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BASELINE DATA ON WILD FLORA OF CROP FIELD BOUNDARIES IN THE AGRO-ECOSYSTEM OF POTHWAR PLATEAU, PAKISTAN

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Abstract

Wild flora along crop field boundaries in farmlands not only increases habitat heterogeneity but also serves multiple beneficial functions. We collected baseline data on wild flora bordering the crop fields of Pothwar plateau. Overall we selected four study sites including two sites of wheat-maize/millet and two of wheat-groundnut cropping system. We recorded 51 species of plants including 12 species of trees, 14 species of shrubs and 25 species of grasses/herbs. Two tree species namely *Acacia modesta* and *Zizyphus mauritiana* and two shrub species namely *Calotropis procera* and *Ziziphus nummularia* were common indicating their widespread presence in the area. Among herbs/grasses *Abutilon indicum*, *Amaranthus* spp., *Cyperus rotundus* and *Erogrostis poroles* were common at sites with wheat-maize/millet cropping pattern while *Chenopodium album*, *Datura stramonium* and *Tribulus terrestris* were common at sites with wheat-groundnut cropping system. The tree and shrub densities did not differ significantly among the study sites. Wheat-groundnut cropping system had higher populations/diversity/species of shrubs as compared to wheat-maize/millet cropping system. Density of grasses/herbs significantly differed across the study sites but there was no association of herb/grass density with cropping practice.

Key words: Wild flora, Agro-ecosystem, Pothwar plateau.

Introduction

Agricultural habitats are a mosaic of cropped and non-cropped areas. Their field margins play an important role in the biodiversity of farmland. The presence of uncultivated wild vegetation along field margins serves as fitness-producing habitat for biodiversity conservation (Smith *et al*., 2005; Concepcion & Diaz, 2010). Generally, the crop field vegetation in agricultural landscape is not characterized by any specific plant but is presented by a range of vegetation communities (Marshall & Moonen, 2002).

The increasing scale of agricultural activity over the past several decades has resulted in destruction of strips of vegetation bordering crop fields, variously termed 'fence rows', 'shelter belts' or 'hedgerows' (Medley *et al*., 1995). This loss is of concern because of the ecological benefits commonly attributed to field borders, including soil erosion control, conservation of biodiversity and pest control (Tainter, 2000; Walker & Meyers, 2004).

Pothwar plateau has sub-tropical dry scrub vegetation and has rich floral diversity (Nawaz *et al*., 2010). Trees and shrubs bearing specific characteristic of scrub forest are abundant here (Nawaz *et al*., 2012). *Acacia modesta*, *Olea ferruginaea* and *Tecomella undulata* are important tree species while dominant shrubs of the region include *Dodonaea viscosa*, *Justicia adhatoda*, *Maytenus royleanus* and *Ziziphus nummularia*. Several grass species are native to Pothwar region including the most abundant species of *Chrysopogon serrulatus*, *Heteropogon contortus*, *Dichanthium foveolatum*, *Cynodon dactylon* and *Aristida mutabilis* (Ahmad *et al*., 2008a). In Pothwar plateau, agricultural fields have invariably thick undisturbed field boundaries maintained to conserve water. Along the field boundaries, apart from wild vegetation of shrubs, fast growing trees are planted for browse and fodder purpose (Hussain *et al*., 2003).

Species richness and cover of wild vegetation bordering the crop fields is crucial to be recorded because of its potential role in providing food as well as nesting and roosting sites for biodiversity (Bota *et al*., 2005; Llusia & Onate, 2005). Since such information on agricultural flora of agro ecosystem is lacking for Pothwar plateau. Therefore, density and cover of vegetation bordering the selected croplands were studied in order to collect baseline data on wild flora in this agro ecosystem.

Materials and Methods

Study area: This study was conducted in Pothwar plateau of Pakistan (33° 30′ 0″ N and 73° 0′ 0″ W) which is a dissected region with undulating topography, gullies, low fertility and erratic rainfall falling mainly in July and August. The total area of Pothwar plateau is ~ 13,000 km^2 with elevation varying between 305 - 610 m (Nadeem *et al*., 2012). Climate is semi-arid to humid. The summer temperature ranges between 15°C and 40°C while the range of winter temperature is generally between 4°C and 25°C but it can occasionally drop below freezing (Hussain *et al*., 2003). Around 110,600ha area of Pothwar plateau is being cultivated (GOP, 2002-03). Four percent of the cultivated area of Pothwar plateau is irrigated while 96% is dependent on rain (Majeed *et al*., 2010).

