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RE-COLONIZATION POTENTIAL OF NATIVE VEGETATION IN HABITATS FRAGMENTED FOR CONSTRUCTION OF MOTORWAYS

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Abstract

Habitat fragmentation imparts several environmental stresses on habitats by changing ecosystem structural and function. Accordingly, changed abiotic attributes in isolated areas adversely affect the plant growth performance and distribution. The potential of three native species *i.e., Cynodon dactylon*, *Cenchrus ciliaris* and *Calotropis procera* for recolonizing the areas cleared for construction of motorways was evaluated. Plant species composition and diversity was also assessed to conclude how environmental and soil factors drive the plant communities reestablishment in fenced and unfenced areas of selected Motorways. The ecological attributes were sampled from fenced and unfenced areas of different habitats using quadrat method. The changes in ecological attributes were plotted against soil physicochemical attributes and time elapsed to fragmentation caused by disturbance. Additionally, soil samples were also collected for physicochemical analysis. There was a significant variation in plant species composition in old and recent constructed Motorways. The fragmented areas of old constructed Motorways had stable environmental and soil conditions which supported the distribution of selected species as compared to recently fragmented Motorways. The unfenced areas showed less infestation of selected grass species due to high grazing pressure as compared to fenced areas. Concluding the study, each plant community along the time elapsed to fragmentation was differently influenced by environmental and soil physicochemical attributes.

Key words: Habitat fragmentation, Habitat isolation, Rehabilitation, Ecological attributes soil physicochemical properties.

Sites numbers (Used in RDA): 1=KLK, 2=KTM, 3=PNB, 4=SHK, 5=PNS, 6=TTS, 7=KNW, 8=SHA, 9=GRM, 10=SWB, 11=ZRM, 12=HAS, 13=SMB, 14=WDS, 15=WHN, 16=MRD. **Site abbreviations:** KLK: Kallar Kahar, KTM: Kot Moman, PNB: Pindi Bhattian, SHK: Sheikupura, PNS: Painsra, TTS: Toba Tek Singh, KNW: Khanewal, SHA: Shujabad, GRM: Garhi Momin, SWB: Swabi, ZRM: Zara Miana, HAS: Hassan Abdal, SMB: Sambrial, WDS: Wadala Sandhuan, WHN: Wahndo, MRD: Muridky. **Ecological data:** RD=relative density, RF=relative frequency, RC=relative cover, IV= importance value. **Soil traits:** MC= moisture content, SP= saturation percentage, P= phosphorous, NO= NO^{3-}, Na, K, Ca, Mg. **Environmental attributes:** MxT= maximum temperature, MiT= minimum temperature, RH= relative humidity, MAP= maximum air precipitation.

Introduction

Fragmentation and habitat loss greatly affect the biodiversity dynamics. In tropical areas, natural habitats are frequently changed into agriculture and grassland (Strassburg *et al*., 2017; Laurance *et al*., 2018). Habitat fragmentation and urbanization significantly affect species distribution, growth performance and their colonization, which reduce the population diversity and gene flow (Shaw & Etterson, 2012; Bovendorp *et al*., 2019). These traits are not well studied at spatial scales. Moreover, anthropogenic activities may reduce the species diversity and also affect the ecosystem function and structure (De Matos *et al*., 2021). The changed environmental attributes in fragmented areas indicate more risk for species loss (McKinney, 2006). However, disturbed habitats by human activities have mostly destitute natural features (Shochat *et al*., 2006), and hence, there is a basic need to explore the adaptive strategies on temporal and spatial scale in fragmented habitats.

Among the studied species, *Cynodon dactylon* (L.) Pers. and *Cenchrus ciliaris* L. belonging to the family Poaceae, are perennial weedy grasses and extensively grow in tropical and subtropical areas of the world (Majeed *et al*., 2022). *Cynodon dactylon* is a multi-purpose weedy grass. It is used at different religious events (Dubey *et al*., 2000), in medicine and as an antioxidant, and as a pasture grass in many regions (Auddy *et al*., 2003). This species also has importance in erosion control and soil maintenance (Zhao *et al*., 2019). Buffel grass show rapid invasion and is resistant to wildfire regimes and competes native flora. Rainfall and soil texture have direct impacts on its germination, growth and establishment (Marshall *et al*., 2012). *C. Ciliaris* is a valuable forage grass due to its highly nutritious value (Mganga *et al*., 2019). *Calotropis procera* (Aiton) W.T. Aiton is a member of family Apocynaceae, a hostile weedy species, also known as milkweed (Muriira *et al*., 2018). This weed grows widely in a variety of environments (Hassan *et al*., 2015). It can grow and rapidly infest along ruined areas i.e., roadsides, creek edges and overgrazed grasslands. It is known as "drought deciduous re-sprouting" due to its dormant condition in unfavorable environmental conditions and re-germinate their leaves and shoots under favorable environmental conditions (Pompelli *et al*., 2019). Traditionally, it has importance in folk medicine and used in treating ulcer, tumors and piles as well as has anticancer and anticoagulant properties. The plant latex is important for cardiac glycoside content (Hameed *et al*., 2011).

Roads are constructed between different areas and to assist the trade. Though, it is very essential to maintain the roads for the commercial and financial improvement of any county (Dierkes & Geiger, 1999). National Highway Authority (NHA) was assigned the project of building Motorways for an efficient, well-organized and widespread road setup for fastest-growing transport in the Pakistan. The construction of multiple motorways was made to attain this goal (Akbar *et al*., 2011). These motorways are multiple-lane, controlled-access and high-speed which are managed and operated federally by Pakistan's National Highway Authority (NHA). Motorway (M-1) Peshawar-Islamabad was constructed in 2007 to join the Punjab and Khyber

PukhtunKhwa with total length 155km (Bibi *et al*., 2016). The Islamabad-Lahore motorway (M-2) was finalized in 1997 and its length is 376 km. It is first constructed motorway in the South Asia (Ahmad, 2010). Pindi-Bhattian-Faisalabad-Multan, Motorway (M-4) was built in 2003 and its length is 309 km. Motorway (M-11) Sailkot-Lahore was completed in 2019 and its length is 230 km.

Considering the ecological concerns of road construction, it is a main cause of fragmentation which significantly influences the composition of flora (Holzapfel & Schmidt, 1990). The structure of highways, roadways and railways report many direct and indirect changes. Direct impact is alteration of current habitat and establishing new one with distinctive features. Roadside vegetation imparts many changes in in environmental features and edaphic factors persuaded by fragmentation (Ullmann *et al*., 1990). The role of roadside vegetation interrelated with environmental perspectives is less understood (Wilson *et al*., 1992) and need exploration.

The construction of motorways is accompanied by land clearing followed by fencing after completion of the project. This leads to fragmentation of natural habitats that once were one open large agro- or natural ecosystems. At the same time, it provides best opportunity to understand how these cleared habits will be recolonized by native flora and what environmental factors are most important in regulating re-establishment. It was hypothesized that the environmental conditions of the soil and atmosphere in the fenced habitats after completion of motorway project should have been different from those surrounding non-fenced vegetated habitats due to creation of bare land that is likely influence the reestablishment capacity of the native flora. The present study was conducted to determine the pattern of flora reestablishment after disturbance (clearing) and to evaluate the influence of soil physico-chemical properties and environmental factor on re-establishment capacity of three native species. i.e., *Cynodon dactylon*, *Cenchrus ciliaris* and *Calotropis procera.* The outcome of this study is of great ecological importance because the first two are pasture species and the third one is of great medicinal importance. Therefore, it would be helpful to understand how these species will respond to the creation of open space and in deciphering their reestablishment patterns.

Material and Methods

A phytosociological study was carried out to explore the pattern of reestablishment of three native species (i.e., *Cynodon dactylon*, *Cenchrus ciliaris* and *Calotropis procera*) with reference to time of habitat fragmentation in fenced and unfenced areas of old and newly constructed motorways. Four motorway complexes M-1, M-2, M-4 and M-11 were selected to collect ecological data. From each section, sites were selected at the distance of at least 30 km apart in fenced and unfenced habitats for estimation of ecological traits.

Selected motorways: The selected motorways included **M-1 section** from Peshawar-Islamabad, length 155 km, 6 Lanes and completed in 2007. The **M-2 section** from Islamabad-Lahore, length 376 km**,** 6 Lanes and completed in 1997. The **M-4 section,** Pindi Bhattian-Faisalabad-Multan, length 309 km, 4 lanes and completed from Pindi Bhattian-Faisalabad in 2003 and Faisalabad-Multan in 2019. The **M-11 section**, Sialkot-Lahore, length 230 km, 4 lanes and completed in 2019.

Environmental data: The data for mean annual temperature and for rainfall were obtained from Meteorological Department substations near study sites. For coordinates and elevation data, a GPS system (Etrex 20 CAN310, Garmin, USA) was used.

Vegetation sampling: Four sampling sites were selected in fenced and unfenced areas of each Motorway. The quadrate method was used along a transect line for vegetation sampling (Fig. 1). A transect line of 150 m length was set at each sampling site, where each sampling point was separated by 50 m from the next. At each transect, ten quadrats (5 m^2 for shrubs and 1 m^2 for grasses) were taken at 10m intervals along a transect line.

Ecological data: The data for attributes i.e., relative density, relative frequency, relative cover and importance value were measured for each plant species in each quadrate. The following formulae were used to calculate ecological attributes.

$$\text{Frequency \%} = \frac{\text{Number of quadrats in which a species occurred}}{\text{Total number of quadrats}} \times 100$$

$$\text{Density \%} = \frac{\text{Total number of individuals of a species in quadrate}}{\text{Total number of individuals of all species in a quadrates}} \times 100$$

$$\text{Coverage \%} = \frac{\text{Area covered by a species in quadrate}}{\text{Total area covered by all the species}} \times 100$$

These values were then used to calculate the relative values.

$$\text{Relative frequency \%} = \frac{\text{Frequency value of a particular species}}{\text{Total frequency values of all the species}} \times 100$$

$$\text{Relative density \%} = \frac{\text{Density of a particular species in a site}}{\text{Total density of all the species in that site}} \times 100$$

$$\text{Relative coverage \%} = \frac{\text{Coverage value of a particular species}}{\text{Total coverage values of all the species}} \times 100$$

$$\text{Importance value} = \text{Relative frequency} + \text{Relative density} + \text{Relative coverage}$$

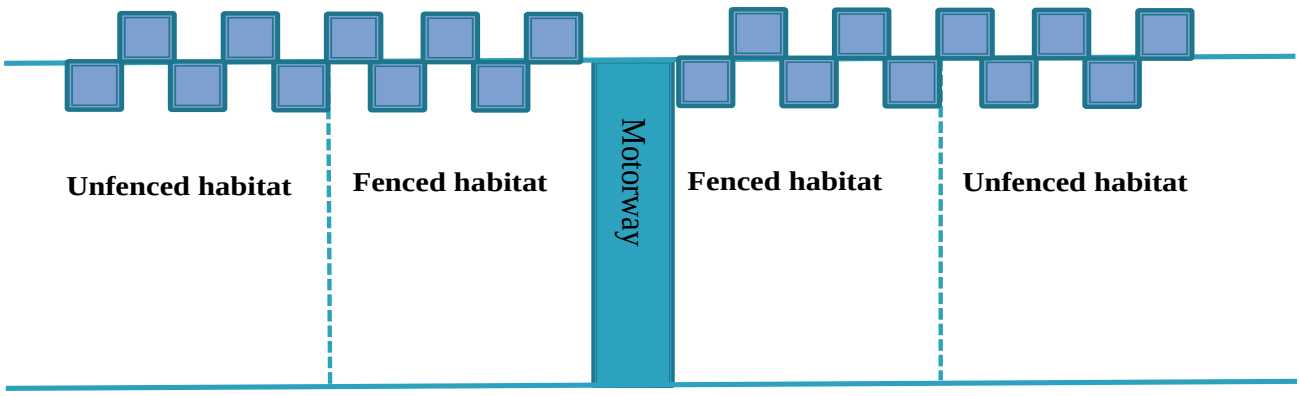

Fig. 1. Experimental design of quadrate setup in fenced and unfenced area of Motorways.

Table 1. Geographical locations and environmental attributes of selected Motorway sites.

Motorways	Sites	Latitude (E)	Longitude (N)	MAP (mm)	MxT (°C)	MiT (°C)	RH
M2	KLK	32.77955	72.71076	555	43	9	54%
	KTM	32.27698	72.97742	575	45	10	39%
	PNB	31.89910	73.28952	385	44	9	46%
	SHK	31.71484	73.97333	455	44	9	26%
M4	PNS	31.34790	72.81785	247	46	10	24%
	TTS	31.05710	72.54727	650	46	10	32%
	KNW	30.27595	70.91078	173	46	11	26%
	SHA	29.86194	71.32834	206	46	11	28%
M1	GRM	34.07379	71.71723	507	47.7	5.5	45%
	SWB	34.04841	72.61544	350	34	3	59%
	ZRM	34.07517	72.08507	918	42	8	48%
	HAS	33.82737	72.78298	982	41	7	38%
M11	SMB	32.48359	74.34599	391	41	10	22%
	WDS	32.19414	74.39684	319	39	6	54%
	WHN	32.03161	74.39640	331	40	8	40%
	MRD	31.80959	74.25323	244	39	7	20%

Abbreviations for parameters: M: Motorway, **Max:** Maximum temperature, **Min:** Minimum temperature
Abbreviations for sites: KLK: Kallar Kahar, **KTM:** Kot Moman, **PNB:** Pindi Bhattian, **SHK:** Sheikupura, **PNS:** Painsra, **TTS:** Toba Tek Singh, **KNW:** Khanewal, **SHA:** Shujabad, **GRM:** Garhi Momin, **SWB:** Swabi, **ZRM:** Zara Miana, **HAS:** Hassan Abdal, **SMB:** Sambrial, **WDS:** Wadala Sandhuan, **WHN:** Wahndo, **MRD:** Muridky

Statistical analysis

The data were analyzed separately for each motorway with one-way Analysis of Variance (ANOVA) keeping the sites as single main factor. The LSD values were calculated and used to place letters of significance on ecological attributes for sites located in one motorway section (Steel & Torrie, 1980). All ecological attributes were plotted on a RDA triplots and response curves were drawn to evaluate the effect of time to fragmentation using Canoco software (v 4.5 for windows).

Results

Environmental data: Along M2 study sites, the mean annual precipitation (MAP) ranged from 385mm to 575mm along selected sites, with the lowest at PNB site and highest at KTM site. The average minimum and maximum temperature were recorded as 9°C and 44°C. The relative humidity (RH) ranged from 26% to 54%, being the minimum at SHK and the maximum at KLK sites. Along M4 sites, the MAP ranged from 173mm to 650mm along selected sites of M4 with the lowest MAP at KNW site and the highest at TTS site. The average minimum and maximum temperature ranged between 10°C and 46°C. The RH ranged from 24% to 36%, with the minimum at PNS and maximum at TTS sites. In M1 sites, the MAP varied from 350mm to 982mm where the lowest MAP was recorded at SWB and the highest at HAS sites. The average minimum and maximum temperature were recorded as 3°C and 47.7°C. The RH ranged from 38% to 59%, with the minimum at HAS and maximum at SWB sites. Along M11 sites, the MAP varied from 244mm to 391mm, with the lowest MAP being at MRD and the highest at SMB sites. The average minimum and maximum temperature were recorded as 6°C and 41°C. The RH ranged from 20% to 54%, being the minimum at MRD and the maximum at WDS sites (Table 1).

Soil analysis: Significant variation was notes in soil physicochemical traits of *Calotropis procera* growing along fenced and unfenced areas of selected motorways. Soil was generally sandy loam, while silt loam soil was observed in fenced areas of TTS site along M4 and GRM site along M1. Most of the habitats were characterized by slightly alkaline pH ranging from 7.8 to 8.6. Considerable variation for electrical conductivity ECe was noted in rhizospheric soil of all ecotypes, varying from 0.98 to 3.45.

However, the maximum ECe was noted at fenced area of MRD site, while the minimum at unfenced areas of SWB site along M11 and M1, respectively. Soil Na^+ content varied from 18.5 to 75.0 mg L^{-1}. Among all selected habitats, the maximum soil Na^+ was noted in fenced area of TTS site along M1 and minimum in fenced area of MRD site along M11. Soil K^+ content ranged from 4.8 to 12.5 mg L^{-1}, where the maximum was in fenced area of GRM and TTS habitats along M1 and M4 respectively, and minimum in fenced area of SMB habitat along M11. Soil calcium content significantly varied from 7.56 to 12.9 mg L^{-1}, where the maximum value was recorded in fenced area of GRM site along M1 and the minimum was in fenced area of SMB site along M11. Soil Mg^{2+} content ranged from 0.32 to 0.78 mg L^{-1}, where the maximum was observed in unfenced area of PNS site along M4 and minimum in fenced area of HAS site along M1. All selected ecotypes showed significant variation in NO ranged from 0.22 to 0.68 mg L^{-1}, where the maximum was noted in fenced area of KTM site along M2 and minimum in unfenced area of GRM site and fenced area of HAS site along M1. Phosphorus content in soil ranged from 0.018 to 0.042 mg L^{-1}, as its high values was observed in fenced area of MRD site along M11 and the lowest in fenced area of SHK along M2. Moisture content ranged from 1.2 to 3.6, where the highest value was observed in fenced areas of KTM and TTS sites along M2 and M4, respectively. The lowest was recorded in fenced area of MRD along M11. Saturation percentage significantly varied from 19.3 to 36.2, where the maximum was observed in fenced area of GRM site along M1 and the minimum in fenced area of KNW site along M4 (Table 2).

Table 2. Physico-chemical characteristics of *Calotropis procera* rhizospheric soil collected from motorways.

