, Acacia nilotica, Albizia lebbeck, Albizia procera, Leucaena lecocephala, Pithecellobium dulce*
Myrtaceae (Group I)	*Eucalyptus camaldulensis*
Myrtaceae (Group II)	*Eucalyptus kitosoniana, Eucalyptus malanophloia, Eucalyptus rudis, Eucalyptus torelliana*
Myrtaceae (Group III)	*Eucalyptus malanopholia, Eucalyptus torriliana, Euphorbua helioscopia*
Papilionaceae	*Dalbergia sissoo, Erythrina suberosa, Pongamia pinnata*
Poaceae	*Dendrocalamus giganteus*

Results

A total of 10 plantation groups were studied in the Gatwala forest (Table 1) where Mimosaceae was the largest group comprising of 6 species. Myrtaceae (Group-II & III) was the second largest with 4 species each. Species diversity was the maximum in Mimosaceae plantation where 23 species were recorded in under-storey vegetation. It was followed by Myrtaceae (Group-II) with 21 species, Bignoniaceae with 19 species and Papilionaceae with 17 species. The minimum diversity of ground flora was recorded in Poaceae plantation, where only 4 species were recorded.

Dicot species (*Atriplex crassifolia, Medicago lupulina* and *Vicia sativa*) dominated the ground flora in Bignoniaceae plantation (Tables 2 and 3). However, grass contributed a little in under-storey vegetation, where the *Cynodon dactylon* being the most dominant grass. Two dicot species (*Chenopodiun murale* and *Malvastrum coromandelianum*) along with a grass *Cynodon dactylon* dominated the ground vegetation in Bombacaceae plantation. However, *Coronopus didymus* and *Panicum antidotale* contributed considerably to ground vegetation.

Table 2. Relative density of ground flora species at Gatwala forest plantation.

Plant species	Big	Bom	Cae	Mel	Mim	Myr-I	Myr-II	Myr-III	Pap	Poa
Abutilon fruticosum			1.94		1.66		0.47			
Achyranthes aspera	0.71	1.87	3.3		3.12	2.9	0.47		2.84	
Ageratum conyzoides					0.21					
Anagallis arvensis	0.23				0.01		1.17			
Atriplex crassifolia	32.07			6.15	0.42	1.45				
Avena sativa							2.8			
Cenchrus ciliaris						0.72				
Cenchrus pennisetiformis	0.26		10.68	29.1	15.39		7.71		0.19	
Cenchrus setigerus							6.54			
Chenopodium album	0.01				0.06	6.52	0.23		1.89	
Chenopodium murale		26.59			3.12		0.23			
Cirsium arvense	0.14		5.24	2.05	0.05	3.99	0.47			
Conyza boneriensis									0.19	
Coronopus didymus	0.16	9.36			2.08	11.96	2.57	1.45	0.38	
Cynodon dactylon	2.78	20.6	27.38	22.95	22.87	54.35	29.21		26.52	52.17
Dichanthium annulatum	0.01		4.66	6.56	0.83		13.32		5.3	
Euphorbua helioscopia	1.18		2.72					0.58	4.36	
Fumaria officinalis			0.19		2.08					
Imperata cylindrical								85.76	1.89	
Kochia indica							0.23			
Lactuca serriola	0.26	3.75	2.72		2.7			0.29	0.38	
Lathyrus aphaca							0.23			
Malva parviflora				1.23	0.62	0.72	0.23			
Malvestrum coromandelianum	0.61	17.98	0.19	16.8	0.02	31.88	10.75		2.65	13.04
Medicago lupulina	16.63									
Melilotus indica	0.22		1.55						8.52	
Melilotus alba									9.66	
Nicotiana plumbaginifolia					2.5					
Oxalis corniculata	0.22		7.38	1.23	5.2	26.45	7.94		1.89	
Panicum antidotale	0.01	5.99			3.12	1.45	3.5			
Phalaris monor					0.21					4.35
Prosopis cineraria										4.35
Sisymbrium irio	0.46	1.87	3.5	0.82	14.35	0.72	0.23	0.29	10.61	
Solanum nigrum							0.47		0.19	
Sonchus oleraceus	0.12	3.75	4.47		5.61	1.45	0.47	3.49	4.92	
Spergularia flaccida					0.05					
Vicia sativa	17.81									
Xanthium strumarium			0.19							

Big: Bignoniaceae, Bom: Bombacaceae, Ceas: Ceasalpiniaceae, Mel: Meliacea, Mim: Mimosaceae, Myr -I: Myrtaceae Group -I, Myr -II: Myrtaceae Group-II, Myr -III: Myrtaceae Group -III, Pap: Papilionaceae, Poa: Poaceae

Table 3. Relative cover of ground flora species at Gatwala forest plantation.