Traditionally two types of cropping systems are present in this region i.e. wheat-maize/millet and wheat-groundnut (Arif & Malik, 2009). We designed this study by selecting two representative sites in each agricultural system. One site was located in district Attock, another in district Rawalpindi and the remaining two in district Chakwal (Fig. 1). At each selected site, we chose an intact area of 10 × 10 ha to sample.

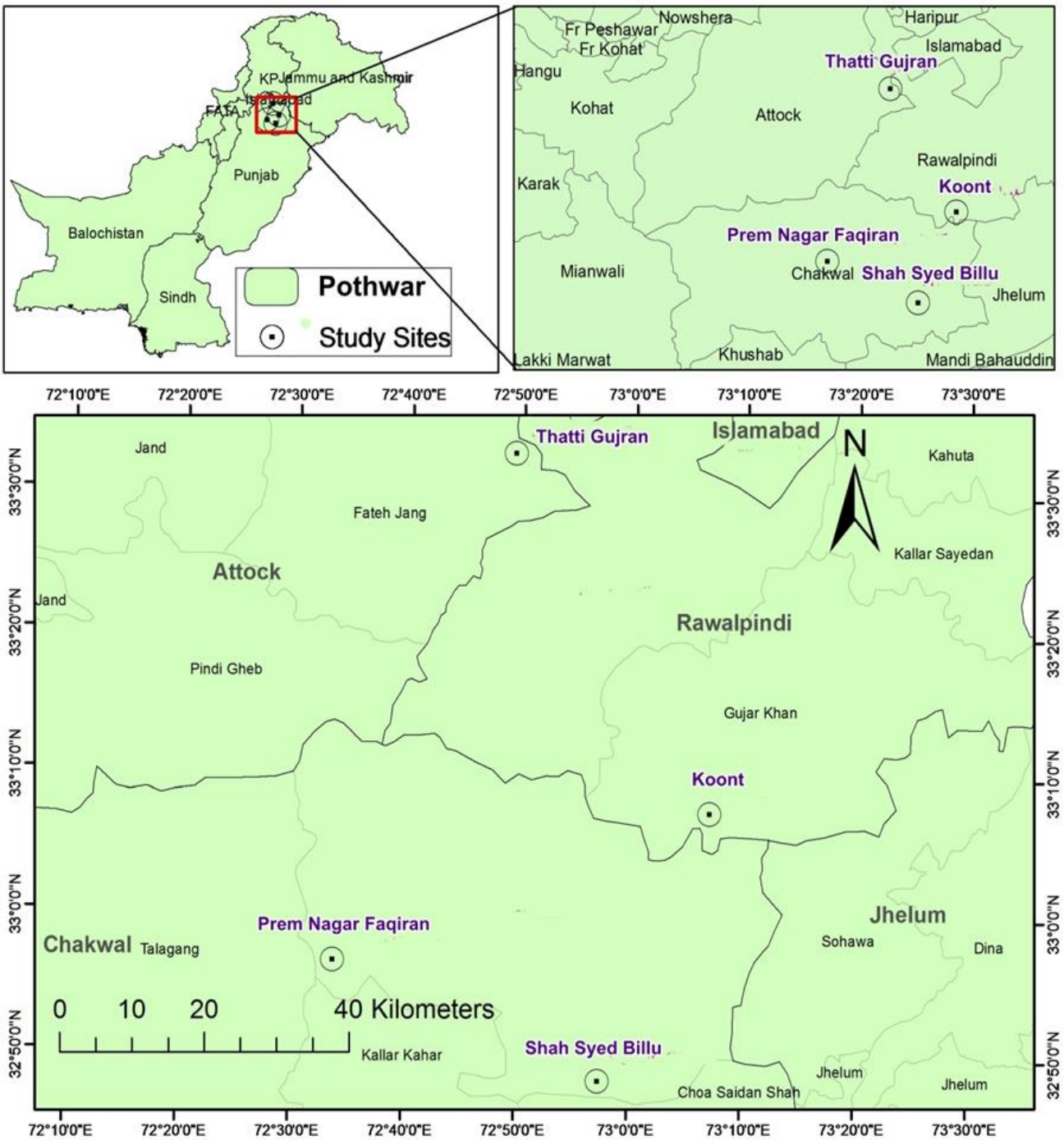

Fig. 1. Map of the study area showing the locations of selected study sites in agroecosystem of Pothwar plateau, Pakistan.