Sites	Fencing type	Soil texture	pH	ECe	Na	K	Ca	Mg	NO	P	MC	SP
KLK	Fenced	SL	8.2	1.94	37.0	6.4	9.18	0.57	0.32	0.026	3.2	27.5
	Unfenced	SL	8.1	2.04	45.3	5.9	8.28	0.52	0.29	0.035	2.9	25.7
KTM	Fenced	L /Si L	8.3	1.73	65.3	8.9	10.1	0.63	0.49	0.022	3.6	34.7
	Unfenced	L /Si L	8.0	2.03	63.6	8.1	9.36	0.55	0.42	0.024	2.1	31.6
PNB	Fenced	SL	7.8	2.73	31.8	5.5	7.92	0.45	0.23	0.025	2.1	22.6
	Unfenced	SL	8.0	2.14	25.8	6.7	10.1	0.57	0.36	0.024	2.8	34.1
SHK	Fenced	CL	8.1	1.56	62.8	7.4	12.4	0.71	0.68	0.018	3.8	32.3
	Unfenced	L /Si L	8.0	2.14	25.8	6.7	10.1	0.57	0.36	0.024	2.8	34.1
PNS	Fenced	SL	8.0	1.64	67.4	10.3	11.7	0.63	0.58	0.021	3.4	34.2
	Unfenced	SL	7.9	1.98	62.5	8.5	10.9	0.78	0.52	0.022	3.2	30.2
TTS	Fenced	CL	8.4	1.21	75.0	12.5	12.2	0.65	0.53	0.022	3.6	35.2
	Unfenced	CL	8.0	1.47	67.4	11.4	10.3	0.56	0.38	0.025	3.1	24.1
KNW	Fenced	SL	7.8	3.21	18.9	4.9	7.38	0.35	0.23	0.039	1.5	19.3
	Unfenced	SL	8.0	2.78	24.6	5.3	8.64	0.45	0.26	0.031	1.9	23.4
SHA	Fenced	SL	8.0	2.34	23.8	5.5	8..46	0.43	0.31	0.027	1.8	22.5
	Unfenced	L /Si L	8.1	1.24	28.4	6.1	9.54	0.49	0.35	0.022	2.3	27.4
GRM	Fenced	L /Si L	8.3	1.52	67.9	12.5	12.9	0.56	0.25	0.021	2.5	36.2
	Unfenced	L /Si L	8.1	1.79	56.2	8.7	10.6	0.52	0.22	0.025	2.1	32.8
SWB	Fenced	SL	8.0	1.18	34.6	5.2	9.18	0.44	0.27	0.026	2.1	25.9
	Unfenced	L /Si L	8.1	0.98	41.6	5.7	9.54	0.46	0.32	0.024	2.3	26.4
ZRM	Fenced	L /Si L	8.6	1.34	63.0	9.2	12.1	0.62	0.46	0.033	3.8	32.5
	Unfenced	L /Si L	8.2	1.11	45.0	6.1	8.82	0.48	0.43	0.041	2.7	25.4
HAS	Fenced	CL	8.2	1.62	23.8	5.3	8.10	0.32	0.22	0.028	2.3	23.6
	Unfenced	L /Si L	8.5	1.32	47.3	5.8	9.18	0.41	0.27	0.021	2.5	32.5
SMB	Fenced	SL	7.9	2.56	20.7	4.8	7.56	0.44	0.35	0.035	1.7	22.5
	Unfenced	SL	8.3	1.78	32.1	6.2	10.3	0.58	0.41	0.022	2.4	28.3
WDS	Fenced	SL	8.4	1.14	34.8	6.4	10.1	0.51	0.43	0.026	2.1	25.4
	Unfenced	SL	8.2	2.94	18.7	5.3	7.92	0.38	0.37	0.032	2.0	22.6
WHN	Fenced	L /Si L	8.0	3.21	22.1	5.5	8.64	0.42	0.28	0.032	1.8	18.9
	Unfenced	SL	8.3	2.56	23.4	6.2	9.54	0.47	0.32	0.028	1.9	21.4
MRD	Fenced	SL	7.8	3.45	18.5	5.2	8.10	0.38	0.31	0.042	1.2	21.5
	Unfenced	SL	8.2	2.12	24.6	6.7	9.18	0.43	0.36	0.039	1.5	24.6

Abbreviations and units: ECe = electrical conductivity (dS m^{-1}) **Na:** sodium (mg L^{-1}), **K:** potassium (mg L^{-1}), **Ca:** calcium (mg L^{-1}), **Mg:** magnesium (mg L^{-1}), **N:** nitrogen (mg L^{-1}), **P:** phosphorus (mg L^{-1}), **MC:** moisture content (%), **SP:** saturation percentage (%), **SL:** sandy loam, **L/Si L:** loam/silt loam, **LS:** loam sand

Abbreviations for sites: KLK: Kallar Kahar, **KTM:** Kot Moman, **PNB:** Pindi Bhattian, **SHK:** Sheikupura, **PNS:** Painsra, **TTS:** Toba Tek Singh, **KNW:** Khanewal, **SHA:** Shujabad, **GRM:** Garhi Momin, **SWB:** Swabi, **ZRM:** Zara Miana, **HAS:** Hassan Abdal, **SMB:** Sambrial, **WDS:** Wadala Sandhuan, **WHN:** Wahndo, **MRD:** Muridky

Soil physicochemical characteristics of *Cenchrus ciliaris* growing along fenced and unfenced areas of selected motorways varied significantly in all motorway complexes. Soil texture was mostly sandy loam, while silt loam was observed in fenced areas of PNS site along M4, GRM site along M1 and in fenced and unfenced areas of KTM site along M2, and ZRM and HAS sites along M1. Slightly alkaline pH varying from 7.8 to 8.5 was found in the rhizospheric soil of most of the ecotypes of *C. ciliaris*. Substantial variation for electrical conductivity was recorded in all ecotypes, varying from 0.89 to 2.12, where the maximum was observed in fenced area of MRD site along M11, while the minimum in fenced area of ZRM site along M1. Soil Na^+ content ranged from 16.0 to 65.5 mg L^{-1} with the maximum in fenced area of HAS site along M1 and the minimum in fenced areas of KNW and MRD sites along M4 and M11, respectively. Soil K^+ content varied from 4.8 to 19.8 mg L^{-1}, where the maximum was recorded in fenced area of GRM site along M1, and minimum in fenced area of MRD site along M11. Calcium contents significantly varied from 9.5 to 47.0 mg L^{-1}, where the maximum was noted in fenced area of MRD along M11 and minimum was in fenced area of HAS site along M1. Soil Mg^{2+} content ranged from 0.32 to 0.78 mg L^{-1}, where the maximum was noted in unfenced area of PNS site along M4 and the minimum in fenced area of HAS along M1. Significant variation in NO was seen in all ecotypes ranged from 0.16 to 0.68 mg L^{-1}, while the maximum was noted in fenced area of KNW site along M4 and minimum in unfenced area of SWB site along M1. Phosphorus content in soil varied from 0.016 to 0.038 mg L^{-1}, as its high value was noted in unfenced area of HAS site along M1 and the lowest in unfenced area of SMB site along M11. Moisture content varied from 1.8 to 5.2, where the maximum was found in fenced areas of HAS site along M1, while the minimum in fenced area of MRD site along M11. Saturation percentage ranged from 22.5 to 46.8%, where the highest value was noted in fenced area of HAS site along M1 and lowest value was recorded in unfenced area of SHK site along M2 (Table 3).

Table 3. Physico-chemical characteristics of *Cynodon dactylon* rhizospheric soil collected from motorways.

Sites	Fencing type	Soil texture	pH	ECe	Na	K	Ca	Mg	NO	P	MC	SP
KLK	Fenced	SL	8.0	1.45	45.0	11.0	17.4	0.53	0.28	0.028	3.2	32.1
	Unfenced	SL	8.1	1.61	32.0	11.7	15.9	0.46	0.21	0.035	3.0	28.6
KTM	Fenced	L /Si L	8.2	1.32	76.0	14.0	11.6	0.69	0.37	0.018	4.5	44.5
	Unfenced	L /Si L	8.4	1.63	71.0	14.2	12.6	0.57	0.45	0.031	4.4	41.3
PNB	Fenced	SL	7.9	1.97	28.0	8.9	28.7	0.41	0.43	0.023	2.6	29.1
	Unfenced	SL	8.2	1.48	34.0	10.0	21.8	0.51	0.51	0.019	2.8	33.7
SHK	Fenced	CL	8.3	1.15	42.0	13.0	10.3	0.58	0.65	0.015	4.8	53.6
	Unfenced	L /Si L	8.0	1.34	46.0	18.0	11.3	0.45	0.63	0.026	4.6	42.6
PNS	Fenced	SL	8.2	1.57	69.0	15.0	11.5	0.64	0.48	0.022	5.1	34.2
	Unfenced	SL	8.0	1.89	64.0	12.0	16.3	0.61	0.42	0.027	4.7	31.5
TTS	Fenced	CL	8.5	1.31	84.0	17.0	9.4	0.78	0.37	0.025	5.5	57.3
	Unfenced	CL	8.3	1.53	61.0	14.0	13.5	0.56	0.56	0.031	5.3	51.2
KNW	Fenced	SL	7.8	2.47	32.0	7.6	32.0	0.35	0.52	0.037	2.0	27.4
	Unfenced	SL	8.0	2.21	36.0	8.1	27.4	0.37	0.43	0.026	2.3	32.3
SHA	Fenced	SL	8.4	1.98	45.0	9.6	23.0	0.41	0.22	0.021	2.6	34.7
	Unfenced	L /Si L	8.3	2.12	52.0	10.5	21.5	0.50	0.21	0.019	2.8	43.7
GRM	Fenced	L /Si L	8.2	1.67	64.0	11.0	11.2	0.58	0.32	0.022	4.3	42.1
	Unfenced	L /Si L	8.1	1.94	57.0	13.0	9.6	0.55	0.48	0.028	4.0	49.2
SWB	Fenced	SL	7.9	2.23	53.0	7.0	15.3	0.43	0.19	0.017	3.2	31.2
	Unfenced	L /Si L	8.0	2.12	51.0	7.6	12.3	0.45	0.32	0.024	3.5	37.2
ZRM	Fenced	L /Si L	8.4	1.45	62.0	14.5	6.7	0.71	0.36	0.024	5.2	48.5
	Unfenced	L /Si L	8.2	1.82	42.0	15.0	9.3	0.60	0.25	0.036	4.6	36.6
HAS	Fenced	CL	8.6	1.21	71.0	9.8	5.2	0.76	0.35	0.028	5.7	52.6
	Unfenced	L /Si L	7.8	1.65	54.0	11.0	7.8	0.63	0.52	0.031	4.3	46.3
SMB	Fenced	SL	8.5	1.98	32.0	11.7	21.0	0.52	0.21	0.022	1.8	30.0
	Unfenced	SL	8.4	1.23	31.0	13.0	17.0	0.56	0.19	0.021	2.1	32.4
WDS	Fenced	SL	8.0	2.34	25.0	5.6	34.0	0.39	0.24	0.035	2.6	24.2
	Unfenced	SL	7.6	1.72	29.0	6.0	26.0	0.42	0.23	0.032	3.0	27.8
WHN	Fenced	L /Si L	8.2	2.12	27.0	7.9	27.0	0.42	0.26	0.028	2.2	35.0
	Unfenced	SL	8.5	1.56	31.0	8.0	21.0	0.47	0.21	0.021	2.5	32.5
MRD	Fenced	SL	7.8	2.45	21.3	6.2	38.0	0.34	0.18	0.032	2.5	26.4
	Unfenced	SL	8.2	1.98	25.0	6.7	32.0	0.40	0.17	0.028	2.7	31.6

Abbreviations and units: ECe = electrical conductivity (dS m^{-1}) **Na:** sodium (mg L^{-1}), **K:** potassium (mg L^{-1}), **Ca:** calcium (mg L^{-1}), **Mg:** magnesium (mg L^{-1}), **N:** nitrogen (mg L^{-1}), **P:** phosphorus (mg L^{-1}), **MC:** moisture content (%), **SP:** saturation percentage (%), **SL:** sandy loam, **L/Si L:** loam/silt loam, **LS:** loam sand

Abbreviations for sites: KLK: Kallar Kahar, **KTM:** Kot Moman, **PNB:** Pindi Bhattian, **SHK:** Sheikupura, **PNS:** Painsra, **TTS:** Toba Tek Singh, **KNW:** Khanewal, **SHA:** Shujabad, **GRM:** Garhi Momin, **SWB:** Swabi, **ZRM:** Zara Miana, **HAS:** Hassan Abdal, **SMB:** Sambrial, **WDS:** Wadala Sandhuan, **WHN:** Wahndo, **MRD:** Muridky

Table 4. Physico-chemical features of *enchrus ciliaris* rhizospheric soil collected from motorways.

Sites	Fencing type	Soil texture	pH	ECe	Na	K	Ca	Mg	NO	P	MC	SP
KLK	Fenced	SL	8.2	1.65	43.0	10.4	18.0	0.65	0.34	0.027	3.4	32.0
	Unfenced	SL	8.0	1.78	39.0	7.6	23.0	0.52	0.27	0.033	3.0	28.0
KTM	fenced	L /Si L	8.3	0.95	63.5	16.8	12.0	0.73	0.25	0.022	4.2	37.0
	Unfenced	L /Si L	8.1	1.23	57.5	15.4	15.0	0.78	0.31	0.027	4.1	36.0
PNB	Fenced	SL	8.0	1.89	23.5	9.1	25.0	0.56	0.58	0.029	2.8	26.8
	Unfenced	SL	8.2	1.32	27.0	16.3	18.0	0.45	0.45	0.021	3.1	29.0
SHK	Fenced	SL	8.5	1.03	54.0	18.5	9.8	0.53	0.35	0.023	4.3	32.5
	Unfenced	SL	8.3	1.21	49.0	11.3	15.0	0.73	0.42	0.035	4.0	22.5
PNS	Fenced	L /Si L	8.3	1.15	61.5	12.2	15.0	0.76	0.41	0.021	4.0	38.4
	Unfenced	SL	8.0	1.30	57.0	7.2	21.0	0.88	0.55	0.031	3.2	31.7
TTS	Fenced	SL	8.5	0.83	63.5	14.6	11.0	0.70	0.56	0.024	4.4	45.7
	Unfenced	SL	8.1	1.12	62.0	9.5	25.0	0.61	0.42	0.028	4.1	43.1
KNW	Fenced	SL	7.8	2.06	16.0	6.7	45.0	0.83	0.68	0.032	1.9	25.5
	Unfenced	SL	8.0	1.67	21.0	8.2	31.0	0.53	0.28	0.031	2.2	27.2
SHA	Fenced	SL	7.9	1.45	20.5	8.6	21.5	0.68	0.26	0.027	2.8	31.2
	Unfenced	SL	8.2	1.21	27.5	13.4	11.0	0.84	0.21	0.021	3.0	33.2
GRM	Fenced	L /Si L	8.0	0.95	31.5	19.8	14.0	0.74	0.28	0.024	4.2	38.6
	Unfenced	SL	7.9	1.04	35.5	8.5	28.0	0.96	0.23	0.029	4.0	32.5
SWB	Fenced	SL	7.8	1.15	25.5	9.0	24.0	0.67	0.21	0.031	3.5	23.4
	Unfenced	SL	8.0	1.34	30.0	13.6	13.0	0.62	0.16	0.022	3.2	25.4
ZRM	Fenced	L /Si L	8.3	0.89	57.0	12.4	16.4	0.85	0.41	0.026	4.7	42.3
	Unfenced	L /Si L	8.0	1.20	48.5	5.2	32.0	0.88	0.32	0.028	4.5	40.6
HAS	Fenced	L /Si L	8.0	0.56	65.5	10.4	9.5	0.76	0.31	0.021	5.2	46.8
	Unfenced	L /Si L	7.8	1.22	59.0	6.7	21.0	0.93	0.23	0.038	4.8	41.3
SMB	Fenced	SL	8.1	1.56	21.5	8.7	17.0	0.47	0.18	0.028	2.7	33.2
	Unfenced	SL	8.4	1.43	27.0	13.5	13.0	0.42	0.27	0.016	2.8	34.6
WDS	Fenced	SL	7.8	2.01	19.2	5.6	32.0	0.58	0.26	0.031	2.0	22.9
	Unfenced	SL	8.0	1.11	23.4	9.4	25.0	0.51	0.25	0.021	2.3	27.5
WHN	Fenced	SL	8.0	1.93	23.0	6.8	24.0	0.53	0.21	0.025	2.4	28.5
	Unfenced	SL	8.2	1.23	26.0	5.4	21.0	0.62	0.18	0.018	2.5	31.4
MRD	Fenced	SL	8.2	2.12	16.0	4.8	47.0	0.40	0.28	0.034	1.8	22.6
	Unfenced	SL	8.5	1.34	22.5	7.9	32.0	0.48	0.24	0.028	2.1	28.4

Abbreviations and units: ECe = electrical conductivity (dS m^{-1}) **Na:** sodium (mg L^{-1}), **K:** potassium (mg L^{-1}), **Ca:** calcium (mg L^{-1}), **Mg:** magnesium (mg L^{-1}), **N:** nitrogen (mg L^{-1}), **P:** phosphorus (mg L^{-1}), **MC:** moisture content (%), **SP:** saturation percentage (%), **SL:** sandy loam, **L/Si L:** loam/silt loam, **LS:** loam sand

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For of *Cynodon dactylon,* substantial variation was noted in soil texture from sandy loam and clay loam. Soil pH varied from 7.6 to 8.5 was measured. Soil electrical conductivity in rhizospheric soil of all ecotypes ranged from 1.21 to 2.47, where the highest value was noted in fenced area of KNW site along M4, while the lowest value was found in fenced area of HAS site along M1. Soil Na^+ content ranged from 21.3 to 84.0 mg L^{-1} where, the maximum was found in fenced area of TTS site along M4 and minimum in fenced areas of MRD site along M11. Soil K^+ content ranged from 5.6 to 18.0 mg L^{-1}, where the maximum was noted in unfenced area of SHK site along M2, and minimum was noted in fenced area of WDS site along M11. Calcium contents significantly varied from 5.2 to 38.0 mg L^{-1}, where the maximum was found in fenced area of MRD site along M11 and minimum was in fenced area of HAS site along M1. Soil Mg^{2+} content ranged from 0.34 to 0.78 mg L^{-1}, while the highest value was observed in fenced area of TTS site along M4 and lowest value in fenced area of MRD site along M11. Significant variation in NO was noted in all ecotypes ranging from 0.17 to 0.65 mg L^{-1}, with the maximum in fenced area of SHK site along M2 and minimum in unfenced area of MRD site along M11. Soil phosphorus content ranged from 0.017 to 0.037 mg L^{-1}, as its high value was found in fenced area of KNW site along M4 and the lowest in fenced area of SWB site along M1. Moisture content significantly differed from 1.8 to 5.7, where the maximum was found in fenced areas of HAS site along M1, while the minimum in fenced area of SMB site along M11. Saturation percentage varied from 24.2 to 57.3%, where the highest value was measured in fenced area of TTS site along M4 and lowest value in fenced area of WDS site along M11 (Table 4).

Species composition in fenced and unfenced areas of motorways

Species composition of selected sites of M-2: Dominant flora of fenced area of KLK belonged to family Poaceae followed by Fabaceae family, whereas of unfenced area, a combination of herbs and shrubs owing to the existence of substantial herbaceous layer of *Cynodon dactylon* was found. Plant community of fenced area of KTM were significantly dominated by herbaceous monocots, while in unfenced area, dominant flora was a combination of herbs and shrubs. Vegetation of fenced area of PNB was dominated by tree species followed by monocots, whereas, in unfenced area, the vegetation was a combination of herbs and shrubs. Dominant flora of fenced and unfenced areas of SHK was mostly herbs (Sup. Tables 1 to 4, see at the end).

Species composition of selected sites of M-4: Dominant vegetation of fenced area of PNS belonged to family Poaceae while trees were dominant in unfenced area. Plant community of fenced area of TTS site was substantially dominated by herbaceous plants, while trees were dominant in unfenced area. Vegetation of fenced area of KNW site was dominated by herbaceous layer, whereas, in unfenced area, the plant community mostly consisted of shrubs. Dominant flora of fenced area of SHA site was a combination of herbs and shrubs, however trees were dominant in unfenced area (Sup. Tables 5 to 8, see at the end).

Species composition of selected sites of M-1: Mostly vegetation of fenced area of GRM site was herbs and in unfenced area dominant flora belongs to family Poaceae. Plant community of fenced of SWB site was dominated by herbaceous monocots while in unfenced areas, was a combination of herbs and shrubs. Flora of fenced area of ZRM site was dominated by herbaceous monocots, while trees were dominant in unfenced area. Vegetation of fenced area of HAS been dominated by members of Poaceae family, whereas, in unfenced area, the vegetation was a combination of herbs and shrubs, however, *Cenchrus ciliaris* and *Cynodon dactylon* formed a considerable herbaceous layer (Sup. Tables 9 to 12, see at the end).

Species composition of selected sites of M-11: Fenced area of SMB site was dominated by trees belonging to the family Poaceae, whereas a combination of shrubs and herbs formed the dominant flora of unfenced area. Plant community of fenced area of WDS site were significantly dominated by herbaceous monocots, while shrubs were dominant in unfenced area as dominant flora was a combination of herbs and shrubs. Vegetation of fenced area of WHN site was dominated by a combination of herbs and shrubs while herbaceous plants were grown in unfenced area. Plant community of fenced area of MRD site was dominated by herbaceous plants whereas, in unfenced area, the vegetation mostly consists of shrubs (Sup. Tables 13 to 16, see at the end).

Ecological analysis of selected species: The fenced areas of old constructed motorways M2 and M4 showed the maximum relative density of *C. procera* plants and the highest relative density was recorded in SHK and KTM sites along M2 as compared to M4. Whereas unfenced areas of SHA (M4) and GRM (M1) sites showed the maximum relative density (Fig. 2). The maximum relative frequency was noted in unfenced areas of all studied sites of motorway complexes and the maximum was measured in WHN and MRD sites along M11 and PNS site along M4. The unfenced areas of all studied sites of M4, M1 and M11 showed high importance value, while fenced areas of old fragmented motorway M2 showed maximum importance value of *C. procera* (Fig. 3).

The maximum relative density and frequency of *C. ciliaris* were recorded in unfenced areas of M2 and M11. However, fenced areas of M4 and M1 showed the maximum relative density and frequency except in fenced areas of GRM and TTS sites along M1and M4, respectively, which showed less relative density and frequency (Fig. 4). The greater biomass, relative cover and importance value were measured in unfenced areas of SHK site along M2, TTS along M2 and WHN and MRD sites along M11. The fenced areas of M1 showed high relative cover and importance value (Fig. 5).

The unfenced areas (PNB and KLK) of old fragmented motorway M2 and SMB site of newly fragmented motorway M11 showed the maximum relative density of *C. dactylon*. Whereas fenced areas of newly fragmented motorway M11 showed maximum relative density. The fenced sites of GRM (M1) and KNW (M4) ecotypes and unfenced sites PNB (M2) showed high relative density (Fig. 6). The fenced areas of all studied ecotypes of M4 and M11 showed high relative density, relative cover and importance value of *C. dactylon* (Fig. 7).