Plant species	Big	Bom	Cae	Mel	Mim	Myr-I	Myr-II	Myr-III	Pap	Poa
Abutilon fruticosum			1.92		4.04		0.19			
Achyranthes aspera	0.61	2.53	0.77		0.65	11.93	0.1		1.94	
Ageratum conyzoides					0.08					
Anagallis arvensis	0.26				0		0.39			
Atriplex crassifolia	13.82			2.26	0.16	0.95				
Avena sativa							2.34			
Cedrela toona				26.97						
Cenchrus ciliaris						0.95				
Cenchrus pennisetiformis	0.11		5.76	24.89	6.46		1.95		0.12	
Cenchrus setigerus							1.95			
Chenopodium album	0.01				0.07	2.86	0.1		0.24	
Chenopodium murale		20.2			0.65		0.1			
Cirsium arvense	0.15		1.92	0.45	0.1	0.48	0.1			
Conyza boneriensis									0.12	
Coronopus didymus	0.19	5.05			0.32	5.73	2.14	17.08	0.24	
Cynodon dactylon	1.9	10.1	28.79	11.31	5.65	28.64	12.67		15.78	3.13
Dichanthium annulatum	0.01		5.76	2.26	0.32		6.43		2.43	
Euphorbua helioscopia	1.38		1.92					2.66	0.73	
Fumaria officinalis			0.19		0.81					
Imperata cylindrical								4.17	0.73	
Kochia indica							0.1			
Lactuca serriola	0.09	2.53	1.15		4.85			0.19	0.12	
Lathyrus aphaca							0.1			
Malva parviflora				0.45	0.16	0.95	0.1			
Malvestrum coromandelianum	0.76	15.15	19	6.79	0.01	5.73	3.9		1.21	9.38
Medicago lupulina	6.91									
Melilotus indica	0.11		0.58						3.64	
Melilotus alba									3.64	
Nicotiana plumbaginifolia					0.97					
Oxalis corniculata	0.19		5.76	1.36	1.62	5.97	1.27		0.73	
Panicum antidotale	0.01	5.05			1.62	8.59	1.36			
Phalaris monor					0.08					1.56
Sisymbrium irio	0.57	0.51	0.96	0.45	4.85	0.95	0.1	0.19	4.85	
Solanum nigrum							0.1		0.12	
Sonchus oleraceus	0.07	1.01	3.84		16.96	0.95	0.1	3.04	2.43	
Spergularia flaccida					0.02					
Vicia sativa	6.91									
Xanthium strumarium			0.19							

Big: Bignoniaceae, Bom: Bombacaceae, Ceas: Ceasalpiniaceae, Mel: Meliacea, Mim: Mimosaceae, Myr -I: Myrtaceae Group -I, Myr -II: Myrtaceae Group -II, Myr -III: Myrtaceae Group-III, Pap: Papilionaceae, Poa: Poaceae

A single grass species, *Cynodon dactylon*, dominated the under-storey vegetation, whereas, *Cenchrus pannisetiformis* also significantly contributed to the ground vegetation in Ceasalpiniaceae. Two grass species, *Cenchrus pannisetiformis* and *Cynodon dactylon* completely dominated the ground vegetation along with the dicot *Malvastrum coromandelianum* in Meliaceae plantation. *Cynodon dactylon*, *Cenchrus pannisetiformis* and *Sisymbrium irio* contributed over 80% of the ground flora to Mimosaceae plantation.

Cynodon dactylon along with a dicot species *Malvastrum coromandelianum* dominated the ground flora in Myrtaceae (Group-I), whereas, *Oxalis corniculata* also significantly contributed to the under-storey vegetation. Two grasses, *Cynodon dactylon* and *Dichanthium annulatum*, and one dicot *Malvastrum coromandelianum* contributed to the ground vegetation in Myrtaceae (Group-II), whereas, in (Group-III), *Imperata cylindrica* was the solitary dominant species in the under-storey vegetation.

Cynodon dactylon along with three dicot species (*Sisymbrium irio*, *Melilotus alba* and *Melilotus indica*) contributed to the major portion of ground vegetation in Papalionaceae plantation, whereas, in Poaceae plantation (*Dendrocalamus giganteus*), *Cynodon dactylon* was recorded in a very few patches only with *Malvastrum coromandelianum*.

Discussion

In Gatwala Artificial Forest Plantation, 58 tree species have been planted in early 1900, most of these species were of exotic origin. However, some common native species were *Tecomella undulata, Bombax ceiba, Cassia fistula, Crataeva religiosa, Terminalia arjuna, Putranjiva roxburghii, Azadirachta indica, Cedrela toona, Melia azedarach, Acacia modesta, A. nilotica, A. senegal, Bauhinia purpuria, Syzygium cumini, Dalbergia sissoo* and *Pongamia pinnata*, which were collected from different regions of the country. The impact of the Gatwala plantation on ground vegetation of native flora was quite prominent, where some species had resulted in complete elimination of ground flora. This effect has been mainly due to dense canopy cover, occurring because of poor sunlight penetration (Pierson *et al*., 2004). Another reason may be the allelopathic effect of the planted species on ground vegetation (Moral & Muller, 1970). A large amount of leaf shedding of the planted species, which make harder ground flora to germinate or grow could be another sound reason (Michelsen *et al*., 1996; Nawaz *et al.*, 2011).