Habitat evaluation and vegetation analysis: Habitats of the four study sites were evaluated in terms of following variables.

A) Substrate/soil type: Classified as sandy (gritty with large particles), silt (soft with medium sized particles) and/or hard (rocky soil).
B) Cropping pattern: Two major cropping patterns were classified as wheat-maize/millet and wheat-groundnut.
C) Water availability: The presence of water body i.e., small ponds and streams if any was recorded.
D) Area under cultivation (%): The percentage of area under crop cultivation within each study site was estimated.
E) Vegetation analysis: Three transects each of 200 m length were laid down randomly within each sampling site. Six quadrates were selected randomly along each transect. The size of the quadrates was 10 × 10 m for trees, 4 × 4 m for shrubs and 1 × 1 m for grasses/herbs. Density, relative density, frequency, relative frequency and dominance/cover of different plant species were estimated in each quadrate. Vegetation was analyzed by using the Importance Value Index (IVI), calculated by adding Relative density + Relative frequency + Relative cover. Following Shukla & Chandel (2008) and Kothari (2009) they were estimated as follows:

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrates}}$$

$$\text{Relative density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

$$\text{Frequency} = \frac{\text{Number of quadrates in which a species occurs}}{\text{Total number of quadrates}}$$

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

$$\text{Cover} = \frac{\text{Basal area of individuals of a species}}{\text{Total basal area of all species}}$$

$$\text{Relative cover} = \frac{\text{Total basal area of individual species}}{\text{Total basal area of all species}} \times 100$$

In addition to Importance Value Index (IVI) the Summed Dominance Ratio (SDR) was calculated for all plant species observed. Following Chul and Moody (1983) and Olorunmaiye *et al.* (2011) it was calculated as follows:

$$\text{Summed dominance ratio (SDR)} = \frac{\text{Importance value index (IVI)}}{3}$$

Statistical analysis: The two cropping systems were compared by using two sample t-tests based on averages and sums within sites. The resultant two degrees of freedom (for t tests) implies relatively low power, so *P* values < 0.1were interpreted. ANOVA was used to compare the difference in vegetation of sampling sites using sampling quadrat as replicate.

Results

The habitats of all selected study sites were of mixed type harboring crop fields, associated patches of wild vegetation, human settlements as well as access roads and rainwater ponds or small dams.

Habitat evaluation and vegetation of Thatti Gujran (Site I): The site-1 was located in village Thatti Gujran, tehsil Fatehjang, district Attock. The soil of the study site is silt loam type. Wheat with maize/millet was the main cropping system at this site. A large rainwater pond (150 x 70m approx.) was situated in the immediate vicinity of the site (Table 1). Eighty percent of the area was under cultivation and there was less human disturbance due to its location away from human dwelling/village.

A total of seven tree species were recorded at this site namely *Acacia modesta*, *Acacia nilotica*, *Dalbergia sissoo*, *Eucalyptus camaldulensis*, *Melia azadarach*, *Prosopis juliflora* and *Zizyphus mauritiana*. An equal number of shrubs species observed included *Calotropis procera*, *Cannabis sativa*, *Carissa opaca*, *Dodonaea viscosa*, *Lantana camara*, *Prosopis cineraria* and *Ziziphus nummularia* (Table 2). The highest Summed Dominance Ratio (SDR) among trees was estimated for *Acacia modesta* followed by *Melia azadarach*, *Dalbergia sissoo*, *Zizyphus mauritiana*, *Acacia nilotica*, *Prosopis juliflora* and *Eucalyptus camaldulensis*.

The highest Summed Dominance Ratio (SDR) among shrubs was calculated for *Dodonaea viscosa* followed by *Cannabis sativa*, while the lowest was recorded for *Lantana camara* (Fig. 2). Ten species of herbaceous vegetation were recorded namely *Abutilon indicum*, *Alhaji maurorum*, *Amaranthus hybridus*, *Anagalis arvensis*, *Aerva javanica*, *Cenchrus ciliaris*, *Cynodon dactylon*, *Cyperus rotundus*, *Eragrostis poroles* and *Saccharum bengalense* (Table 2). The highest SDR value among grasses/herbs was estimated for *Cenchrus ciliaris* and minimum for *Abutilon indicum* (Fig. 1).