Multivariate analysis of ecological data: The RDA was plotted to evaluate the effect of soil and environmental attributes on distribution of *C. procera* grown in fenced and unfenced areas of motorway complexes (Fig. 8). The relative density (RD) was affected by soil moisture content and saturation percentage of fenced area of KTM habitat along M2. The importance value (IV) was linked with time of habitat fragmentation of fenced areas of KNW site along M4. The relative cover (RC) was associated with maximum air precipitation (MAP) of PNB site along M2, and SWB, ZRM and HAS sites along M1. Soil pH and ECe were strongly influenced the relative frequency (RF) of this plant growing in fenced areas of TTS and SHA sits along M4 and all ecotypes of M11. The RC was affected by MAP of unfenced area of KLK site along M2. The importance value (IV) of *C. procera* growing in unfenced areas was linked with time of habitat fragmentation and relative humidity (RH) of KTM site along M2. Soil potassium of TTS and SWB sites along M4 and M1, respectively, significantly influenced the relative density (RD). The RF was linked with soil traits (ECe, NO, Na), maximum temperature and time of habitat fragmentation of unfenced areas of SMB and WDS sites along M11. The response curves plotted against time of habitat fragmentation of motorways showed that relative density (RD), relative cover (RC) and importance value of *C. procera* growing on fenced areas of motorway complexes showed positive slopes along time of habitat fragmentation. However, relative density of this plant grown in unfenced areas showed positive slope as compared to other studied ecological traits showed negative slopes against time of habitat fragmentation.

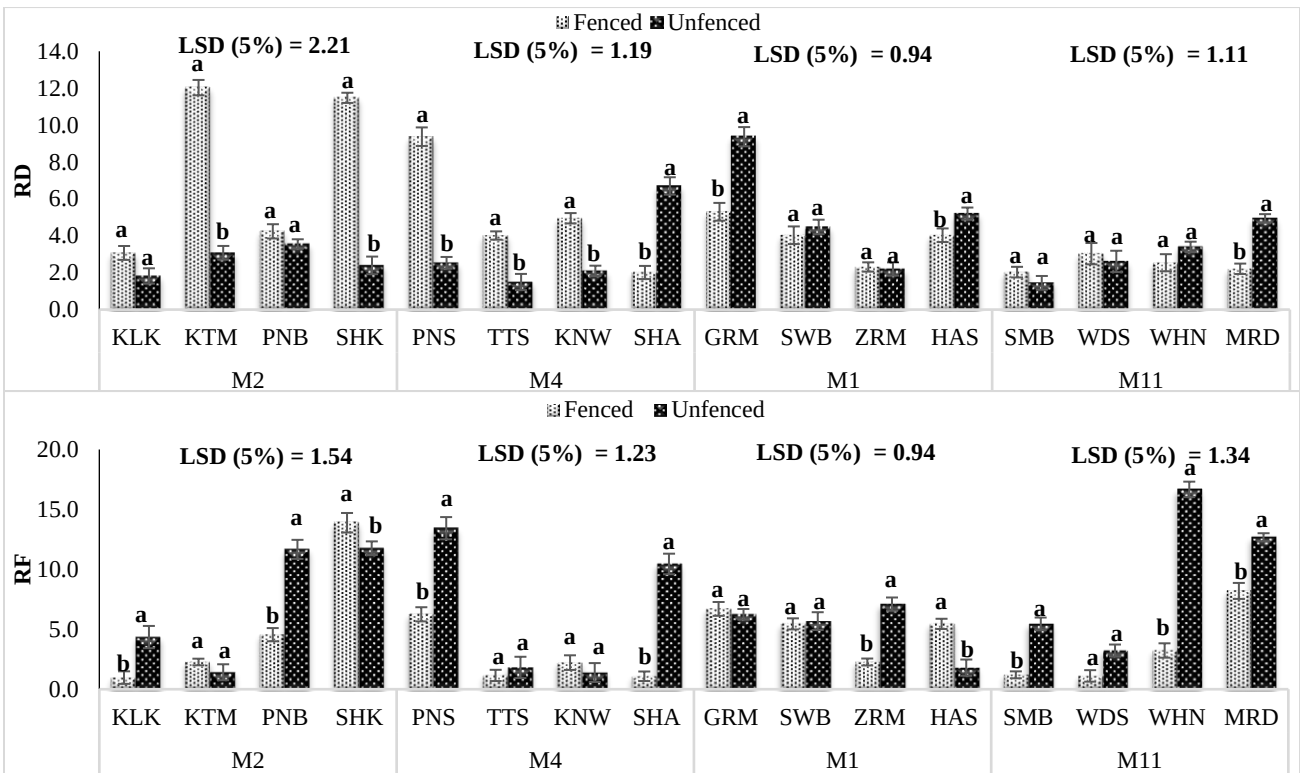

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Fig. 2. Relative density (RD) and relative frequency (RF) of *Calotropis procera* growing at fenced and unfenced areas along different Motorways.

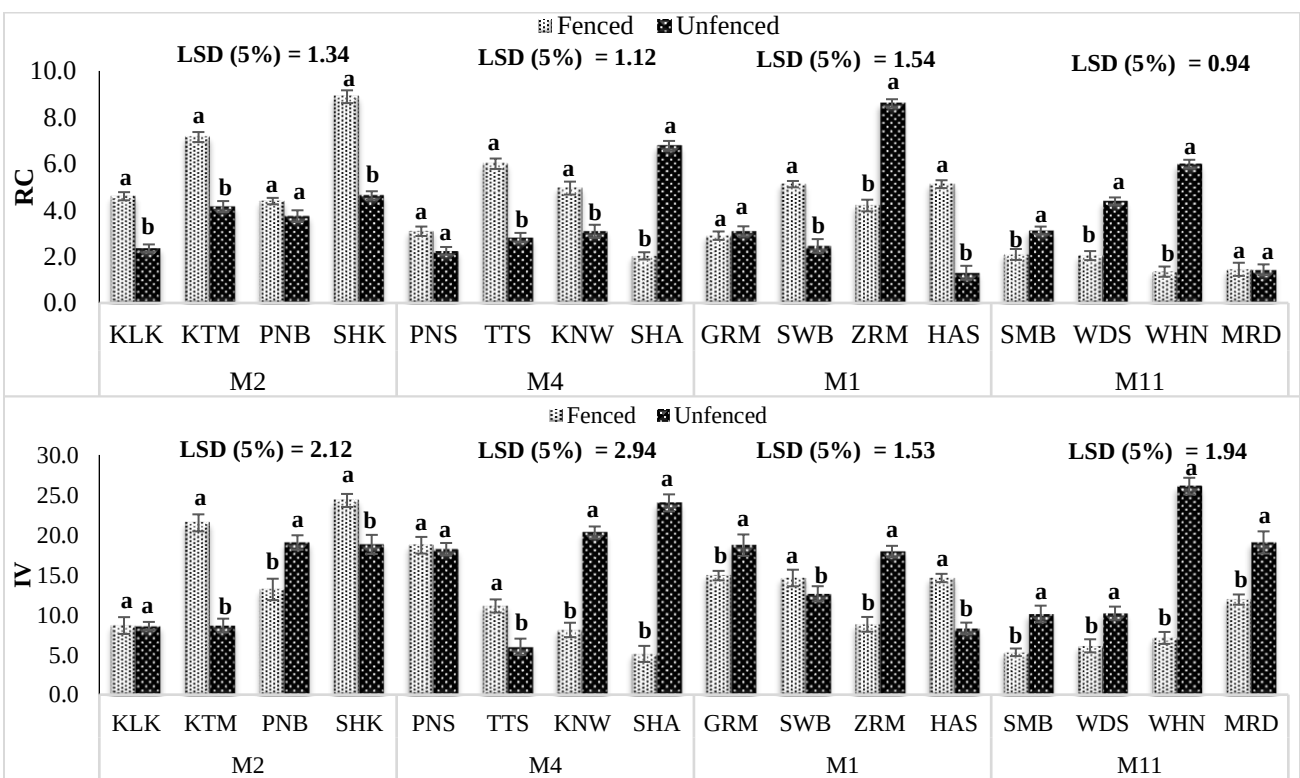

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Fig. 3. Relative cover (RC) and importance value (IV) of *Calotropis procera* growing at fenced and unfenced areas along different Motorways.

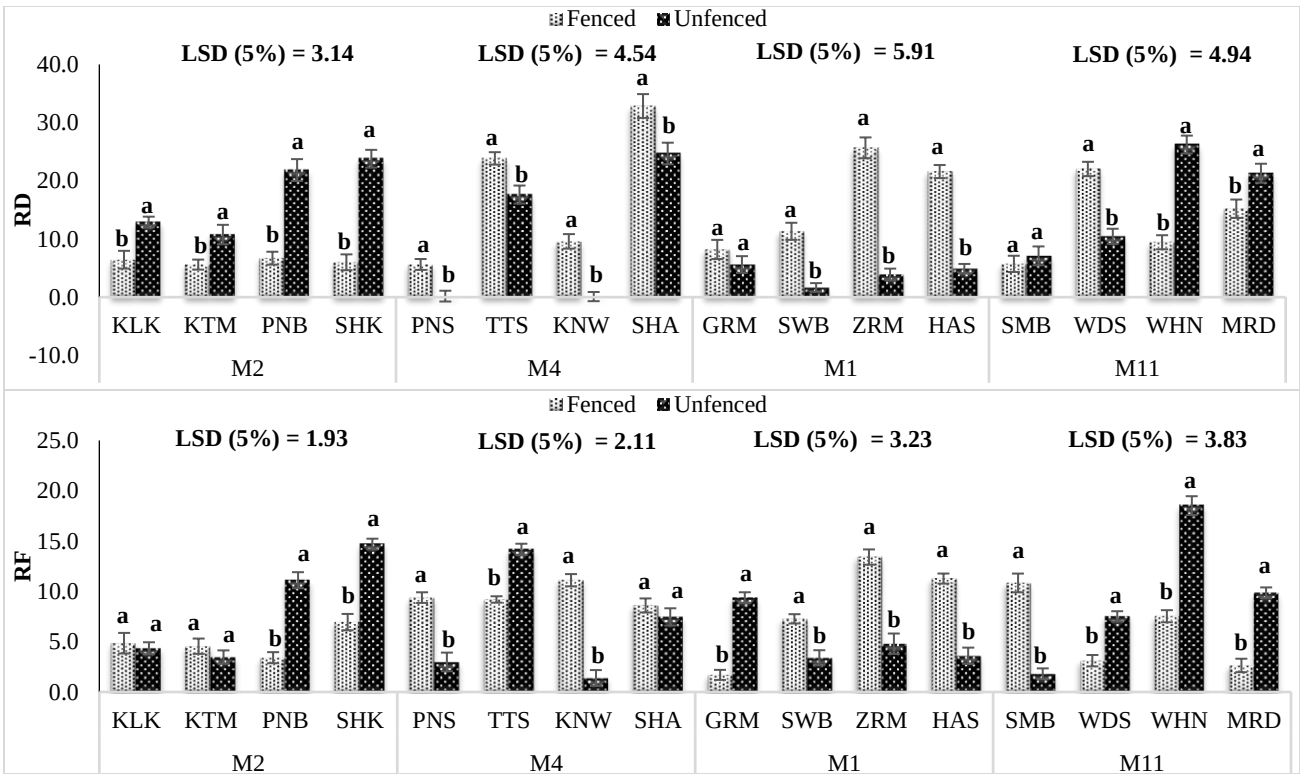

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Fig. 4. Relative density (RD) and relative frequency (RF) of *Cenchrus ciliaris* growing at fenced and unfenced areas along different Motorways.

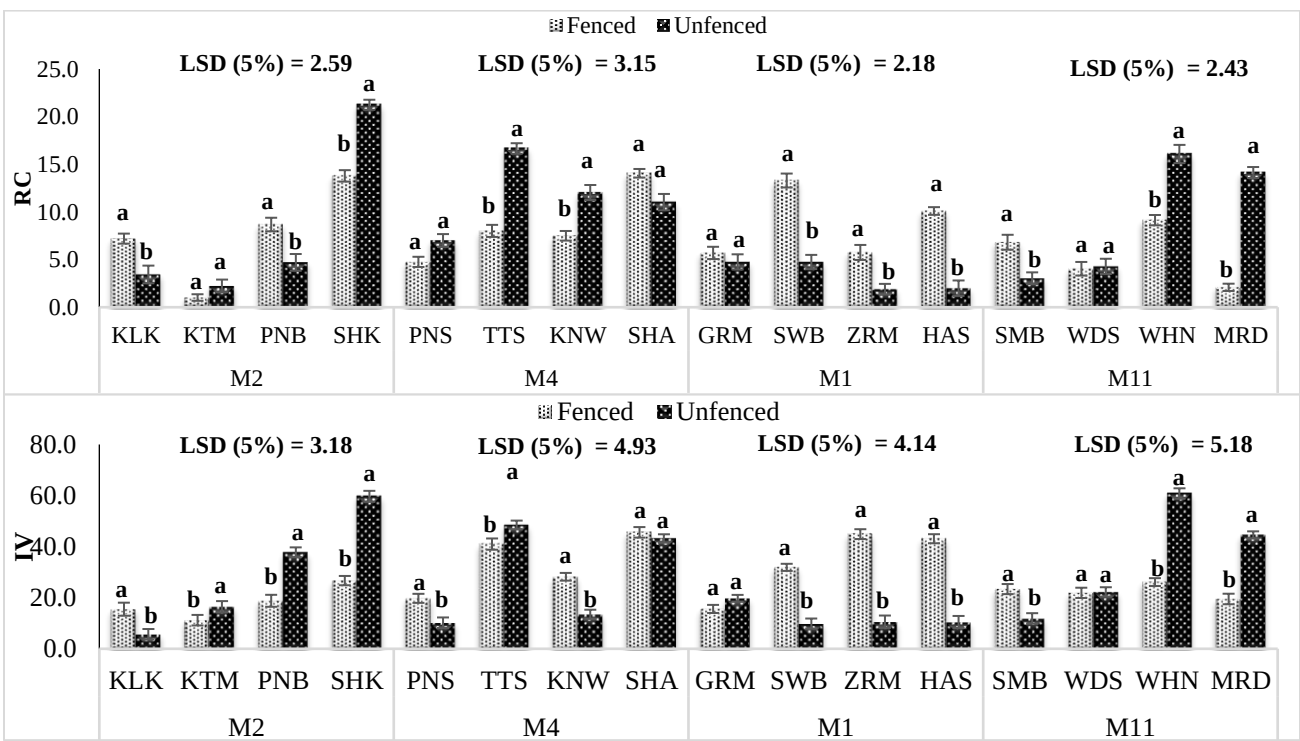

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Fig. 5. Relative cover (RC) and importance value IV) of *Cenchrus ciliaris* growing at fenced and unfenced areas along different Motorways.

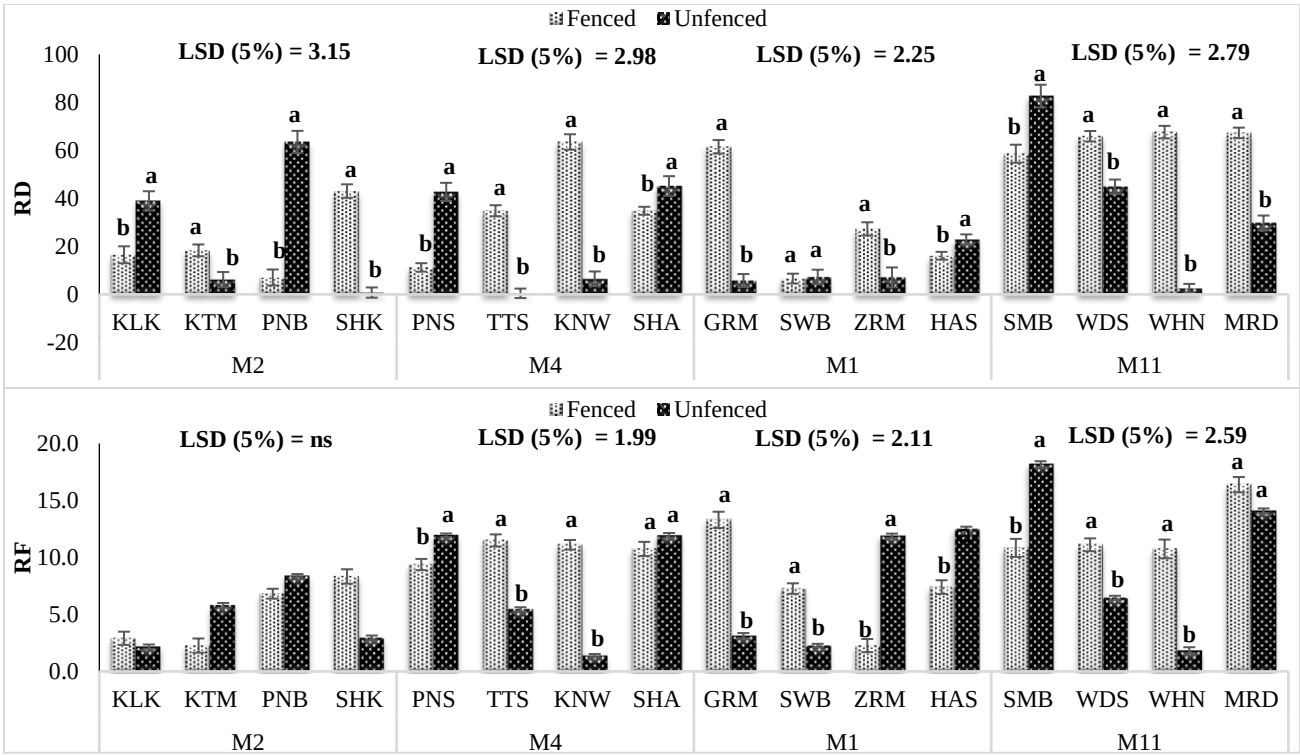

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Fig. 6. Relative density (RD) and relative frequency (RF) of *Cynodon dactylon* growing at fenced and unfenced areas along different Motorways.