Bignoniaceae includes medium-sized exotic species with deciduous leaves (Nasir, 1979). Canopy of these trees were relatively lax, which mainly supported under-shrubs like *Atriplex crassifolia* (Frietag *et al*., 2001) and creeping /climbing herbs like *Medicago lupulina* and *Vicia sativa* (Ali, 1977). All the other ground species were relatively rare and scattered in these plantation blocks.

Bombax ceiba is the large native tree of Pakistan (Qaiser, 1978). The plantation supported three herbaceous dicots (*Chenopodium murale, Malvastrum coromandelianum* and *Coronopus didymus*). Grasses like spreading or mat forming *Cynodon dactylon* and tussock forming *Panicum antidotale* were present in patches, but in significant amount. Both these grasses were significantly tolerant to several abiotic stresses mainly drought and salinity (Hameed & Ashraf, 2008; Hameed & Ashraf, 2009; Naz *et al.*, 2010; Ahmad *et al.*, 2010), therefore, quite well adapted to saline and arid soils of Gatwala forest plantation.

Papilionaceae includes three native species (*Butea frondosa*, *Dalbergia sissoo* and *Pongamia pinnata*) and one species *Dalbergia latifolia* native to western southeastern Asia (Ali, 1977). These plantations have single dominant grass species *Cynodon dactylon*, which covered 50% of the ground area. Other leguminous family, Mimosaceae, includes three native species of the genus *Acacia* (*A. nilotica, A.modesta and A. sanegal*) and along with several introduced species. Ground cover was relatively thin in these plantations, which was mainly dominated by grasses like *Cenchrus pennisetiformis* and *Cynodon dactylon.*

Caesalpiniaceae the third leguminous family, contains two native species (*Cassia fistula* and *Bauhinia purpurea*) and two exotic species (Ali, 1973). *Cynodon dactylon* was the major component of ground vegetation along with two other grasses *Dichanthium annulatum* and *Cenchrus pennisetiformis.*

Meliaceae plantation includes three native species including deciduous native tree like *Azadirachta indica, Melia azedarach* and *Cedrela toona* (Abdulla, 1972). Ground vegetation was dominated by grasses mainly *Cenchrus pennisetiformis* and *Cynodon dactylon.* Both these grasses are reported to be resistant to a variety of abiotic stresses (Mansoor *et al.*, 2002; Hameed & Ashraf, 2008), and therefore, quite likely to be adapted to arid and semi-arid climates of Gatwala plantation and may also tolerate the falling leaves of planted trees.

All the *Eucalyptus* species have been introduced in Pakistan through various resources from Australia (Ahmad, 2007). Mixed type of *Eucalyptus* plantation that includes mainly *E. camaldulensis, E. malanopholia* and *E. rudis* supported mainly grass species like *Cynodon dactylon* and *Dichanthium annulatum.*

Eucalyptus camaldulensis plantation supported herbaceous dicot species, which includes *Chenopodium album, Coronopus didymus* and *Oxalis corniculata*. However, *Cynodon dactylon* was the most dominant grass species of the ground cover that was distributed throughout the plantation block. *Cynodon dactylon* dominated ground cover species while it was not dominated in *Eucalyptus* plantation while studying Kuppi forest plantation (Javed *et al*., 2006).

Dendrocalamus giganteus had slowly decaying and enormously shedding scaly and other foliar leaves, which seemed to have inhibited the germination and growth of ground cover species (Cope, 1982). Only a few species were recorded in the ground cover, among which, *Cynodon dactylon* was the most dominant.

In conclusion, the species with extensively falling litter like *Dendrocalamus giganteus* strongly inhibit ground cover species and that may be due to the poor penetration of sunlight to ground soil. In addition allelopathic effect of this species may hamper the growth of other plant species, but this is to be investigated in future studies. Leguminous species including the members of family Papilionaceae, Caesalpiniaceae and Mimosaceae promoted the growth of ground vegetation as a number of herbaceous and grass species were recorded in these plantation blocks. This might be due to the reason that falling leaves of deciduous species of these families may add good amount of litter and nutrients to soil and ultimately important for the germination and growth of ground flora (Ahmad *et al.*, 2011).

Eucalyptus plantation blocks were the second best regarding the diversity of ground flora. *E camaldulensis* and mixed plantation of other *Eucalyptus* species promoted the species diversity of ground flora. However, *Bombax ceiba* plantation and that of family Meliaceae restricted the germination and growth of several ground cover species. On the whole, *Cynodon dactylon* was the most dominant among ground flora, which was followed by *Cenchrus pennisetiformis* and *Dichanthium annulatum.* Among dicots, *Conyza boneriensis, Coronopus didymus, Atriplex crassifolia, Malvastrum coromandelianum, Sisymbrium irio* and *Malva parviflora* were the dominant species.

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(Received for publication 20 February 2010)