Habitat evaluation and vegetation of Prem Nagar Faqiran (Site II): The study site II was located in village Prem Nagar Faqiran, Balkassar, district Chakwal. The soil substrate of the area was silt loam with a rain-water pond (120 x 80m approx.) with water available all around the year as water access point. Seventy five percent of the area was being cultivated under wheat-maize/millet cropping system and there was moderate human disturbance in the area due to traffic (Table 1).

The tree flora of this site was comprised of *Acacia modesta*, *Capparis decidua*, *Eucalyptus camaldulensis*, *Melia azadarach*, *Morus alba* and *Zizyphus mauritiana* while the six shrub species recorded included *Calotropis procera*, *Justicia adhatoda*, *Lantana camara*, *Saccharum griffithii* and *Ziziphus nummularia*. A total of ten species of grasses/herbs were found at site II namely *Abutilon indicum*, *Amaranthus virdics*, *Cannabis sativa*, *Carthamus oxycantha*, *Cyperus rotundus*, *Erogrestis poroles*, *Helioscopia europa*, *Sonchus asper*, *Typha latifolia* and *Xanthium strumarium* (Table 3). Fig. 3 shows that the highest Summed Dominance Ratio (SDR) among trees was calculated for *Zizyphus mauritiana* while the lowest for *Morus alba*. Among shrubs *Justicia adhatoda* was dominant with maximum SDR and least value was estimated for *Lantana camara*. Among grasses/herbs *Carthamus oxycantha* had the highest SDR value while *Helioscopia europa* at the bottom.

Table 1. Description of four study sites selected in agricultural landscape of Pothwar Plateau, Pakistan.

Site No.	Site name and location	Cropping system	Substrate type	Water resource available?	Area under cultivation (%)
I	Thatti Gujran (Fatehjang, Attock)	Wheat-millet/maize	Silt loam	Rain water pond present	80
II	Prem Nagar Faqiran (Balkassar, Chakwal)	Wheat-millet/maize	Silt loam	Rain water pond present	75
III	Koont (Gujjar Khan, Rawalpindi)	Wheat-groundnut	Hard soil	Absent	75
IV	Shah Syed Billu (Choa Saden Shah, Chakwal)	Wheat-groundnut	Hard soil	Absent	60

Table 2. Density, relative density (RD), relative frequency (RF), relative cover (RC) and Importance Value Index (IVI) of different floral species recorded at study site I (Thatti Gujran) in agro-ecosystem of Pothwar plateau, Pakistan.

Tree species	**Density/ha**	**RD**	**RF**	**RC**	**IVI**
Acacia modesta	2.91	34.48	27.88	17.29	79.65
Melia azadarach	1.89	22.39	27.93	17.29	67.61
Dalbergia sissoo	0.99	11.73	19.92	23.46	55.11
Zizyphus mauritiana	0.97	11.49	9.37	24.42	45.28
Acacia nilotica	1.02	12.08	5.61	5.98	23.67
Prosopis juliflora	0.33	3.91	5.31	4.79	14.01
Eucalyptus camaldulensis	0.33	3.91	3.98	5.45	13.34
Shrubs species	**Density/4m^2**	**RD**	**RF**	**RC**	**IVI**
Dodonaea viscosa	1.55	30.57	32.27	22.04	84.88
Cannabis sativa	0.91	17.95	25.14	31.4	74.49
Ziziphus nummularia	0.67	13.21	12.43	43.21	68.85
Carissa opaca	0.66	13.02	18.98	8.34	40.34
Prosopis cineraria	0.79	15.58	4.67	11.75	32
Calotropis procera	0.3	5.92	3.77	3.29	12.98
Lantana camara	0.19	3.75	2.74	5.31	11.8
Herb/Grass species	**Density/1m^2**	**RD**	**RF**	**RC**	**IVI**
Cenchrus ciliaris	2.2	33.74	22.27	24.43	80.44
Eragrostis poroles	0.99	15.18	9.89	22.75	47.82
Saccharum bengalense	0.99	15.18	10.67	20.75	46.6
Cynodon dactylon	0.14	2.15	13.61	29.94	45.7
Cyperus rotundus	0.8	12.27	5.14	14	31.41
Amaranthus hybridus	0.7	10.74	6.34	14	31.08
Aerva javanica	0.15	2.3	8.35	18.25	28.9
Alhagi maurorum	0.2	3.07	7.14	13.76	23.97
Anagalis arvensis	0.2	3.07	11.89	5.55	20.51
Abutilon indicum	0.15	2.3	4.7	5.15	12.15

Table 3. Density, relative density (RD), relative frequency (RF), relative cover (RC) and Importance V alue Index (IVI) of different floral species recorded at study site II (Prem Nagar Faqiran) in agro-ecosystem of Pothwar plateau, Pakistan.