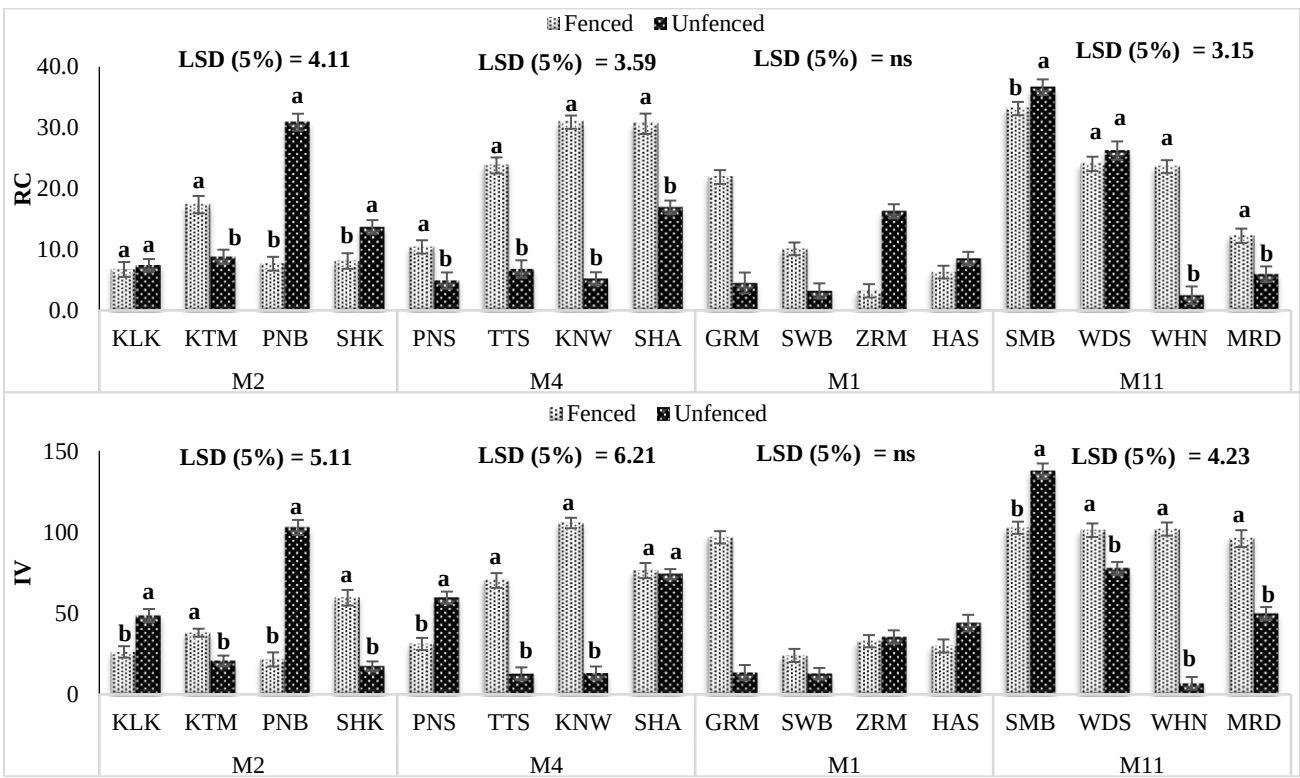

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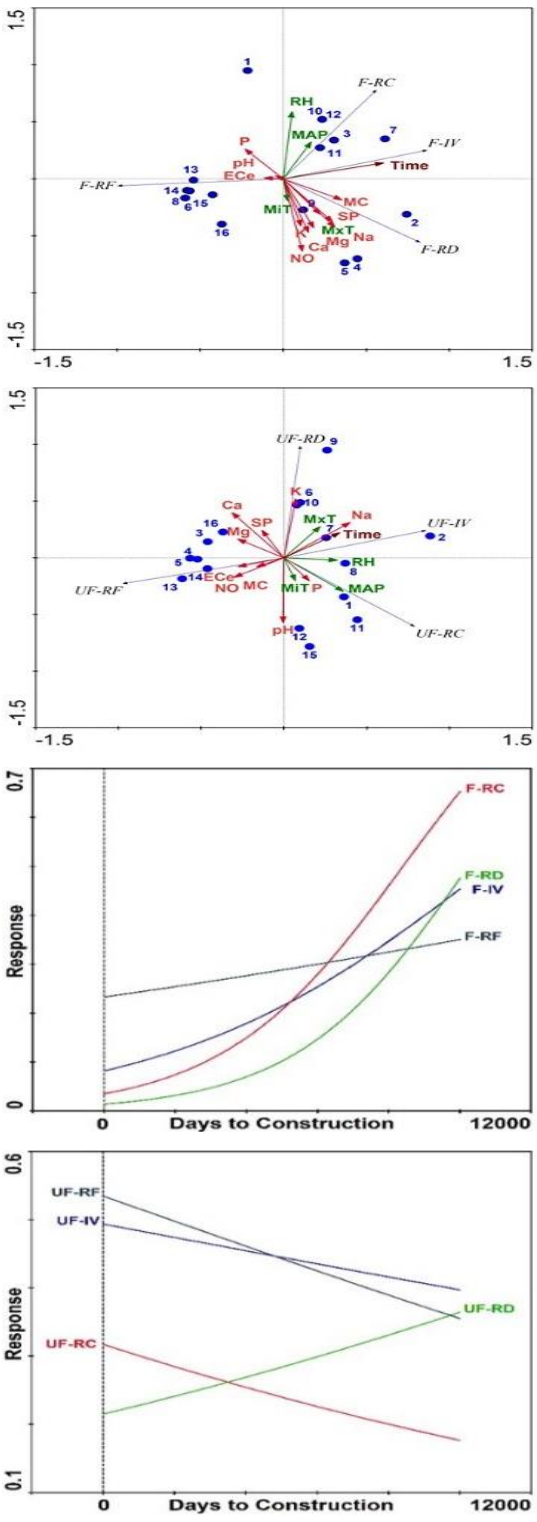
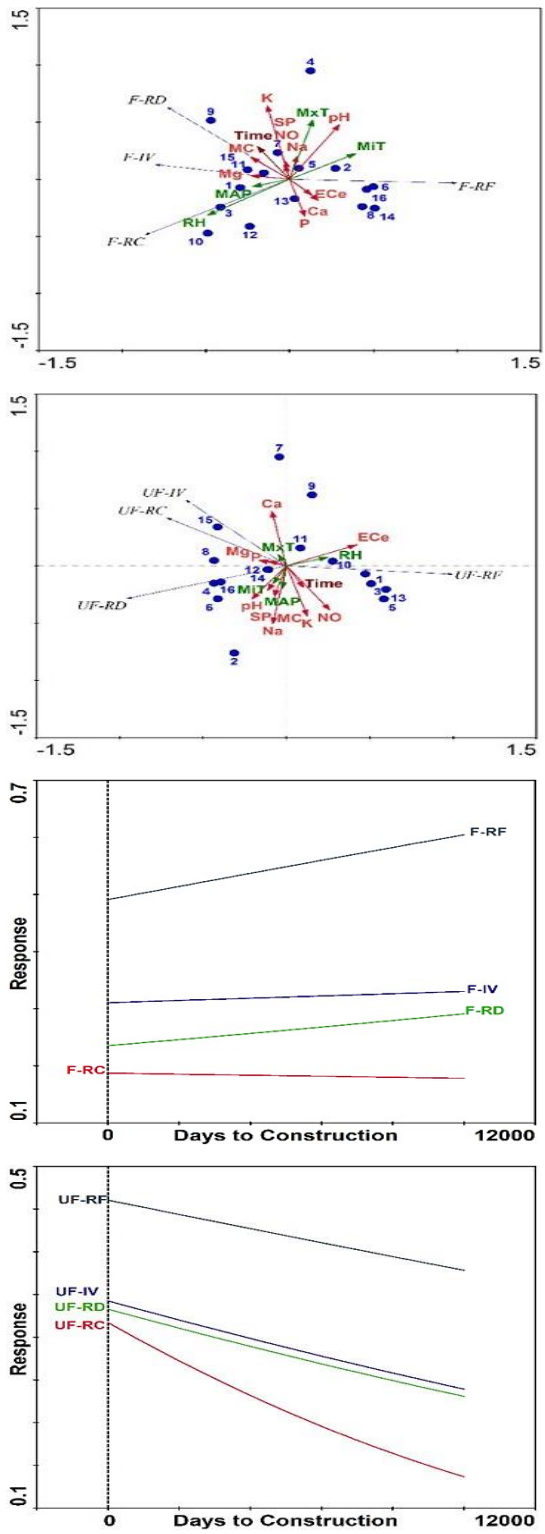
Fig. 7. Relative cover (RC) and importance value (IV) of *Cynodon dactylon* growing at fenced and unfenced areas along different Motorways.



Sites numbers: 1=KLK, 2=KTM, 3=PNB, 4=SHK, 5=PNS, 6=TTS, 7=KNW, 8=SHA, 9=GRM, 10=SWB, 11=ZRM, 12=HAS, 13=SMB, 14=WDS, 15=WHN, 16=MRD.
Site abbreviations: KLK: Kallar Kahar, KTM: Kot Moman, PNB: Pindi Bhattian, SHK: Sheikupura, PNS: Painsra, TTS: Toba Tek Singh, KNW: Khanewal, SHA: Shujabad, GRM: Garhi Momin, SWB: Swabi, ZRM: Zara Miana, HAS: Hassan Abdal, SMB: Sambrial, WDS: Wadala Sandhuan, WHN: Wahndo, MRD: Muridky.
Fencing type: F= Fenced, UF = Unfenced
Ecological data: RD= Relative density, RF= Relative frequency, RC= Relative cover, IV= Importance value
Soil traits: MC= Moisture content, SP= Saturation percentage, P= Phosphorous, NO= NO^{3-}, Na, K, Ca, Mg
Environmental attributes: MxT= Maximum temperature, MiT= Minimum temperature, RH= Relative humidity, MAP= Maximum air precipitation

Fig. 8. RDA tri-plot plotted (against physico-chemical attributes of soil and environmental attributes) and response curves (plotted against time of habitat fragmentation) for ecological data of *Calotropis procera* along different Motorways.



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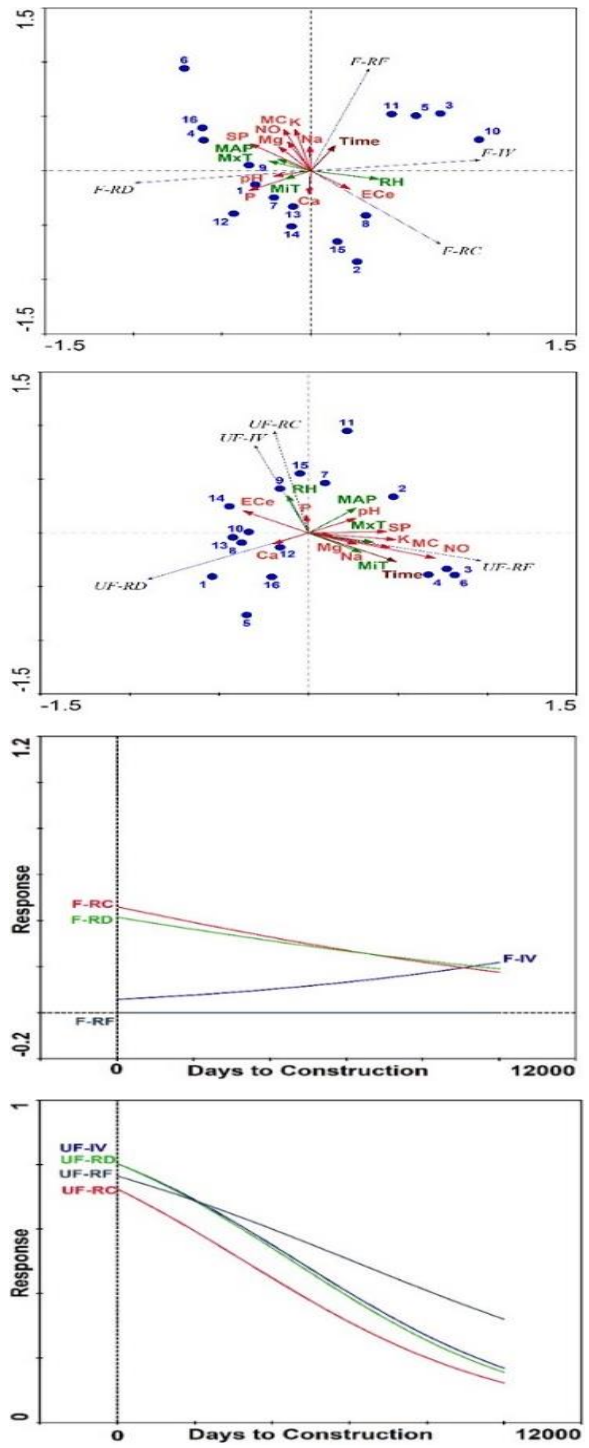
Fencing type: F= Fenced, UF= Unfenced
Ecological data: RD= Relative density, RF= Relative frequency, RC= Relative cover, IV= Importance value
Soil traits: MC= Moisture content, SP= Saturation percentage, P= Phosphorous, NO= NO^{3-}, Na, K, Ca, Mg
Environmental attributes: MxT= Maximum temperature, MiT= Minimum temperature, RH= Relative humidity, MAP= Maximum air precipitation

Fig. 9. RDA tri-plot plotted (against physico-chemical attributes of soil and environmental attributes) and response curves (plotted against time of habitat fragmentation) for ecological data of *Cenchrus ciliaris* along different Motorways.



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Fencing type: F= Fenced, UF = Unfenced
Ecological data: RD= Relative density, RF= Relative frequency, RC= Relative cover, IV= Importance value
Soil traits: MC= Moisture content, SP= Saturation percentage, P= Phosphorous, NO= NO^{3-}, Na, K, Ca, Mg
Environmental attributes: MxT= Maximum temperature, MiT= Minimum temperature, RH= Relative humidity, MAP= Maximum air precipitation

Fig. 10. RDA tri-plot plotted (against physico-chemical attributes of soil and environmental attributes) and response curves (plotted against time of habitat fragmentation) for ecological data of *Cynodon dactylon* along different Motorways.

The relative frequency (RF) of *C. ciliaris* was not influenced by any soil parameter of fenced areas of TTS (M4) and MRD (M11) sites (Fig. 9). The relative density (RD) was affected by moisture content (MC) and also by time of habitat fragmentation of fenced areas of habitat GRM along M1. The importance value (IV) was strongly linked with Mg content of rhizospheric soil in fenced areas of ZRM and WHN sites along M1 and M11, respectively. Relative humidity and maximum air precipitation of fenced areas of PNB and KLK along M2 were significantly associated with relative cover of this grass species. The plants grown on unfenced areas of all ecotypes were not closely linked with time of fragmentation, environmental and soil parameters except soil Mg and P which showed the association with relative cover on habitat WHN along M11. The response curves related the relative frequency showed the positive slope, relative density and importance cover showed almost linear slop whereas relative density showed negative slop against time to fragmentation of fenced areas of motorways. The ecological traits of plants grown on unfenced areas showed negative slopes against time to fragmentation.

The relative cover (RC) of *C. dactylon* grown on fenced areas was linked with ECe of SHA site along M4 and the importance value (IV) was influenced by relative humidity of fenced area at SWB site along M1 (Fig. 10). The relative frequency (RF) was affected by time to fragmentation but was not specific to any habitat. The pH of rhizospheric soil of KLK and GRM sites along M2 and M1 was closely influenced the relative density (RD) of *C. dactylon*. The relative frequency (RF) was affected by environmental and soil traits (Na, K, Mg, NO, MC), and time to fragmentation of unfenced areas of PNB and SHK sites at M2, and TTS site at M4 habitats. The RC and IV were linked with soil phosphorus and relative humidity of unfenced areas of GRM (M1) and WHN (M11) habitats. Soil Ca of SHA (M4) and HAS (M1) habitats affect the RD of this grass species. The response curve plotted against time of fragmentation for ecological distribution of plants grown on fenced areas indicated that importance value showed positive slopes for relative density and cover negative slopes. The ecological parameters measured on unfenced areas showed the negative slopes against time to fragmentation.

Discussion

The ecological analysis showed that population of *C. procera* grew abundantly in unfenced areas of newly constructed Motorways M1 and M11. The unfenced areas of recently fragmented M11 showed dominance of this species. Similar to our work Delnevo *et al*., (2021) also recorded the high density of *C. procera* in fenced areas of old fragmented motorways. The maximum seed dispersal rate and soil condition of old fragmented patches are the reasons behind the dominance of this species (Liu *et al*., 2019). The silky pappus nature of the seed and disperse by wind favors the growth of this species over hundred meters (Francis, 2003) and invade in newly habitats (Sobrinho *et al*., 2013). Light and moisture content are the major environmental variables showing a significant effect on

species distribution on old and newly fragmented habitats. High light intensity and less moisture significantly increase the seed germination and dispersal of plant species in newly fragmented M11 casing establishment of seedlings that are not at maturity stage yet.

The vigorously growing weedy grass *C. ciliaris* acts a pasture plant in dry areas and grows well under stress conditions (Friedel *et al*., 2006). The seeds are widely distributed over long distances through wind, water and animal (Fensham *et al*., 2013). The unfenced areas of M11 under study showed high invasion of this grass (Wright *et al*., 2021), indicating that newly fragmented habitats have favorable environmental conditions for the high infestation of this species. However, the unfenced areas of M1 and M4 had low invasion this species due to high gazing pressure (Formiga *et al*., 2012).

The environmental conditions of fragmented habitats considerably affect the distribution and growth rate of *C. dactylon*. The self-dispersal rate on barren areas significantly affects the growth of this grass species. The colonization of this species was greatly reduced by the competition with other plants for light and other resources (Guglielmini & Satorre, 2004). In current study, the environmental conditions of unfenced areas of newly fragmented patches of M11 were unfavorable for the invasion of this weed. Moreover, the fenced areas of newly fragment patches provided suitable conditions for the establishment of this species due to less competition with other plants due to limitation of their seed dispersers in fenced areas (Liu *et al*., 2019). The old fragmented M1, M2, and M4 showed less invasion of *C. dactylon* due to establishment of tress and shrubby plants which reduce the light penetration (Guglielmini & Satorre, 2004). The heavy grazing and disturbances seemed to be the main causes of less infestation in unfenced areas (Mayengo *et al*., 2020).

Conclusion

Environmental conditions affect the plant species composition and distribution in several ways by changing the structure and function of ecosystem. The old fragmented motorways (M2 and M4) had stable environmental and soil conditions which ensured high infestation of selected plant species. The plants grown in fenced areas of these motorways do not face grazing pressure and other disturbances. Whereas, in unfenced areas, anthropogenic activities and high grazing pressure adversely affected growth of both forage grasses. Low plant diversity was observed in newly and recent fragmented motorways M1 and M11. Environmental stresses and poor conditions of disturbed soil retard the growth and establishment of plant species. Moreover, *C. procera* grew well on disturbed and degraded habitats and among grasses, *C. ciliaris* showed more tolerance against these stresses as compared to *C. dactylon*.

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Supplementary Table 1. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Garhi Momin site along motorway M1.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Acacia modesta Wall.	Fab	0.2	-	5.1	-	0.3	-	5.5	-
Acrachne racemose (B. Heyne ex Roth) Ohwi	Poa	-	1.3	-	3.1	-	0.8	-	5.0
Aristida adscensionis L.	Poa	0.4	6.5	1.7	4.5	0.1	3.8	2.2	15.3
Atylosia mollis Benth.	Pap	0.2	-	1.7	-	0.1	-	2	-
Calotropis procera (Aiton) W.T. Aiton	Apo	5.3	9.4	6.7	6.3	2.9	3.1	14.9	18.8
Capparis decidua (Forssk.) Edgew.	Cap	-	0.3	-	1.6	-	1.2	-	3.4
Cenchrus pennisetiformis Hochst. & Steud.	Poa	-	3.5	-	7.8	-	4.7	-	16.6
Cenchrus ciliaris L.	Poa	8.2	5.6	1.7	9.4	5.7	4.8	15.6	19.8
Cymbopogon jwarancusa (Jones) Schult., Mant.	Poa	-	4.6	-	3.1	-	7.8	-	15.9
Cynodon dactylon (L.) Pers.	Poa	61.5	5.8	13.3	3.1	21.9	4.5	96.7	13.3
Datura stramonium L. (DS)	Sol	1	-	4	-	1	-	6	-
Dichanthium annulatum (Forssk.) Stapf.	Poa	4.9	-	8.3	-	2.1	-	15.3	-
Dichanthium foveolatum (Delile) Roberty	Poa	-	2.9	-	3.1	-	4.5	-	10.3
Dicliptera bupleuroides Nee	Poa	0.4	-	1.7	-	0.2	-	2.3	-
Digitaria sanguinalis (L.) Scop.	Poa	-	4.2	-	3.1	-	2.7	-	9.9
Dodonaea viscosa (L.) Jacq.	Sap	2.1	0.8	15	1.6	32.6	1.9	49.7	4.5
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	Poa	5.3	1.1	6.7	2.2	2.9	8.6	14.9	11.6
Hordeum murinum L.	Poa	-	32.8	-	18.7	-	11.5	-	56.4
Imperata cylindrica (L.) Raeuschel	Poa	2.5	-	1.7	-	4.8	-	9	-
Justicia adhatoda L.	Aca	1.6	2.2	5.7	4.9	2.1	5.4	9.4	12.9
Lantana camara L.	Ver	0.6	-	3.3	-	2.4	-	6.3	-
Lespedeza floribunda Bunge	Fab	0.4	2.6	1.7	2.1	0.1	3.9	2.2	7.9
Maytenus royleana (Wall. ex M. A. Lawson) Cufod.	Cel	0.4	-	2.8	-	0.5	-	3.7	-
Ochthochloa compressa (Forssk.) Hilu	Poa	-	2.4	-	3.1	-	6.7	-	12.2
Polygala erioptera DC. Prod.	Pol	0.2	-	1.7	-	0.1	-	2	-
Prosopis cineraria (L.) Druce	Fab.	-	2.3	-	10.9	-	13.5	-	26.5
Prosopis juliflora (Sw.) DC.	Fab	2.1	5.5	10.4	3.5	12.4	8.6	24.9	17.6
Rhynchelytrum repens (Willd.) C.E. Hubb.	Poa	-	1.0	-	1.6	-	1.9	-	3.8
Saccharum bengalense Retz.	Poa	-	3.7	-	2.2	-	2.1	-	8.5
Salicornia brachiate Roxb.	Ama	-	2.2	-	4.7	-	0.2	-	7.7
Sporobolus arabicus Boiss., Diagn.	Poa	2.1	-	3.7	-	7.6	-	13.4	-
Xanthium strumarium L.	Ast	0.7	-	1.7	-	0.5	-	2.9	-
Ziziphus nummularia (Burm. f.) Wight & Arn.	Rha	0.1	-	1.7	-	0.2	-	2	-

Families (Fam): Aca = Acanthaceae; Ama = Amaranthaceae; Apo = Apocynaceae; Ast = Asteraceae; Cap = Capparidaceae; Cel = Celastraceae; Fab = Fabaceae; Poa = Papilionaceae; Pol = Polygalaceae; Rha = Rhamnaceae; Sap = Sapindaceae; Sol = Solanaceae; Ver = Verbenaceae

Supplementary Table 2. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Swabi site along motorway M1.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon fruticose Guill. & Perr.	Mal	1.0	0.1	2.7	2.3	0.9	0.2	4.7	2.6
Acacia modesta Wall	Mim	1.5	1.6	3.4	9.1	14.3	5.5	19.1	16.2
Acrachne racemose (B. Heyne ex Roth) Ohwi	Poa	0.1	0.1	0.9	1.1	0	0.1	1	1.3
Aerva javanica (Burm. fil.) Schult.	Poa	0.5	-	1.8	-	0.4	-	2.8	-
Aristida adscensionis L.	Poa	0.3	-	0.9	-	0.1	-	1.3	-
Asparagus adscendens Roxb.	Asp	0.1	-	0.9	-	0	-	1	-
Astragalus psilocentros Fisch.	Pap	0.2	-	1.8	-	0.3	-	2.3	-
Calotropis procera (Aiton) W.T. Aiton	Apo	4.1	4.5	5.5	5.7	5.1	2.5	14.6	12.7
Capparis decidua (Forssk.) Edgew.	Cap	-	1.2	-	2.3	-	0.6	-	4
Cenchrus ciliaris L.	Poa	11.3	1.7	7.3	3.4	13.3	4.8	31.9	9.9
Cenchrus pennisetiformis Hochst. & Steud.	Poa	-	1.7	-	3.4	-	0.8	-	5.8
Chrysopogon serrulatus Trin.	Poa	21.3	27.3	5.3	6.8	14.2	29	40.8	63.1
Cymbopogon jwarancusa (Jones) Schult.	Poa	3.7	0.1	4.4	1.1	1.7	0.1	9.8	1.4
Cynodon dactylon (L.) Pers.	Poa	6.9	7.3	7.3	2.3	10.1	3.2	24	12.8
Cynoglossum lanceolatum Forssk.	Poa	0.8	-	2.7	-	0.4	-	3.9	-
Cyperus niveus Retz.	Cyp	1.9	0.4	0.9	1.1	0.5	0.1	3.2	1.6
Dactyloctenium scindicum Boiss.	Poa	4.2	10.3	1.5	4.6	0.9	7.7	6.6	20.4
Desmostachya bipinnata (L.) Stapf	Poa	2.4	4	1.8	4.6	1.8	3.2	6	11.7
Dichanthium annulatum (Forssk.) Stapf	Poa	-	0.2	-	1.1	-	0.1	-	1.4
Dichanthium foveolatum (Delile) Roberty	Poa	1	5.9	1.6	4.6	0.3	3.1	2.9	13.6
Dicliptera bupleuroides Nees	Poa	3.5	-	0.9	-	6.3	-	10.7	-
Digitaria sanguinalis (L.) Scop.	Poa	9.1	0.6	7.3	2.3	4.6	0.3	21	3.2
Dodonaea viscosa (L.) Jacq.	Sap	0.1	10.8	0.9	5.7	0	17.3	1	33.8
Echinochloa colona (L.) Link	Poa	-	0.1	-	1.1	-	0.1	-	1.3
Eragrostis cilianensis (All.) Vign. ex Janchen	Poa	-	0.1	-	1.1	-	0.1	-	1.3
Eragrostis minor Host	Poa	-	0.2	-	1.1	-	0.1	-	1.4
Eragrostis pilosa (L.) P. Beauv.	Poa	0.5	-	1.8	-	0.2	-	2.5	-
Evolvulus alsinoides (L.)	Con.	-	0.2	-	1.1	-	0.1	-	1.4
Fagonia indica Burm.f.	Zyg	-	0.1	-	1.1	-	0.1	-	1.3
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	Poa	2.3	0.3	7.3	2.3	10.1	3.9	19.7	6.5
Ipomoea carnea Jacq.	Con	-	0.1	-	1.1	-	0.1	-	1.3
Lantana camara L.	Ver	1.6	0.1	5.4	1.1	1.5	0.1	7.9	1.3
Lantana indica Roxb.	Ver	-	0.3	-	2.3	-	0.3	-	2.9
Lespedeza juncea (L.) Pers.	Fab	-	4.5	-	5.7	-	2.5	-	12.6
Lotus corniculatus L.	Fab	0.2	-	0.9	-	0	-	1	-
Malvastrum coromandelianum (L.) Garcke	Mal	0.5	-	1.8	-	0.2	-	2.6	-
Maytenus royleana (Wall. ex M. A. Lawson) Cufod.	Cal	2.7	0.1	1.6	1.1	2.4	0.2	6.7	1.5
Nerium oleander L.	Apo	-	0.1	-	1.1	-	0.1	-	1.3
Olea ferruginea Royle	Ole	0.4	3.1	1.8	2.3	0.9	1.6	3.1	7
Opuntia monacantha (Willd.) Haw.	Cac	4	2.1	2.5	2.5	2.1	4.5	8.6	9.1
Panicum atrosanguineum Hochst. ex A. Rich.	Poa	0.1	-	0.9	-	0.7	-	1.7	-
Panicum miliaceum L.	Poa	0.1	-	0.9	-	0	-	1	-
Periploca aphylla Decne.	Apo	0.2	-	0.8	-	0.1	-	1.1	-
Phragmites karka (Retz.) Trin. ex Steud.	Poa	-	0.1	-	1.1	-	0.1	-	1.3
Polygala arvensis Willd.	Poly	0.1	-	0.9	-	0	-	1	-
Polygala erioptera DC.	Poly	0.1	-	0.9	-	0	-	1	-
Prosopis juliflora (Sw.) DC.	Fab	-	0.4	-	2.1	-	1.1	-	3.7
Pupalia lappacea (L.) Juss.	Ama	6.3	-	1.2	-	2.5	-	10	-
Rhamnus pentapomica R. Parker	Rha	0.2	0.1	0.9	1.1	0.1	0.1	1.2	1.4
Rhynchelytrum repens (Willd.) C.E. Hubb.	Poa	1.4	-	0.9	-	0.9	-	3.2	-
Rhynchosia capitata (Heyne ex Roth) DC.	Fab	0.1	-	0.9	-	0.2	-	1.2	-
Saccharum bengalense L.	Poa	-	0.3	-	2.3	-	0.8	-	3.3
Salicornia brachiate Roxb.	Ama	0.1	-	0.9	-	0.5	-	1.5	-
Sporobolus ioclados (Nees ex Trin.) Nees	Poa	5.4	10.2	2.5	6.8	1.6	7.1	9.5	24.1
Stipagrostis hirtigluma (Steud. ex Trin. & Rupr.) De	Poa	0.1	-	0.9	-	0	-	1	-
Tragus roxburghii Panigrahi	Poa	0.1	-	0.9	-	0	-	1	-
Vernonia cinerascens Sch. Bip.	Ast	2.2	-	1.8	-	0.5	-	4.6	-

Families (Fam): Ama = Amaranthaceae; Apo = Apocynaceae Asp = Asparagaceae; Ast = Asteraceae; Cac = Cactaceae; Cal = Celastraceae; Cap = Capparidaceae; Con = Convolvulaceae; Cyp = Cyperaceae; Fab = Fabaceae; Mal = Malvaceae; Min = Mimosaceae; Ole = Oleaceae; Pap = Papilionaceae; Poa = Poaceae

Supplementary Table 3. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Zara Miana site along motorway M1.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Acacia modesta Wall	Fab	1.6	-	9.1	-	5.5	-	16.2	-
Acacia nilotica (L.) Delile	Fab	-	2.2	-	7.1	-	8.6	-	17.9
Aristida mutabilis Trin. & Rupr.	Poa	-	3.9	-	4.8	-	1.2	-	9.9
Calotropis procera (Aiton) W.T. Aiton	Apo	2.3	2.2	2.3	7.1	4.2	8.6	8.8	17.9
Cannabis sativa L.	Can	-	4.1	-	2.9	-	11.3	-	18.3
Capparis decidua (Forssk.) Edgew.	Poa	1.2	-	2.3	-	0.6	-	4	-
Cenchrus ciliaris L.	Poa	25.7	3.9	13.4	4.8	5.8	1.9	44.9	10.6
Chrysopogon serrulatus Trin.	Poa	7.7	-	13.8	-	29	-	5.5	-
Cynodon dactylon (L.) Pers.	Poa	27.3	7.1	2.3	11.9	3.2	16.3	32.8	35.3
Cyperus niveus Retz.	Cyp	0.4	-	1.1	-	0.1	-	1.6	-
Dactyloctenium scindicum Boiss.	Poa	4.5	0.8	3.4	2.4	7.5	0.4	15.4	3.6
Desmostachya bipinnata (L.) Stapf	Poa	4	-	4.6	-	3.2	-	11.7	-
Dichanthium annulatum (Forssk.) Stapf	Poa	-	3.7	-	4.8	-	3.8	-	12.3
Dichanthium foveolatum (Delile) Roberty	Poa	2.9	1.5	4.6	2.4	3.1	0.2	1.6	4.1
Dicliptera bupleuroides Nees	Poa	-	3.9	-	2.1	-	1.5	-	7.5
Digitaria sanguinalis (L.) Scop.	Poa	0.6	-	2.3	-	0.3	-	3.2	-
Dodonaea viscosa (L.) Jacq.	Sap	3.8	4.3	5.7	4.8	15.3	5.2	24.8	14.3
Eulaliopsis binata (Retz.) C.E. Hubb.	Poa	-	46	-	11.9	-	18.4	-	76.3
Grewia tenax (Forssk.) Fiori	Mal	-	4.6	-	2.4	-	11.6	-	18.6
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	Poa	1.4	-	2.3	-	5.9	-	9.6	-
Ipomoea carnea Jacq.	Con	-	0.2	-	2.4	-	0.2	-	2.8
Lantana camara L.	Ver	-	1.5	-	7.1	-	5.8	-	14.4
Lantana indica Roxb.	Ver	0.3	-	2.3	-	0.3	-	2.9	-
Lespedeza juncea (L. f.) Pers	Fab	4.5	-	5.7	-	2.5	-	12.6	-
Maytenus royleana (Wall. ex M. A. Lawson) Cufod.	Cel	-	0.9	-	4.8	-	0.6	-	6.3
Ochthochloa compressa (Forssk.) Hilu	Poa	-	0.3	-	2.4	-	1	-	3.7
Olea ferruginea Royle	Ole	3.1	-	5.3	-	1.6	-	1.0	-
Opuntia monacantha (Willd.) Haw.	Cac	2.1	-	4.6	-	2.5	-	9.1	-
Oxalis corniculata L.	Oxa	-	1.5	-	2.4	-	0.4	-	4.3
Prosopis glandulosa Torr.	Fab	0.4	-	3.4	-	2.6	-	6.4	-
Saccharum bengalense L.	Poa	1.3	-	2.3	-	1.8	-	5.3	-
Saccharum spontaneum L.	Poa	1.5	-	3.4	-	2.7	-	7.5	-
Setaria glauca (L.) P. Beauv.	Poa	-	4.6	-	2.4	-	1.9	-	8.9
Sida cordata (Burm. fil.) Borss. Waalk.	Mal	-	1.2	-	2.4	-	0.2	-	3.8
Sporobolus ioclados (Nees ex Trin.) Nees	Poa	3.6	-	6.8	-	2.6	-	13	-
Verbascum thapsus L.	Scr	-	0.2	-	2.4	-	0.4	-	3
Vernonia cinerascens Sch. Bip.	Ast	-	0.8	-	2.4	-	0.2	-	3.4
Ziziphus nummularia (Burm. f.) Wight & Arn.	Rha	-	0.6	-	2.4	-	1	-	4

Families (Fam): Apo = Apocynaceae; Ast = Asteraceae; Cac = Cactaceae; Can = Cannabaceae; Cel = Celasteraceae; Con = Convolvulaceae; Cyp = Cyperaceae; Feb = Fabaceae; Mal = Malvaceae; Ole = Oleaceae; Oxa = Oxalidaceae; Poa = Poaceae; Rha = Rhamnaceae; Spa = Sapindaceae; Scr = Scrophulariaceae; Ver = Verbenaceae

Supplementary Table 4. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Hassan Abdal site along motorway M1.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon fruticosa Guill. & Perr.	Mal	1.0	-	2.7	-	0.9	-	4.7	-
Acacia modesta Wall	Mim	1.5	0.3	6.4	3.6	14.3	0.7	22.1	4.6
Aerva javanica (Burm. fil.) Schult.	Poa	0.6	-	1.8	-	0.4	-	2.8	-
Aristida adscensionis L.	Poa	0.3	-	0.9	-	0.1	-	1.3	-
Astragalus psilocentros Fisch.	Fab	0.2	-	1.8	-	0.3	-	2.3	-
Bidens pilosa L.	Poa	0.4	-	1.8	-	0.2	-	2.4	-
Brachiaria eruciformis (Sm.) Griseb.	Poa	-	7.9	-	8.9	-	8.6	-	25.4
Calotropis procera (Aiton) W.T. Aiton	Apo	4.0	5.2	5.5	1.8	5.1	1.3	14.6	8.3
Cenchrus ciliaris L.	Poa	21.6	4.9	11.3	3.6	10.1	2.0	43.0	10.5
Chrysopogon serrulatus Trin.	Poa	5.6	13.1	3.2	1.8	14.3	3.3	23.1	18.2
Cymbopogon jwarancusa (Jones) Schult	Poa	3.8	-	4.4	-	1.7	-	9.8	-
Cynodon dactylon (L.) Pers.	Poa	16.1	22.9	7.4	12.5	6.3	8.5	29.8	43.9
Cynoglossum lanceolatum Forssk.	Poa	0.8	-	2.7	-	0.4	-	3.9	-
Cyperus niveus Retz.	Cyp	1.8	-	0.9	-	0.5	-	3.2	-
Dactyloctenium scindicum Boiss.	Poa	4.2	-	2.7	-	0.9	-	7.9	-
Desmostachya bipinnata (L.) Stapf	Poa	2.4	-	1.8	-	1.8	-	6.0	-
Dichanthium annulatum (Forssk.) Stapf	Poa	-	8.2	-	12.5	-	12.5	-	33.2
Dichanthium foveolatum (Delile) Roberty	Poa	1.0	-	3.6	-	0.3	-	4.9	-
Dicliptera bupleuroides Nees	Poa	1.4	0.2	0.9	1.8	5.5	1.3	7.8	3.3
Digitaria ciliaris (Retz.) Koeler	Poa	-	4.9	-	3.6	-	2.0	-	10.5
Digitaria sanguinalis (L.) Scop.	Poa	8.5	-	7.3	-	8.1	-	23.9	-
Dodonaea viscosa (L.) Jacq.	Sap	-	1.8	-	5.4	-	2.0	-	9.2
Eragrostis pilosa (L.) P. Beauv.	Poa	0.5	-	1.8	-	0.2	-	2.5	-
Eucalyptus camaldulensis Dehnh.		-	0.8	-	1.8	-	0.1	-	2.7
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	Poa	1.4	0.2	0.9	1.8	5.5	1.3	7.8	3.3
Hordeum murinum L.	Poa	3.8	-	1.4	-	1.5	-	6.7	-
Justicia adhatoda L.	Aca	-	18.3	-	12.4	-	49.5	-	80.2
Launaea procumbens (Roxb.) Amin	Ast	-	2.5	-	3.6	-	0.9	-	7.0
Malvastrum coromandelianum (L.) Garcke	Mal	0.6	0.3	1.8	1.8	0.2	0.1	2.6	2.2
Maytenus royleana (Wall. ex M. A. Lawson) Cufod.	Cel	0.7	1.0	4.6	3.6	1.4	3.0	6.7	7.6
Olea ferruginea Royle	Ole	0.4	-	1.8	-	0.9	-	3.1	-
Opuntia monacantha (Willd.) Haw.	Cac	4.0	-	5.5	-	5.1	-	14.6	-
Oxalis corniculata L.	Oxa	-	1.0	-	3.6	-	0.3	-	4.9
Panicum atrosanguineum Hochst. ex A. Rich.	Poa	0.1	-	0.9	-	0.7	-	1.7	-
Periploca aphylla Decne.	Apo	-	1.5	-	3.6	-	0.9	-	6.0
Phoenix dactylifera L.	Are	-	1.3	-	1.8	-	1.3	-	4.4
Prosopis juliflora (Sw.) DC.	Fab	-	0.8	-	2.8	-	0.1	-	3.7
Pupalia lappacea (L.) Juss.	Ama	2.3	-	3.6	-	5.8	-	11.8	-
Rhynchelytrum repens (Willd.) C.E. Hubb.	Poa	1.4	-	0.9	-	0.9	-	3.2	-
Saccharum bengalense L.	Poa	-	1.6	-	2.5	-	0.3	-	4.4
Sida cordata (Burm. fil.) Borss. Waalk.	Mal	-	0.2	-	1.8	-	0.7	-	2.7
Sporobolus ioclados (Nees ex Trin.) Nees	Poa	3.4	-	4.6	-	1.6	-	9.6	-
Suaeda fruticosa (L.) Forssk.	Ama	0.1	-	0.9	-	0.5	-	1.5	-
Vernonia cinerascens Sch.Bip.	Ast	1.9	-	1.8	-	0.5	-	4.3	-
Ziziphus mauritiana Lam.	Rha	-	0.2	-	1.8	-	1.0	-	3.0
Ziziphus nummularia (Burm. f.) Wight & Arn.	Rha	-	0.8	-	1.8	-	0.1	-	2.7

Families (Fam): Aca = Acanthaceae; Ama = Amaranthaceae; Apo = Apocynaceae; Are = Araceae; Ast = Asteraceae; Cac = Cactaceae; Cel = Celastraceae; Cyp = Cyperaceae; Fab = Fabaceae; Mal = Malvaceae; Mim = Mimosaceae; Ole = Oleaceae; Oxa = Oxalidaceae; Poa = Poaceae; Rha = Rhamnaceae; Sap = Sapindaceae