Tree species	**Density/ha**	**RD**	**RF**	**RC**	**IVI**
Zizyphus mauritiana	2.89	42	42.04	34.72	118.76
Acacia modesta	1.88	27.33	24.44	17.22	68.99
Melia azadarach	0.96	13.95	8.9	7.45	29.94
Eucalyptus camaldulensis	0.43	6.25	8.9	5.39	20.54
Morus alba	0.29	4.22	7.78	3.99	15.99
Shrubs species	**Density/4m^2**	**RD**	**RF**	**RC**	**IVI**
Justicia adhatoda	0.71	17.93	6.58	75	99.51
Saccharum griffithii	0.66	16.67	28.83	12.5	58
Calotropis procera	0.44	11.11	12.33	31.4	54.84
Ziziphus nummularia	0.65	16.41	14.77	20.6	51.78
Lantana camara	0.25	6.31	4.21	8.34	18.86
Capparis decidua	0.43	6.25	7.93	3.2	17.38
Herb/Grass species	**Density/1m^2**	**RD**	**RF**	**RC**	**IVI**
Carthamus oxycantha	1.5	17.75	21.29	50	89.04
Eragrostis poroles	1.8	21.31	20.06	47.21	88.58
Cannabis sativa	1.25	31.57	33.27	19.73	84.57
Typha latifolia	2	23.67	12.26	38.93	74.86
Amaranthus virdics	1.6	18.93	8.95	37.71	65.59
Sonchus asper	0.5	5.92	13.62	33.33	52.87
Cyperus rotundus	0.5	5.92	3.88	30.33	40.13
Xanthium strumarium	0.2	2.37	6.62	20.75	29.74
Abutilon indicum	0.2	2.37	9.25	7.6	19.22
Helioscopia europa	0.15	1.77	4.06	8.25	14.08