Supplementary Table 5. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Kallar Kahar site along motorway M2.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon muticum (Delile) Webb	Mal	0.1	0.4	1	3.3	0.1	0.3	1.1	3.9
Acacia modesta Wall.	Fab	1.2	1.8	6.8	9.8	12.2	29.6	20.2	41.2
Acacia nilotica (L.) Delile	Fab	0.1	-	1	-	0.1	-	1.2	-
Aerva javanica (Burm. fil.) Schult.	Poa	0.4	0.1	1.9	1.1	0.7	0	3	1.2
Aristida adscensionis L.	Poa	0.6	0.4	1	1.1	0.2	0.4	1.8	1.9
Aristida mutabilis Trin. & Rupr	Poa	2.5	-	2.9	-	8.7	-	14.1	-
Bidens pilosa L.	Ast	-	0.2	-	1.1	-	0	-	1.3
Boerhavia procumbens Banks ex Roxb.	Poa	0.1	-	1	-	0.1	-	1.1	-
Brachiaria reptans (L.) C.A. Gardner & C.E. Hubb.	Poa	0.3	-	1	-	0.1	-	1.4	-
Butea monosperma (Lam.) Taub.	Fab	0.2	-	1.9	-	3	-	5.2	-
Buxus papillosa C.K. Schneid.	Bux	-	0.1	-	1.1	-	0	-	1.2
Calotropis procera (Aiton) W.T. Aiton	Apo	3.1	1.8	1	4.4	4.6	2.4	8.7	8.6
Capparis decidua (Forssk.) Edgew.	Cap	0.1	0.1	1	1.1	0.1	0.4	1.2	1.6
Capparis spinosa L.	Cap	0.6	-	1.9	-	0.2	-	2.8	-
Cenchrus ciliaris L.	Poa	6.4	-	1.9	-	7.2	-	15.5	-
Cenchrus pennisetiformis Hochst. & Steud.	Poa	0.2	0.2	4.9	2.2	0.1	0.1	5.2	2.5
Cenchrus ciliaris L.	Poa	-	2.9	-	4.4	-	3.4	-	10.7
Chrysopogon serrulatus Trin.	Poa	6.4	5.1	4.9	5.4	7.2	7.4	18.5	18
Cymbopogon jwarancusa (Jones) Schult.	Poa	9	12.9	3.9	4.4	7.2	15.7	20.2	32.9
Cynodon dactylon (L.) Pers.	Poa	16.5	39	2.9	2.2	6.7	7.4	26.1	48.5
Cyperus niveus Retz.	Poa	0.1	1.5	1	1.1	0.1	0.1	1.1	2.7
Dactyloctenium aegyptium (L.) Willd.	Poa	0.1	-	1	-	0.1	-	1.1	-
Dactyloctenium scindicum Boiss.	Poa	13	3.8	3.9	1.1	5.4	0.9	22.2	5.7
Desmostachya bipinnata (L.) Stapf	Poa	0.2	2.3	1	2.2	0.1	1.3	1.2	5.8
Dichanthium foveolatum (Delile) Roberty	Poa	3.6	2.3	1.9	1.1	2.6	0.9	8.1	4.2
Dicliptera bupleuroides Nees	Poa	10.7	-	2.9	-	3	-	16.6	-
Digitaria sanguinalis (L.) Scop.	Poa	4.1	1.5	2.9	1.1	4.8	5.2	11.8	7.8
Dodonaea viscosa (L.) Jacq.	Sap	0.1	1.8	1	4.4	0.1	4.4	1.2	10.5
Eragrostis pilosa (L.) P. Beauv.	Poa	0.3	1.3	1.9	2.2	0.1	0.4	2.4	3.9
Eragrostis tenella (L.) P. Beauv. ex Roem. & Schult.	Poa	0.5	3.8	1	1.1	0.2	0.4	1.2	5.3
Eriophorum comosum (Wall.) Nees	Poa	1	0.4	1	1.1	0.1	0.2	2	1.6
Fagonia indica Burm.f.	Zyg	0.1	-	1	-	0.1	-	1.1	-
Festuca rubra L.	Poa	0.1	0.8	1	3.3	0.1	0.4	1.1	4.5
Indigofera argentea Burm.f.	Leg	0.1	-	1	-	0.1	-	1.1	-
Ipomoea carnea Jacq.	Con	0.1	-	1	-	0.1	-	1.1	-
Justicia adhatoda L.	Aca	0.1	2.9	1	4.4	0.1	4.2	1.1	11.5
Lantana indica Roxb.	Ver	0.1	-	1	-	0.1	-	1.1	-
Lespedeza floribunda Bunge.	Fab	0.3	-	1.9	-	0.1	-	2.4	-
Leucas nutans (Roth) Spreng.	Lam	0.1	0.4	1	1.1	0.1	0	1.1	1.5
Lotus corniculatus L.	Fab	0.1	-	1	-	0.1	-	1.1	-
Malvastrum coromandelianum (L.) Garcke	Mal	0.1	2.8	1	5.4	0.1	1.1	1.1	9.4
Maytenus royleana (Wall. ex M. A. Lawson) Cufod.	Cel	0.2	0.1	1	1.1	0.6	0.1	1.7	1.3
Melhania futteyporensis Munro ex Mast.	Ste	-	0.5	-	2.2	-	0.9	-	3.5
Mukia maderaspatana (L.) M. Roem.	Cuc	-	0.1	-	1.1	-	0.2	-	1.3
Nerium oleander L.	Apo	0.2	-	1	-	1.2	-	2.4	-
Ochthochloa compressa (Forssk.) Hilu	Poa	3	-	2.9	-	2.3	-	8.2	-
Olea ferruginea Royle	Ole	0.1	0.2	1	3.3	0.1	3.2	1.1	6.7
Panicum atrosanguineum Hochst. ex A. Rich.	Poa	0.4	-	1	-	0.1	-	1.4	-
Periploca aphylla Decne.	Apo	0.1	-	1	-	0.1	-	1.1	-
Pupalia lappacea (L.) Juss.	Ama	0.1	0.4	1	1.1	0.1	0.1	1.1	1.6
Saccharum griffithii Munro ex Boiss.	Poa	4.6	1.1	4.9	1.1	7.8	1.5	17.3	3.7
Sida cordifolia L.	Mal	0.1	0.1	1	1.1	0.1	0	1.1	1.2
Solanum incanum L.	Sola	-	0.4	-	3.3	-	0.3	-	4
Solanum surattense Burm. f.	Sola	0.1	-	1	-	0.1	-	1.1	-
Sporobolus arabicus Boiss. Diagn.	Poa	8.2	4.1	1.9	4.4	4.8	1.4	14.9	9.9
Tamarix dioica Roxb. ex Roth	Tam	0.1	-	1	-	0.1	-	1.1	-
Trianthema triquetra Rottler & Willd.	Aiz	0.2	-	1	-	0.1	-	1.2	-
Verbena officinalis L.	Ver	0.1	-	1	-	0.1	-	1.1	-
Vernonia cinerascens Sch. Bip.	Ast	0.1	0.8	1	2.2	0.1	0.1	1.1	3.1
Wattakaka volubilis (L.f.) Stapf	Asc	0.3	-	1.9	-	0.7	-	2.9	-
Ziziphus nummularia (Burm. fil.) Wight & Arn.	Rha	0.1	0.5	1	4.4	0.1	3.5	1.2	8.3

Families (Fam): Aca = Acanthaceae; Aiz = Aizoaceae; Ama = Amaranthaceae; Apo = Apocynaceae; Asc = Asclepiadaceae; Ast = Asteraceae; Bux = Buxaceae; Cap = Capparidaceae; Cel = Celastraceae; Com = Commelinaceae; Con = Convolvulaceae; Cuc = Cucurbitaceae; Eup = Euphorbiaceae; Fab = Fabaceae; Lam = Lamiaceae; Lg = Leguminosae; Mal = Malvaceae; Ole = Oleaceae; Poa = Poaceae; Rha = Rhamnaceae; Sal = Salvadoraceae; Sap = Sapindaceae; Sol = Solanaceae; Ste = Sterculiaceae; Tam = Tamaricaceae; Til = Tiliaceae; Ver = Verbenaceae; Zyg = Zygophyllaceae

Supplementary Table 6. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Kot Moman site along motorway M2.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Acacia modesta Wall.	Fab	0.52	-	3.41	-	4.7	-	8.63	
Acacia nilotica (L.) Delile	Fab	0.23	-	3.41	-	2.45	-	6.09	
Aristida adscensionis L.	Poa	0.23	-	3.41	-	2.45	-	6.09	
Aristida mutabilis Trin. & Rupr.	Poa	0.34	-	5.68	-	1.4	-	7.42	
Boerhavia procumbens Banks ex Roxb.	Nyc	0.11	-	1.14	-	0.05	-	1.3	
Brachiaria reptans (L.) C.A. Gardner & C.E. Hubb.	Poa	1.6	-	4.55	-	1.02	-	7.17	
Calotropis procera (Aiton) W.T. Aiton	Apo	12	3.08	2.3	1.42	7.2	4.16	21.5	8.65
Capparis decidua (Forssk.) Edgew.	Cap	4.01	-	2.27	-	2.55	-	8.83	
Capparis spinosa L.	Cap	0.17	-	2.27	-	0.1	-	2.54	
Cenchrus ciliaris L.	Poa	5.6	10.80	4.6	3.50	1	2.20	11.2	16.50
Cenchrus pennisetiformis Hochst. & Steud.	Poa	4.24	-	2.5	-	1.53	-	8.27	
Chrysopogon serrulatus Trin.	Poa	6.2	13.85	2.27	6.30	2.5	21.57	10.97	41.72
Cymbopogon jwarancusa (Jones) Schult.	Poa	2.46	1.54	3.41	2.70	2.14	0.04	8.01	4.28
Cynodon dactylon (L.) Pers.	Poa	18.3	6.10	2.3	3.50	17.4	8.80	38	18.40
Cyperus niveus Retz.	Cyp	5.73	-	1.14	-	1.53	-	8.4	-
Dactyloctenium aegyptium (L.) Willd.	Poa	0.74	-	1.14	-	0.51	-	2.39	-
Dactyloctenium scindicum Boiss.	Poa	3.2	7.69	2.27	4.78	7.15	6.95	12.62	19.42
Desmostachya bipinnata (L.) Stapf	Poa	4.24	1.54	4.55	0.35	4.39	0.40	13.18	2.29
Dichanthium foveolatum (Delile) Roberty	Poa	2.5	-	4.27	-	17.36	-	23.13	-
Dicliptera bupleuroides Nees	Poa	0.57	6.15	1.14	16.39	0.2	8.79	1.91	31.33
Digitaria sanguinalis (L.) Scop.	Poa	0.34	1.54	1.14	0.04	0.2	0.04	1.68	1.61
Dodonaea viscosa (L.) Jacq.	Sap	0.34	-	3.41	-	1.74	-	5.49	-
Eragrostis minor Host	Poa	-	8.50	-	3.47	-	2.24	-	14.21
Imperata cylindrica (L.) Raeusch.	Poa	-	1.54	-	3.10	-	0.08	-	4.72
Justicia adhatoda L.	Aca	0.34	8.60	1.3	11.60	4.13	15.30	5.77	35.50
Lantana indica Roxb.	Ver	0.11	3.08	1.14	11.50	0.05	0.04	1.3	14.62
Malvastrum coromandelianum (L.) Garcke	Mal	0.17	1.54	2.27	2.80	0.1	1.60	2.54	5.94
Maytenus royleana (Wall. ex M.A. Lawson) Cufod.	Cel	4.24	1.54	5.5	3.60	1.53	1.30	11.27	6.44
Olea ferruginea Royle	Ol	2.46	-	3.41	-	2.14	-	8.01	-
Panicum atrosanguineum Hochst. ex A. Rich.	Poa	2.06	-	3.41	-	1.74	-	7.21	-
Periploca aphylla Decne.	Apo	5.73	-	1.14	-	1.53		8.4	-
Prosopis glandulosa Torr.	Fab	-	3.08	-	5.60	-	0.56		9.24
Salvadora oleoides Decne.	Sal	4.24	-	4.55	-	4.39	-	13.18	-
Solanum surattense Burm.f.	Poa	0.23	-	2.27	-	0.15	-	2.65	-
Sporobolus arabicus Boiss.	Poa	0.57	-	1.14	-	0.2	-	1.91	-
Tamarix dioica Roxb. ex Roth	Tam	0.34	-	1.14	-	0.2	-	1.68	-
Verbena officinalis L.	Ver	3.04	-	4.55	-	2.8	-	10.39	-
Vernonia cinerascens Sch. Bip.	Ast	0.69	-	1.14	-	0.2	-	2.03	-
Wattakaka volubilis (L.f.) Stapf.	Asc	1.66	-	3.41	-	0.71	-	5.78	-
Withania somnifera (L.) Dunal.	Sol	-	1.54	-	3.50	-	1.10	-	6.14
Xanthium strumarium L.	Ast	-	3.10	-	5.80	-	2.40	-	11.30
Ziziphus nummularia (Burm. fil.) Wight & Arn.	Rha	0.8	1.54	1.14	1.80	0.41	1.50	2.35	4.84

Families (Fam): Aca =Acanthaceae; Apo =Apocynaceae; Asc =Asclepiadaceae; Ast =Asteraceae; Cap =Capparidaceae; Cel =Celastraceae; Cyp =Cyperaceae; Fab =Fabaceae; Mal =Malvaceae; Nyc=Nyctaginaceae; Ole =Oleaceae; Poa =Poaceae; Rha =Rhamnaceae; Sal =Salvadoraceae; Sap =Sapindaceae; Sol =Solanaceae; Rha =Rhamnaceae; Tam =Tamaricaceae; Ver =Verbenaceae

Supplementary Table 7. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Pindi Bhattian site along motorway M2.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Achyranthes aspera L.	Ama	0.06	0.09	1.14	1.67	0.05	0.11	1.25	1.86
Abutilon muticum (Delile ex DC.) Sweet	Mal	0.8	2.52	1.14	12.22	0.41	0.78	2.35	15.52
Acacia jacquemontii Benth.	Fab	1.66	-	3.41	-	0.71	-	5.78	-
Acacia nilotica (L.) Delile	Mim	10.08	-	3.95	-	16.54	-	30.57	-
Alhagi maurorum Medic.	Fab	4.01	-	2.27	-	2.55	-	8.83	-
Anagallis arvensis L.	Pri	1.15	-	1.14	-	1.02	-	3.31	-
Anethum graveolens L.	Api	0.06	-	1.14	-	0.05	-	1.25	-
Asparagus adscendens Roxb.	Asp	-	0.05		0.56		0.04	-	0.64
Bolboschoenus maritimus L.	Cyp	2.06	-	1.41	-	1.74	-	5.21	-
Bombax ceiba L.	Mal	-	0.65		12.67	-	0.84	-	0.64
Calotropis procera (Aiton) W.T. Aiton	Apo	4.20	3.60	4.60	11.70	4.40	3.70	13.2	19.00
Cannabis sativa L.	Can	0.06	1.59	1.14	7.78	0.05	7.50	1.25	16.87
Capparis decidua (Forssk.) Edgew.	Cap	4.24	-	2.55	-	4.39	-	11.18	-
Carthamus oxyacantha M. Bieb.	Ast	0.06	-	1.14	-	0.05	-	1.25	-
Cenchrus ciliaris L.	Poa	6.70	21.80	3.40	11.10	8.70	4.70	18.8	37.60
Chenopodium murale L.	Ama	0.06	-	1.14	-	0.05	-	1.25	-
Chenopodium album L.	Ama	0.06	0.05	1.14	0.56	0.05	0.04	1.25	0.64
Cnicus arvensis L.	Ast	0.06		1.14		0.05		1.25	-
Convolvulus arvensis L.	Con	0.23	0.05	3.41	0.56	2.45	0.04	6.09	0.64
Conyza ambigua DC.	Ast	-	0.18	-	0.56	-	0.04	-	0.77
Croton bonplandianus Baill.	Eup	0.34	-	1.68	-	4.13	-	6.15	-
Cynodon dactylon (L.) Pers.	Poa	7.04	63.51	6.82	8.40	7.66	30.91	21.52	102.82
Dalbergia sissoo Roxb.	Fab	0.06	0.14	1.14	1.67	0.05	2.11	1.25	3.91
Datura stramonium L.	Sol	0.57	-	1.14	-	0.51	-	2.22	
Desmostachya bipinnata	Poa	-	0.95	-	1.78	-	4.95	-	7.68
Dichanthium annulatum (Forssk.) Stapf.	Poa	6.7	0.85	3.41	1.11	8.68	0.71	18.79	2.67
Eleocharis palustris (L.) Roem. & Schult.	Cyp	0.06	-	1.14	-	0.05	-	1.25	-
Eucalyptus camaldulensis Dehn.	Myr	0.06	1.23	1.14	10.33	0.05	23.31	1.25	34.88
Euphorbia prostate L.	Eup	-	0.05	-	0.56	-	0.04	-	0.64
Fimbristylis dichotoma (L.) Vahl	Cyp	0.06	-	1.14	-	0.05	-	1.25	-
Heliotropium europaeum L.	Bor	0.34	-	3.41	-	1.74	-	5.49	-
Imperata cylindrica (L.) Raeuschel	Poa	18.33	-	5.27	-	13.36	-	36.96	-
Lantana camara L.	Ver	-	0.14	-	1.78	-	1.13	-	3.04
Launaea nudicaulis L.	Ast	0.06	-	1.14	-	0.05	-	1.25	-
Lippia nodiflora (L.) Michx.	Ver	0.06	-	1.14	-	0.05	-	1.25	-
Malvastrum coromandelianum	Mal	-	1.06	-	3.33	-	4.85	-	9.25
Malva neglecta Wallr.	Mal	1.6	-	2.55	-	1.02	-	5.17	-
Mangifera indica L.	Ana	0.06	-	1.14	-	0.05	-	1.25	-
Melilotus indicus (L.) All.	Fab	0.06	-	1.14	-	0.05	-	1.25	-
Morus alba L.	Mor	0.34	-	1.14	-	0.2	-	1.68	-
Oxalis corniculate L.	Oxa	3.04	1.29	2.55	1.89	7.78	1.88	13.37	5.06
Paspalum paspaloides (Michx.) Scribn.	Poa	5.73	-	1.14	-	1.53	-	8.4	-
Paspalum distichum L.	Poa	0.11	-	1.14	-	0.05	-	1.3	-
Phoenix dactylifera L.	Ast	0.23	-	1.14	-	0.1	-	1.47	-
Phragmites karka (Retz.) Trin.	Poa	0.52	-	1.41	-	2.7	-	4.63	-
Polypogon monspeliensis (L.) Desf.	Poa	0.06	-	1.14	-	0.05	-	1.25	-
Populus nigra L.	Sal	0.06	-	1.14	-	0.05	-	1.25	-
Rostraria cristata (L.) Tzvelev	Poa	0.06	-	1.14	-	0.05	-	1.25	-
Rumex dentatus L.	Pol	2.46	-	1.41	-	2.14	-	6.01	-
Saccharum benghalensis L.	Poa	4.24	1.13	2.95	3.56	1.53	8.63	8.72	13.31
Sisymbrium irioides Boiss.	Bra	0.74	-	1.14	-	0.51	-	2.39	-
Solanum nigrum L.	Sol	0.06	-	1.14	-	0.05	-	1.25	-
Sonchus oleraceus L.	Ast	0.06	-	1.14	-	0.05	-	1.25	-
Spergularia rubra (L.) J. Presl & C. Presl	Car	0.11	-	1.14	-	0.05	-	1.3	-
Sporobolus diander (Retz.) P. Beauv.	Poa	0.69	-	1.14	-	0.2	-	2.03	-
Suaeda fruticosa Forssk. ex J.F.	Ama	0.11	-	1.14	-	0.05	-	1.3	-
Typha angustifolia L.	Typ	0.06	-	2.14	-	0.05	-	2.25	-
Withania somnifera (L.) Dunal	Sol	-	0.05		2.11		1.71		3.86
Xanthium strumarium L.	Ast	0.23	0.23	2.27	1.11	0.15	1.07	2.65	2.41
Zannichellia palustris L.	Pot	0.57	-	1.14	-	0.2	-	1.91	-
Ziziphus mauritiana Lam.	Rha	9.16	0.05	2.27	0.56	2.33	0.04	13.76	0.64

Families (Fam): Aca =Acanthaceae; Ama =Amaranthaceae; Ana =Anacardiaceae; Api =Apiaceae; Apo =Apocynaceae; Asc =Asclepiadaceae; Ast =Asteraceae; Bra =Brassicaceae; Bor = Boraginaceae; Can =Cannabaceae; Cap =Capparidaceae; Car =Caryophyllaceae; Cel =Celastraceae; Con =Convolvulaceae; Cyp =Cyperaceae; Eup = Euphorbiaceae; Fab =Fabaceae; Mal =Malvaceae; Mim =Mimosaceae; Mor = Moraceae; Myr =Myrtaceae; Oxa =Oxalidaceae; Poa =Poaceae; Pol =Polygonaceae; Pot =Potamogetonaceae; Pri =Primulaceae Rha =Rhamnaceae; Sal =Salicaceae; Sol =Solanaceae; Rha =Rhamnaceae; Typ =Typhaceae; Ver =Verbenaceae

Supplementary Table 8. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Sheikhupura site along motorway M2.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon muticum (Delile ex DC.) Sweet	Mal	0.20	-	1.39	-	0.04	-	1.63	-
Acacia jacquemontii Benth.	Fab	0.60	-	1.39	-	2.61	-	4.60	-
Achyranthes aspera L.	Ama	0.10	1.61	1.39	10.29	0.04	0.64	1.53	12.54
Brachiaria reptans L.	Poa	-	0.03	-	1.47	-	0.04	-	1.54
Calotropis procera (Aiton) W.T. Aiton	Apo	11.5	2.4	3.9	11.8	8.9	4.6	24.30	18.80
Cannabis sativa L.	Can	11.48	62.79	13.89	14.71	8.89	26.24	34.25	103.74
Cenchrus ciliaris L.	Poa	6	23.8	6.9	14.7	13.8	21.2	26.70	59.70
Chenopodium album L.	Ama	0.10	0.06	1.39	1.47	0.04	0.04	1.53	1.57
Cnicus arvensis (L.)	Ast	1.10	-	2.78	-	0.09	-	3.96	-
Convolvulus arvensis L.	Con	0.70	0.35	4.17	4.41	0.13	0.11	5.00	4.87
Conyza ambigua DC.	Ast	-	0.06		2.94	-	0.07		3.08
Conyza canadensis L.	Ast	2.10	-	5.56	-	0.22	-	7.87	-
Cordia myxa L.	Bor	0.10	-	1.39		0.09	-	1.58	
Cynodon dactylon (L.) Pers.	Poa	43.06	0.76	8.33	2.94	8.10	13.70	59.49	17.40
Dalbergia sissoo Roxb.	Fab	1.40	1.20	4.17	6.71	0.31	8.50	5.87	16.40
Datura alba L.	Sol	-	0.32	-	1.47	-	0.07	-	1.86
Desmostachya bipinnata (Linn.)	Poa	0.50	0.63	1.39	1.47	0.09	0.30	1.98	2.40
Eucalyptus camaldulensis Dehnh.	Myr	4.39	-	10.89	-	21.83	-	37.11	-
Heliotropium strigosum Willd.	Bor	0.50	-	1.39	-	0.04	-	1.93	-
Malvastrum coromandelianum (L.) Garcke	Mal	1.40	3.39	3.33	3.76	0.26	0.64	4.99	7.80
Morus alba L.	Mor	0.20	0.95	1.39	4.71	0.17	21.12	1.76	26.77
Oxalis corniculate L.	Oxa	5.99	0.38	6.94	2.94	0.78	0.07	13.72	3.39
Paspalidium flavidum Retz.	Poa	-	0.03	-	1.47	-	0.04	-	1.54
Prosopis glandulosa Torr.	Fab	0.80	0.06	4.17	2.94	2.18	0.75	7.14	3.75
Saccharum munja Roxb.	Poa	8.09	-	10.89	-	30.99	-	49.97	-
Setaria verticillata L.	Poa	0.10	0.32	1.39	1.47	0.04	0.07	1.53	1.86
Vernonia cinerascens Sch. Bip.	Ast	-	0.63	-	2.87	-	1.54	-	1.54
Withania somnifera (L.) Dunal	Sol	-	0.05	-	2.11	-	1.71	-	3.86
Xanthium strumarium L.	Ast	0.10	0.23	1.39	1.11	0.04	1.07	1.53	2.41
Ziziphus mauritiana Lam.	Rha	-	0.05	-	0.56	-	0.04	-	0.64

Families (Fam): Ama =Amaranthaceae; Apo =Apocynaceae; Ast =Asteraceae; Bor =Boraginaceae; Can= Cannabaceae; Con =Convolvulaceae; Fab =Fabaceae; Mal =Malvaceae; Mor =Moraceae; Myr =Myrtaceae; Oxa =Oxalidaceae; Poa =Poaceae; Rha =Rhamnaceae; Sol =Solanaceae; Rha =Rhamnaceae

Supplementary Table 9. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Painsra site along motorway M4.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
*Acacia nilotica (*L). Delile	Fab	-	0.03	-	1.49	-	3.10	-	4.62
Achyranthes aspera L.	Am	-	0.24	-	4.48	-	5.00	-	9.72
Acrachne racemose (Heyne ex Roem. & Schult.) Ohwi	Poa	1.3	-	3.13	-	0.58	-	5.01	-
Alhagi maurorum Medik.	Fab	0.14	-	1.56	-	0.06	-	1.76	-
Aristida adscensionis L.	Poa	6.48	-	4.69	-	3.86	-	15.03	-
Brachiaria reptans L.	Poa	-	0.24	-	5.97	-	3.90	-	10.11
Calotropis procera (Aiton) W.T. Aiton	Apo	9.4	2.50	6.3	13.40	3.1	2.20	18.8	18.10
Cannabis sativa L.	Can	9.37	42.26	2.25	5.46	3.09	0.24	14.71	47.96
Capparis decidua (Forssk.) Edgew.	Cap	0.29	-	1.56	-	1.29	-	3.14	-
Cenchrus ciliaris L.	Poa	5.6	0.20	9.4	3.00	4.8	7.00	19.8	10.20
Cenchrus pennisetiformis Hochst. & Steud.	Poa	5.62	-	9.38	-	4.76	-	19.76	-
Cnicus arvensis L.	Ast	-	0.03	-	1.49	-	7.00	-	8.52
Cressa cretica L.	Con	2.16	-	3.19	-	0.32	-	5.67	-
Conyza bonariensis L.	Ast	-	0.03	-	1.49	-	3.60	-	5.12
Coronopus didymus (L.) Smith	Cru	-	0.03	-	1.49	-	3.20	-	4.72
Croton bonplandianus Baill.	Eup	0.14	-	1.56	-	0.06	-	1.76	-
Cynodon dactylon (L.) Pers.	Poa	11.24	42.71	9.38	11.94	10.42	4.90	31.04	59.55
Dactyloctenium aegyptiacum L.	Poa	7.21	0.03	4.69	1.49	5.79	4.30	17.69	5.82
Dalbergia sissoo Roxb.	Fab	-	0.30	-	4.46	-	0.10	-	4.86
Desmostachya bipinnata L.	Poa	-	0.18	-	2.99	-	4.10	-	7.27
Dichanthium annulatum (Forssk.) Stapf.	Poa	6.48	-	6.25	-	2.83	-	15.56	-
Digitaria sanguinalis L.	Poa	4.18	-	3.13	-	2.57	-	9.88	-
Dodonaea viscosa L.	Sap	0.86	-	1.56	-	1.93	-	4.35	-
Eragrostis pilosa L.	Poa	5.76	-	3.13	-	4.5	-	13.39	-
Eucalyptus camaldulensis Dehn.	Myr	-	0.24	-	5.97	-	4.09	-	10.30
Heliotropium strigosum Willd.	Bor	-	4.34	-	5.45	-	14.20	-	23.99
Hordeum murinum L.	Poa	1.59		3.13	-	2.86	-	7.58	-
Launaea nudicaulis L.	Ast	-	0.03	-	1.49	-	6.90	-	8.42
Malva neglecta Wallr.	Mal	-	3.44	-	4.48	-	3.00	-	10.92
Malvastrum coromandelianum (L.) Garcke	Mal	-	0.51	-	5.97	-	5.00	-	11.48
Morus alba L.	Mor	-	0.12	-	2.99	-	0.03	-	3.13
Oxalis corniculata L.	Oxa	-	0.54	-	2.99	-	4.70	-	8.23
Prosopis glandulosa Torr.	Fab	-	2.54	-	7.43	-	8.24	-	18.21
Rhynchelytrum repens (Willd.) C.E. Hubb.	Poa	1.01	-	1.56		1.29		3.86	-
Saccharum bengalense L.	Poa	3.75	0.12	3.25	2.99	7.07	0.01	14.07	3.12
Salsola imbricata Forssk.	Ama	4.61		3.13	-	7.85	-	15.59	-
Sporobolus ioclados (Nees ex Trin.) Nees	Poa	4.66	-	2.69	-	8.36	-	15.71	-
Suaeda vera J.F. Gmel.	Ama	2.31	-	10.94	-	13.5	-	26.75	-
Tamarix aphylla L.	Tam	0.03	1.49	5.20	6.72	-	-	-	-
Withania somnifera (L.) Dunal	Sol	6.48	-	4.69	-	8.36	-	19.53	-

Families (Fam): Ama = Amaranthaceae; Apo = Apocynaceae; Asc = Asclepiadaceae; Ast = Asteraceae; Bor =Boraginaceae; Can =Cannabaceae; Cap = Capparidaceae; Con = Convolvulaceae; Eup = Euphorbiaceae; Fab = Fabaceae; Mal = Malvaceae; Mor = Moraceae; Myr =Myrtaceae; = Oleaceae; Oxa =Oxalidaceae; Poa = Poaceae; Sol = Solanaceae; Tam = Tamaricaceae

Supplementary Table 10. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Toba Tek Singh site along motorway M4.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon indicum Mill.	Mal	0.01	4.70	1.15	1.82	0.00	0.04	1.16	6.56
Acacia jacquemontii L.	Fab	0.07	-	2.30	-	4.60	-	6.97	-
Acacia nilotica (L). Delile	Fab	2.01	-	1.15	-	2.10	-	5.26	-
Achyranthes aspera L.	Ama	-	3.20		5.45	-	0.12		8.78
Bombax ceiba L.	Bom	2.01	-	1.15	-	1.10	-	4.26	-
Brachiaria reptans L.	Poa	0.31	-	2.30	-	6.30	-	8.91	-
Calotropis procera (Aiton) W.T. Aiton	Apo	4.00	6.30	1.15	1.80	6.00	2.80	11.15	10.90
Cannabis sativa L.	Can	28.78	-	11.49	-	0.51	-	40.78	-
Cassia occidentalis L.	Fab	0.01	-	1.15	-	1.80	-	2.96	-
Cenchrus ciliaris L.	Poa	23.80	17.60	9.20	14.20	8.00	16.70	41.00	48.50
Chenopodium album L.	Ama	0.01	5.30	1.15	1.82	0.00	0.04	1.16	7.16
Chenopodium murale L.	Ama	0.01	-	1.15	-	0.00	-	1.16	-
Cnicus arvensis L.	Ast	0.01	4.70	1.15	5.45	0.00	0.12	1.16	10.28
Convolvulus arvensis L.	Con	0.01	10.40	1.15	8.09	2.10	4.70	3.26	23.19
Cynodon dactylon (L.) Pers.	Poa	34.84	0.40	11.49	5.50	23.80	6.80	70.14	12.70
Dalbergia sissoo Roxb.	Fab	0.00	1.74	4.60	18.18	4.10	20.77	8.70	40.70
Desmostachya bipinnata L.	Poa	-	2.40	-	1.82	-	0.04		4.26
Dicliptera bupleuroides Nees	Aca	0.14	1.49	1.15	1.82	0.00	0.81	1.29	4.13
Eclipta alba L.	Ast	0.01	-	1.15	-	0.00	-	1.16	-
Eucalypts camaldulensis L.	Myr	-	11.50	-	1.82	-	5.30		18.62
Heliotropium strigosum L.	Bor	0.03	11.70	1.15	1.82	5.30	3.70	6.48	17.22
Imperata cylindrica (L.) Raeuschel.	Poa	0.01	-	1.15	-	0.00	-	1.16	-
Malva neglecta L.	Mal	0.01	-	1.15	-	4.30	-	5.46	-
Malvastrum coromandelianum L.	Mal	2.29	1.34	10.34	3.64	0.02	0.45	12.66	5.43
Momordica dioica Roxb.	Cuc	0.01	-	1.15	-	3.50	-	4.66	-
Morus alba L.	Mor	0.07	1.89	2.30	18.18	0.00	37.40	2.37	57.47
Oxalis corniculata L.	Oxa	0.21	-	4.60	-	3.20	-	8.01	-
Phyla nodiflora L.	Ver	0.01	-	1.15	-	0.00	-	1.16	-
Polygonum barbatum L.	Pol	0.01	-	1.15	-	0.00	-	1.16	-
Prosopis glandulosa Torr.	Fab	0.01	0.05	1.15	1.82	2.80	0.41	3.96	2.28
Ricinus communis L.	Eup	-	0.05	-	1.82	-	0.04		1.91
Rumex dentatus L.	Pol	0.13	-	2.30	-	1.50	-	3.93	-
Saccharum munja Roxb.	Poa	-	7.30	-	1.82	-	0.16		9.28
Setaria glauca (L.) P. Beauv.	Poa	0.01	-	1.15	-	0.00	-	1.16	-
Setaria verticillata L.	Poa	1.02	-	5.75	-	0.01	-	6.77	-
Solanum nigrum L.	Sol	0.01	-	1.15	-	3.50	-	4.66	-
Verbena officinalis L.	Ver	0.01	-	1.15	-	0.00	-	1.16	-
Verbena tenuisecta Briq.	Ver	0.01	-	1.15	-	0.00	-	1.16	-
Vernonia cinerascens L.	Ast	0.01	-	1.15	-	1.60	-	2.76	-
Withania somnifera L.	Sol	0.01	-	1.15	-	5.80	-	6.96	-
Xanthium strumarium L.	Ast	0.20	4.20	4.60	1.82	2.60	0.04	7.40	6.06
Ziziphus mauritiana L.	Rha	0.01	3.90	1.15	1.82	6.00	0.04	7.16	5.76

Families (Fam): Aca =Acanthaceae; Ama =Amaranthaceae; Apo =Apocynaceae; Ast =Asteraceae; Bom =Bombacaceae; Bor =Boraginaceae; Can =Cannabaceae; Con =Convolvulaceae; Cuc =Cucurbitaceae; Eup =Euphorbiaceae; Fab =Fabaceae; Mal =Malvaceae; Myr =Myrtaceae; Mor = Moraceae; Oxa =Oxalidaceae; Poa =Poaceae; Pol =Polygonaceae; Rha =Rhamnaceae; Sol =Solanaceae; Ver =Verbenaceae

Supplementary Table 11. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Khanewal site along motorway M4.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon muticum (Delile ex DC.) Sweet	Mal	2.52	0.2	7.78	1.39	0.78	0.04	11.08	1.63
Acacia jacquemontii L.	Fab	0.05	4.6	1.11	1.39	0.71	2.61	1.87	8.6
Achyranthes aspera L.	Ama	0.09	0.1	2.22	1.39	0.11	0.04	2.42	1.53
Asparagus adscendens Roxb.	Asp	0.05	-	1.11	-	0.04	-	1.2	-
Bombax ceiba L.	Bom	0.05	-	1.11	-	0.04	-	1.2	-
Calotropis procera (Aiton) W.T. Aiton	Apo	2	6.7	1.1	10.5	5	3.1	8.1	20.3
Cannabis sativus L.	Can	3.59	24.48	7.11	13.89	7.5	8.89	18.2	47.26
Cassia occidentalis L.	Fab	0.05	-	1.11	-	0.04	-	1.2	-
Cenchrus ciliaris L.	Poa	9.6	0.1	11.1	1.4	7.5	12	28.2	13.5
Chenopodium album L.	Ama	0.05	0.1	1.11	1.39	0.04	0.04	1.2	1.53
Cnicus Arvensis L.	Ast	-	6.3	-	2.78	-	0.09	-	9.17
Convolvulus arvensis L.	Con	0.05	0.7	1.11	4.17	0.04	0.13	1.2	5
Conyza ambigua DC.	Ast	0.18	2.1	1.11	4.56	0.04	0.22	1.33	6.88
Cynodon dactylon (L.) Pers.	Poa	63.51	6.5	11.11	1.4	30.91	5.2	105.5	13.1
Dalbergia sissoo Roxb.	Fab	0.14	7.5	2.22	4.17	0.11	0.31	2.47	11.98
Desmostachya bipinnata L.	Poa	4.95	5.8	2.22	1.39	4.95	0.09	12.12	7.28
Dichanthium annulatum (Forssk.) Stapf.	Poa	1.85	-	4.44	-	0.71	-	7	-
Eucalyptus camaldulensis Dehn.	Myr	1.3	8.39	11.11	10.89	28.31	41.83	40.72	61.11
Euphorbia prostrata L.	Eup	0.05	-	1.11	-	0.04	-	1.2	-
Heliotropium strigosum Willd.	Bor	3.56	0.5	3.78	1.39	0.74	0.04	8.08	1.93
Lantana camara L.	Ver	0.14	-	2.22	-	1.13	-	3.49	-
Malvastrum coromandelianum L.	Mal	1.96	1.4	3.67	8.33	0.85	0.26	6.48	9.99
Morus alba L.	Mor	-	0.2	-	1.39	-	0.17	-	1.76
Oxalis corniculata L.	Oxa	3.29	12.5	4.44	6.94	0.88	0.78	8.61	20.22
Prosopis cineraria (L.) Druce	Fab	0.05	-	1.11	-	0.04	-	1.2	-
Prosopis glandulosa Torr.	Fab	0.18	0.8	4.44	4.17	1.27	2.18	5.89	7.15
Saccharum bengalense Retz.	Poa	1.13	-	7.89	-	8.63	-	17.65	-
Saccharum munja Roxb.	Poa	-	8.09	-	13.89	-	21.99	-	43.97
Setaria verticillata L.	Poa	-	3.7	-	1.39	-	0.04	-	5.13
Verbascum thapsus L.	Scr	0.05	-	1.11	-	0.04	-	1.2	-
Xanthium strumarium L.	Ast	0.23	0.1	1.11	1.39	0.07	0.04	1.41	1.53
Ziziphus mauritiana Lam.	Rha	0.05	-	1.11	-	0.04	-	1.2	-

Families (Fam): Ama =Amaranthaceae; Apo =Apocynaceae; Asp =Asparagaceae; Ast =Asteraceae; Bom =Bombacaceae; Bor =Boraginaceae; Can =Cannabaceae; Con =Convolvulaceae; Eup =Euphorbiaceae; Fab =Fabaceae; Mal =Malvaceae; Myr =Myrtaceae; Mor = Moraceae; Oxa =Oxalidaceae; Poa =Poaceae; Rha =Rhamnaceae; Scr =Scrophulariaceae

Supplementary Table 12. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Shujaabad site along motorway M4.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon muticum (Delile ex DC.) Sweet	Mal	0.01	-	1.08	-	0.03	-	1.12	-
Acacia jacquemontii L.	Fab	0.07	-	2.15	-	2.66	-	4.88	-
Acacia nilotica (L). Delile	Fab	0.01	0.03	1.08	1.49	0.03	0.04	1.12	1.56
Achyranthes aspera L.	Ama	1.8	0.26	8.6	4.48	1.06	0.12	11.46	4.86
Bombax ceiba L.	Bom	0.01	-	1.08	-	0.03	-	1.12	-
Brachiaria reptans L.	Poa	0.31	0.26	2.15	5.97	0.17	0.12	2.63	6.35
Calotropis procera (Aiton) W.T. Aiton	Apo	2	6.7	1.1	10.5	2	6.8	5.1	24
Cannabis sativus L.	Can	23	9	10.75	7.46	49	24.03	82.75	40.49
Cassia occidentalis L.	Fab	0.01	-	1.08	-	0.03	-	1.12	-
Cenchrus ciliaris L.	Poa	32.9	24.7	8.6	7.5	4.1	11	45.6	43.2
Chenopodium album L.	Ama	0.01	-	1.08	-	0.03	-	1.12	-
Chenopodium morale L.	Ama	0.01	-	1.08	-	0.03	-	1.12	-
Cnicus arvensis L.	Ast	0.01	0.03	1.08	1.49	0.03	0.04	1.12	1.56
Convolvulus arvensis L.	Con	0.01	0.03	1.08	1.49	0.03	0.04	1.12	1.56
Conyza ambigua DC.	Ast	0.01	0.03	1.08	1.49	0.03	0.04	1.12	1.56
Cynodon dactylon (L.) Pers.	Poa	34.84	45.16	10.75	11.94	30.64	16.94	76.23	74.04
Dactyloctenium aegyptiacum L.	Poa	-	0.04	-	1.56	-	0.03	-	1.49
Dalbergia sissoo Roxb.	Fab	0.72	-	10.75		5.4	-	16.87	-
Desmostachya bipinnata L.	Poa	-	0.19	-	2.99	-	0.68	-	3.86
Dicliptera bupleuroides Nees	Aca	0.14	-	1.08	-	0.07	-	1.29	-
Eclipta alba L.	Ast	0.01	-	1.08	-	0.03	-	1.12	-
Eucalyptus camaldulensis Dehn.	Myr	-	0.26	-	5.97	-	5	-	11.23
Heliotropium strigosum Willd.	Bor	0.03	5.5	1.08	5.4	0.03	5.6	1.14	16.5
Imperata cylindrica (L.) Raeuschel	Poa	0.01	-	1.08	-	0.03	-	1.12	-
Launaea nudicaulis L.	Ast	-	0.03		1.49	-	0.04	-	1.56
Malva neglecta Wallr.	Mal	0.01	3.64	1.08	4.48	0.03	0.28	1.12	8.4
Malvastrum coromandelianum L.	Mal	2.29	0.54	2.6	3.2	1.76	0.16	6.65	3.9
Momordica dioica Roxb.	Cuc	0.01	-	1.08	-	0.03		1.12	
Morus alba L.	Mor	0.07	0.13	2.15	2.99	0.23	2.8	2.45	5.92
Oxalis corniculata L.	Oxa	0.21	0.57	4.3	2.99	0.13	0.2	4.64	3.76
Phyla nodiflora L.	Ver	0.01	-	1.08	-	0.03		1.12	
Prosopis glandulosa Torr.	Fab	0.01	2.68	1.08	5.3	0.03	15	1.12	22.98
Rumex dentatus L.	Pol	0.13	-	2.15	-	0.07		2.35	
Saccharum munja Roxb.	Poa	-	0.13	-	2.99		1.36		4.48
Setaria glauca (L.) P. Beauv.	Poa	0.01	-	1.08	-	0.03	-	1.12	-
Setaria verticillata L.	Poa	1.02	-	5.38	-	0.6	-	7	-
Solanum nigrum L.	Sol	0.01	-	1.08	-	0.03	-	1.12	-
Tamarix aphylla L.	Tam	-	0.03	-	1.49		0.04		1.56
Verbena officinalis L.	Ver	0.01	-	1.08	-	0.03	-	1.12	-
Verbena tenuisecta Briq.	Ver	0.01	-	1.08	-	0.03	-	1.12	-
Withania somnifera (L.) Dunal	Sol	0.01	-	1.08	-	0.03	-	1.12	-
Xanthium strumarium L.	Ast	0.2	-	3.3	-	0.63	-	4.13	-
Ziziphus mauritiana Lam.	Rha	0.01	-	1.08	-	0.03	-	1.12	-

Families (Fam): Act = Acanthaceae; Ama =Amaranthaceae; Apo =Apocynaceae; Ast =Asteraceae; Bor =Boraginaceae; Can =Cannabaceae; Cuc =Cucurbitaceae; Fab =Fabaceae; Mal =Malvaceae; Myr =Myrtaceae; Mor = Moraceae; Oxa =Oxalidaceae; Poa =Poaceae; Pol =Polygonaceae; Rha =Rhamnaceae; Sol =Solanaceae; Tam =Tamaricaceae; Ver =Verbenaceae

Supplementary Table 13. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Sambrial site along motorway M11.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon muticum (Delile ex DC.) Sweet	Mal	-	0.05	-	1.82	-	0.04	-	1.91
Acacia nilotica (L). Delile	Fab	0.03	-	1.2	-	0.05	-	1.28	-
Achyranthes aspera L.	Ama	1.11	1.25	8.43	5.45	0.85	0.12	10.39	6.82
Boerhavia procumbens Roxb.	Nyc	0.03	-	1.2	-	0.05	-	1.28	-
Calendula arvensis L.	Ast	0.03	-	1.2	-	0.05	-	1.28	-
Calotropis procera (Aiton) W.T. Aiton	Apo	2	1.5	1.2	5.5	2.1	3.1	5.3	10.1
Cannabis sativus L.	Can	5.72	0.05	10.84	1.82	6.82	0.04	23.38	1.91
Cenchrus ciliaris L.	Poa	5.7	7.1	1.2	1.8	6.8	3	13.7	11.9
Chenopodium album L.	Ama	0.03	0.05	1.2	1.82	0.05	0.04	1.28	1.91
Chenopodium morale L.	Ama	0.03	0.65	1.2	2.09	0.05	0.2	1.28	2.94
Cnicus arvensis L.	Ast	0.12	0.45	2.41	5.45	0.09	0.12	2.62	6.02
Cynodon dactylon (L.) Pers.	Poa	58.62	82.63	10.84	18.18	33.14	36.66	102.6	137.47
Dalbergia sissoo Roxb.	Fab	0.15	1.74	3.61	18.18	0.43	20.77	4.19	40.69
Desmostachya bipinnata L.	Poa	-	0.05	-	1.82	-	0.04	-	1.91
Dicliptera bupleuroides Nees	Aca	-	1.49	-	1.82	-	0.81	-	4.12
Eichhornia crassipes Mart.	Pon	0.29	-	1.2	-	0.19	-	1.68	-
Eucalyptus camaldulensis Dehn.	Myr	-	0.05	-	1.82	-	0.04	-	1.91
Heliotropium strigosum Willd.	Bor	0.62	0.05	2.41	1.82	0.28	0.04	3.31	1.91
Launaea nudicaulis L.	Ast	0.03	-	1.2	-	0.05	-	1.28	-
Malva neglecta Wallr.	Mal	0.03	-	1.8	-	0.05	-	1.88	-
Malvastrum coromandelianum L.	Mal	7.88	1.34	13.2	3.64	11.79	0.45	31.87	5.43
Morus alba L.	Mor	0.06	1.89	2.41	18.18	2.27	33.92	4.74	53.99
Oxalis corniculata L.	Oxa	5.51	-	4.82	-	2.65	-	12.98	-
Paspalidium flavidum (Retz.) A. Camus	Poa	0.12	-	1.2	-	0.05	-	1.37	-
Paspalum paspaloides (Michx.)Scribn.	Poa	0.53	-	2.41	-	0.28	-	3.22	-
Prosopis glandulosa Torr.	Fab	0.21	0.05	6.02	1.82	4.45	0.41	10.68	2.28
Rumex dentatus L.	Pol	0.06	-	1.2		0.05		1.31	
Saccharum munja Roxb.	Poa	0.38	0.05	6.02	1.82	8.15	0.16	14.55	2.03
Xanthium strumarium L.	Ast	10.84	0.05	12.05	1.82	18.37	0.04	41.26	1.91

Families (Fam): Aca =Acanthaceae; Ama =Amaranthaceae; Apo =Apocynaceae; Ast =Asteraceae; Bor = Boraginaceae; Can =Cannabaceae; Fab =Fabaceae; Mal =Malvaceae; Mor = Moraceae; Nyc=Nyctaginaceae; Oxa =Oxalidaceae; Poa =Poaceae; Pol = Polygonaceae; Pon = Pontederiaceae

Supplementary Table 14. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Wdala Sandhuan site along motorway M11.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon indicum Mill.	Mal	0.03	0.04	1.11	1.08	0.04	0.04	1.18	1.16
Achyranthes aspera L.	Ama	0.03	5.01	1.11	2.1	0.04	3.5	1.18	10.61
Asparagus adscendens Willd.	Asp	0.03	0.04	1.11	1.08	0.08	0.04	1.22	1.16
Brachiaria reptans L.	Poa	0.12	0.65	2.22	2.15	0.08	0.26	2.42	3.06
Brachiaria ramosa L.	Poa	-	0.04	-	1.08	-	0.04	-	1.16
Boerhavia procumbens Roxb.	Nyc	-	0.04	-	1.08	-	0.04	-	1.16
Calotropis procera (Aiton) W.T. Aiton	Apo	3	-	1.11	-	2	-	6.11	-
Cannabis sativus L.	Can	0.36	0.61	3.33	3.23	11.2	0.39	14.92	4.23
Cassia occidentalis L.	Fab	0.27	0.04	2.11	1.08	8.9	0.04	11.28	1.16
Cenchrus ciliaris L.	Poa	22	10.5	3.1	7.5	4	4.3	29.1	22.3
Cenchrus pennisetiformis Hochst. & Steud.	Poa	0.03		1.11	-	0.04	-	1.18	-
Chenopodium album L.	Ama	0.95	0.26	5.44	2.15	0.7	0.09	7.09	2.5
Conyza ambigua DC.	Ast	0.03		3.11	-	0.08	-	3.18	-
Cynodon dactylon (L.) Pers.	Poa	65.9	44.9	11.11	6.45	24.1	26.25	101.11	77.6
Cyperus rotundus L.	Cyp	-	0.04	-	1.08	-	0.04	-	1.16
Dactyloctenium aegyptium L.	Poa	0.8		4.33	-	0.53	-	5.66	-
Dalbergia sissoo Roxb.	Fab	1.13	0.57	8.89	6.45	4.22	6.56	14.24	13.58
Desmostachya bipinnata (L.) Stapf.	Poa	-	0.04	-	1.08	-	0.04	-	1.16
Dichanthium annulatum (Forssk.) Stapf.	Poa	0.48	0.04	2.22	1.08	0.2	0.04	2.9	1.16
Dicliptera bupleuroides Nees	Aca	0.06	2.62	1.11	3.23	0.04	1.01	1.21	6.86
Digitaria sanguinalis (Linn.) Scop.	Poa	0.03		1.11		0.04		1.18	-
Ehretia serrata Roxb.	Bor	-	0.04	-	1.08	-	0.04	-	1.16
Euphorbia glomerata A. Berger.	Eup	-	0.04	-	1.08	-	0.04	-	1.16
Ipomoea carnea L.	Con	-	0.04	-	1.08	-	0.04	-	1.16
Malva neglecta Wallr.	Mal	-	0.22	-	1.08	-	0.04	-	1.34
Malvastrum coromandelianum L.	Mal	0.96	10.46	5.11	7.53	0.44	4.29	6.21	22.28
Medicago polymorpha L.	Fab	0.03	0.26	1.11	2.15	0.04	0.09	1.18	2.5
Morus alba L.	Mor	0.18	1.31	5.56	9.68	1.97	26.68	7.71	37.67
Orbivestus cinerascens (Sch. Bip.) H. Rob.	Ast	-	0.22	-	3.23	-	0.52	-	3.97
Oxalis corniculata L.	Oxa	0.03	1.44	1.11	3.23	0.04	1.36	1.18	6.03
Panicum antidotale Retz.	Poa	1.45	-	7.78	-	12.29		21.52	-
Paspalidium flavidum (Retz.) A. Camus	Poa	0.15	0.65	1.11	1.08	5.45	0.04	6.71	1.77
Prosopis juliflora (Sw.) DC.	Fab	0.33	0.31	5.56	4.3	4.5	7.44	10.39	12.05
Ruellia tuberosa L.	Aca	-	11.2	-	2.45	-	5.1	-	18.75
Saccharum bengalense L.	Poa	0.92	0.31	6.77	3.23	18.84	3.94	26.43	7.48
Setaria verticillata L.	Poa	0.45	4.01	3.33	4.3	0.16	1.4	3.94	9.71
Sonchus oleraceus L.	Ast	0.03	-	2.11	-	0.08	-	2.28	-
Verbascum thapsus L.	Scr	0.03	0.04	1.11	1.08	0.04	0.04	1.18	1.16
Verbena officinalis L.	Ver	0.03	0.04	1.11	1.08	0.08	0.04	1.22	1.16
Xanthium strumarium L.	Ast	0.03	1.05	1.11	4.3	0.04	0.83	1.18	6.18
Ziziphus mauritiana Lam.	Rha	0.12	0.13	2.22	2.15	0.25	0.61	22.12	2.89

Families (Fam): Aca =Acanthaceae; Ama =Amaranthaceae; Apo =Apocynaceae; Asp = Asparagaceae; Ast =Asteraceae; Bor = Boraginaceae; Can =Cannabaceae; Con =Convolvulaceae; Cyp =Cyperaceae; Fab =Fabaceae; Eup = Euphorbiaceae; Mal =Malvaceae; Mor = Moraceae; Nyc=Nyctaginaceae; Oxa =Oxalidaceae; Poa =Poaceae; Rha =Rhamnaceae; Scr= Scrophulariaceae; Ver =Verbenaceae

Supplementary Table 15. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Whando site along motorway M11.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon muticum (Delile ex DC.) Sweet	Mal	0.33	-	1.1	-	0.23	-	1.66	-
Acacia jacquemontii L.	Fab	0.16	-	2.15	-	5.8	-	8.11	-
Achyranthes aspera L.	Ama		0.8		12.1	-	0.66		13.56
Asparagus adscendens Roxb.	Asp	0.04	-	1.08	-	0.06	-	1.18	-
Brachiaria ramosa L.	Poa	0.04	-	1.08	-	0.06	-	1.18	-
Brachiaria reptans L.	Poa	1.3	-	5.38	-	1.29	-	7.97	-
Broussonetia papyrifera L.	Mor	0.08	-	1.08	-	0.06	-	1.22	-
Calotropis procera (Aiton) W.T. Aiton	Apo	2.5	3.4	3.2	16.7	1.4	6	7.1	26.1
Cannabis sativus L.	Can	0.54	61.2	3.23	15.8	0.35	42.3	4.12	108.3
Cardiospermum halicacabum L.	Sap	0.04	-	1.08	-	0.06	-	1.18	-
Cassia occidentalis L.	Fab	0.04	-	1.08	-	0.06	-	1.18	-
Cenchrus ciliaris L.	Poa	9.4	26.2	7.5	18.5	9.1	16.1	26	60.8
Chenopodium album L.	Ama	0.04	-	1.08	-	0.06	-	1.18	-
Clerodendrum inerme L.	Ver	0.04	-	1.08	-	0.06	-	1.18	-
Cnicus arvensis (L.) Roth	Ast	0.04	0.18	1.08	3.7	0.06	0.08	1.18	3.96
Convolvulus arvensis L.	Con	1.07	1.15	1.5	5.56	0.35	0.12	2.92	5.83
Conyza ambigua DC.	Ast	0.62	-	3.23	-	0.35	-	4.2	-
Cynodon dactylon (L.) Pers.	Poa	67.63	2.51	10.75	1.85	23.6	2.47	101.98	6.83
Dactyloctenium aegyptiacum L.	Poa	0.16	-	1.08	-	0.06	-	1.3	-
Dalbergia sissoo Roxb.	Fab	0.04	1.6	1.08	2.5	4.7	20.16	5.82	24.26
Desmostachya bipinnata L.	Poa	0.04	-	1.08	-	1.6	-	2.72	-
Dichanthium annulatum (Forssk.) Stapf.	Poa	0.16	-	1.08	-	0.06	-	1.3	-
Digitaria adscendens (Kunth) Henr.	Poa	0.04	-	1.08	-	1.2	-	2.32	-
Eclipta alba L.	Ast	0.04	-	1.08	-	0.06	-	1.18	-
Euphorbia glomerata A. Berger.	Eup	0.16	-	1.08	-	0.06	-	1.3	-
Ficus palmata Forssk.	Mor	0.04	-	1.08	-	0.06	-	1.18	-
Heliotropium strigosum Willd.	Bor	4.1	-	7.53	-	9.14	-	20.77	-
Launaea nudicaulis L.	Ast	0.08	-	1.08	-	1.5	-	2.66	-
Malva neglecta Wallr.	Mal	-	3.22		5.56	-	0.29	-	9.07
Malvastrum coromandelianum (L.) Garcke	Mal	6.4	0.1	10.75	1.85	4.63	0.04	21.78	1.99
Morus alba L.	Mor	-	0.4		6.7	-	11.4	-	18.5
Oxalis corniculata L.	Oxa	2.23	0.03	4.3	1.85	0.94	0.04	7.47	1.92
Populus nigra L.	Sal	1.07	-	7.2	-	24.62	-	32.89	-
Prosopis juliflora (Sw.) DC.	Fab	-	0.03		1.85	-	0.41	-	2.29
Saccharum bengalense Retz.	Poa	0.16	0.03	2.15	1.85	7.4	0.33	9.71	2.21
Setaria glauca (L.) P. Beauv.	Poa	0.04	0.15	1.08	1.85	0.06	0.04	1.18	2.04
Setaria verticillata L.	Poa	0.04	-	1.08	-	0.06	-	1.18	-
Verbena officinalis L.	Ver	0.04	-	1.08	-	0.06	-	1.18	-
Verbena tenuisecta Briq.	Ver	0.04	-	1.08	-	0.06	-	1.18	-
Vernonia cinerascens Sch. Bip.	Ast	0.82	-	2.15	-	0.18	-	3.15	-
Xanthium strumarium L.	Ast	0.45	0.03	2.15	1.85	0.53	0.04	3.13	1.92
Ziziphus mauritiana Lam.	Rha	0.04	-	1.08	-	0.06	-	1.18	-

Families (Fam): Ama =Amaranthaceae; Apo =Apocynaceae; Asp = Asparagaceae; Ast =Asteraceae; Bor = Boraginaceae; Can =Cannabaceae; Con =Convolvulaceae; Fab =Fabaceae; Eup = Euphorbiaceae; Mal =Malvaceae; Mor = Moraceae; Oxa =Oxalidaceae; Poa =Poaceae; Rha =Rhamnaceae; Sal =Salicaceae; Sap =Sapindaceae; Rha =Rhamnaceae; Ver =Verbenaceae

Supplementary Table 16. Ecological data of different species found growing along fenced (F) and unfenced (UF) areas at Muridky site along motorway M11.

Plant species	Fam	RD		RF		RC		IV	
		F	UF	F	UF	F	UF	F	UF
Abutilon fruticosum Guill. & Perr.	Mal	0.2	-	1.64	-	0.09	-	1.93	-
Abutilon indicum Mill.	Mal	1.01	1.41	1.64	0.06	0.18	1.57	2.83	3.04
Achyranthes aspera L.	Ama	0.8	6.3	1.64	8.6	0.09	10.4	2.53	25.3
Asparagus adscendens Willd.	Asp	0.2	-	1.64	-	0.09	-	1.93	-
Brachiaria ramosa L.	Poa	0.2	-	1.64	-	0.09	-	1.93	-
Brachiaria reptans L.	Poa	0.2	-	2.64	-	0.09	-	3.93	-
Calotropis procera (Aiton) W.T. Aiton	Apo	2.2	4.9	8.2	12.7	1.5	1.4	11.9	19
Cannabis sativus L.	Can	-	2.1		1.5	-	3.2	-	6.8
Cenchrus ciliaris L.	Poa	15.2	-	2.2	-	2.1	-	19.5	-
Cenchrus pennisetiformis Hochst. & Steud.	Poa	0.2	-	1.64	-	0.09	-	1.93	-
Cenchrus setigerus (Vahl)	Poa	0.2	-	1.64	-	0.09	-	1.93	-
Chenopodium album L.	Ama	0.2	-	1.64	-	0.09	-	1.93	-
Cnicus arvensis L.	Ast	-	5.63		0.3	-	4.1	-	10.03
Convolvulus arvensis L.	Con	-	1.7		0.24	-	1.7	-	3.64
Conyza ambigua DC.	Ast	0.2	-	1.64	-	0.09	-	1.93	-
Cynodon dactylon (L.) Pers.	Poa	67.3	29.7	16.39	14.1	12.24	6	95.93	49.8
Dactyloctenium aegyptium L.	Poa	0.2	-	1.64	-	0.09	-	1.93	-
Dalbergia sissoo Roxb.	Fab	-	4.5		12.4	-	23.6	-	40.5
Dichanthium annulatum (Forssk.) Stapf.	Poa	0.4	-	1.64	-	0.09	-	2.13	-
Digitaria adscendens (Kunth) Henr.	Poa	0.2	-	1.64	-	0.09	-	1.93	-
Eucalyptus camaldulensis Dehn.	Myr	4.1	-	11.3	-	50.3	-	65.7	-
Euphorbia prostrata Aiton.	Eup	0.2	-	1.64	-	0.09	-	1.93	-
Ficus palmata L.	Mor	0.2	-	1.64	-	0.09	-	1.93	-
Heliotropium strigosum Willd.	Bor	2.21	-	8.2	-	0.45	-	10.86	-
Leptochloa chinensis L.	Poa	0.2	-	1.64	-	0.09	-	1.93	-
Malvastrum coromandelianum L.	Mal	2.2	3.2	6.64	6.78	0.39	5.6	8.93	15.58
Morus alba L.	Mor	-	8.4	-	32.7	-	13.5	-	54.6
Oxalis corniculata L.	Oxa	-	1.41	-	0.06	-	1.57	-	3.04
Paspalidium flavidum (Retz.) A. Camus	Poa	0.2	1.41	1.64	0.06	0.09	1.57	1.93	3.04
Polygonum barbatum L.	Pol		1.41	-	1.1	-	1.57	-	4.08
Prosopis juliflora (Sw.) DC.	Fab	2.1	-	12.4	-	31.28	-	45.78	-
Ruellia tuberosa L.	Aca	-	1.41	-	0.06	-	1.68	-	3.15
Setaria verticillata L.	Poa	-	1.41	-	0.06	-	1.57	-	3.04
Sporobolus coromandelianus L.	Poa	0.2	-	1.64	-	0.09	-	1.93	-
Suaeda fruticosa Forssk.	Ama	0.2	-	1.64	-	0.09	-	1.93	-
Xanthium strumarium L.	Ast		2.82	-	0.71	-	4.48	-	8.01
Ziziphus mauritiana Lam.	Rha	0.2	1.41	1.64	0.24	0.09	2.49	1.93	4.14

Families (Fam): Aca =Acanthaceae; Ama =Amaranthaceae; Apo =Apocynaceae; Asp = Asparagaceae; Ast =Asteraceae; Bor = Boraginaceae; Can =Cannabaceae; Con =Convolvulaceae; Fab =Fabaceae; Eup = Euphorbiaceae; Mal =Malvaceae; Mor = Moraceae; Myr =Myrtaceae; Oxa =Oxalidaceae; Poa =Poaceae; Pol = Polygonaceae; Rha =Rhamnaceae