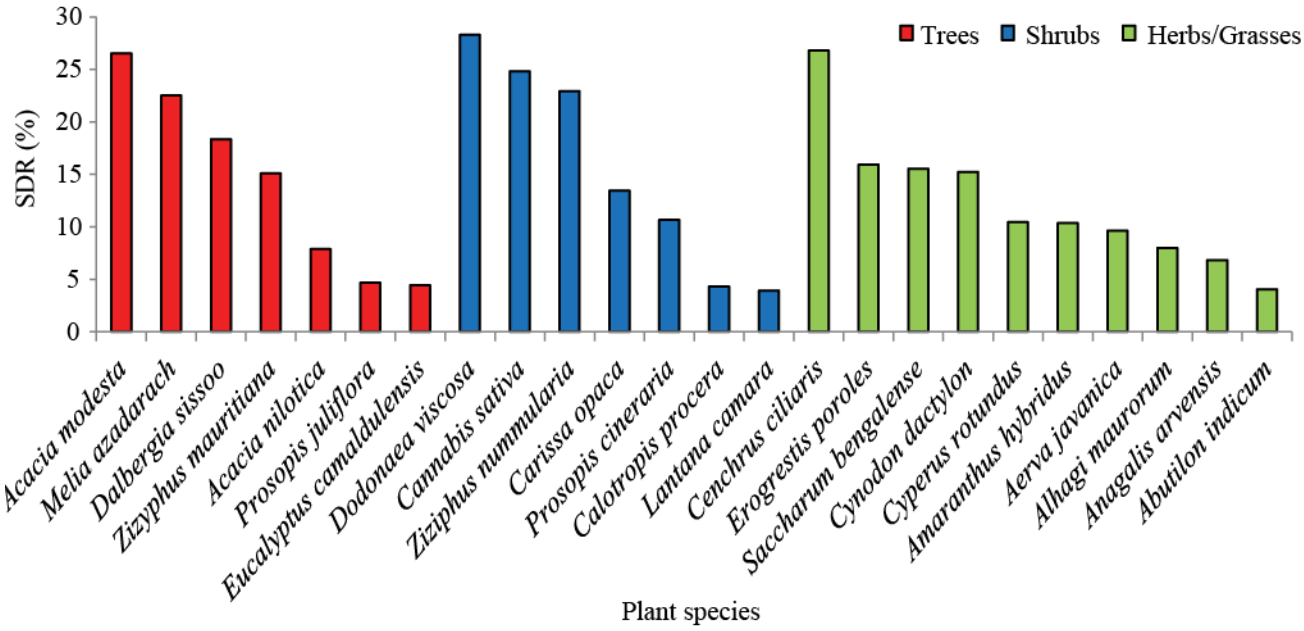

Fig. 2. Summed Dominance Ratio (SDR) of the plant species observed at study Site I (Thatti Gujran) in agro-ecosystem of Pothwar plateau, Pakistan.

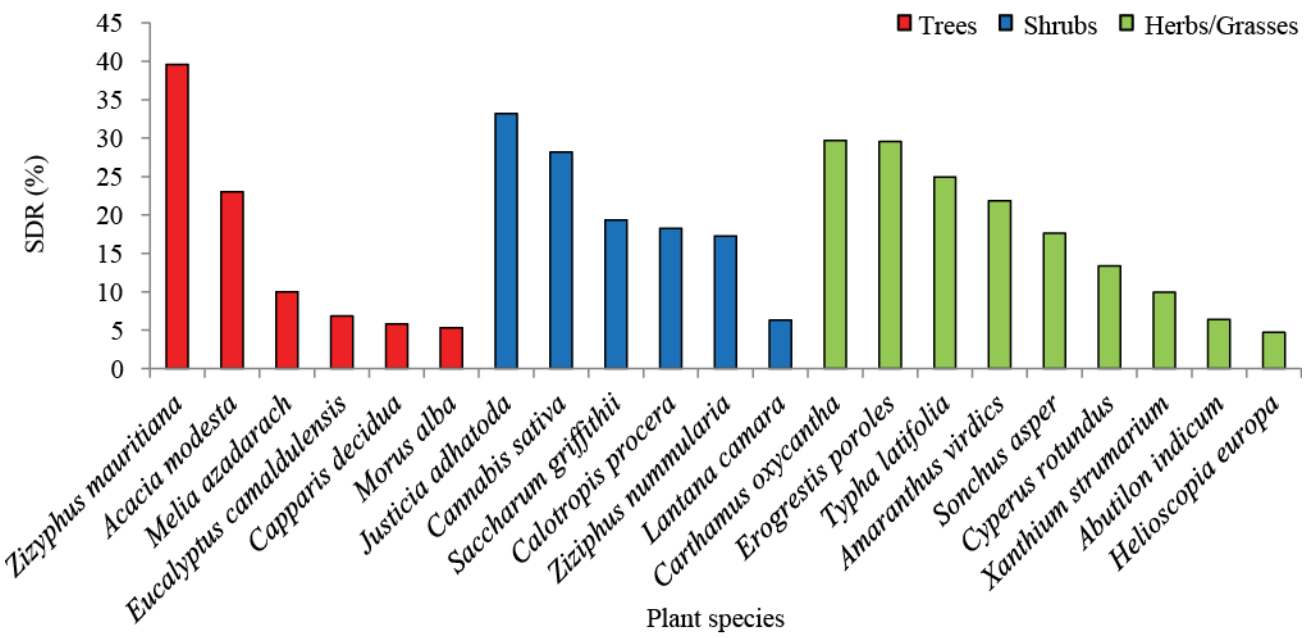

Fig. 3. Summed Dominance Ratio (SDR) of the plant species observed at study Site II (Prem Nagar Faqiran) in agro-ecosystem of Pothwar plateau, Pakistan.

Habitat evaluation and vegetation of Koont (Site III): Cropping system of study site-III namely Koont, Gujjar Khan district Rawalpindi, was consisting on wheat-groundnut combination and soil of the area was hard clay (Table 1). No water source in shape of rain water pond, small dam or rain water stream was available on the site or in nearby areas therefore the area was completely rain-fed. There was high human activity since this area was near a village and 75% of the area of selected site was being cultivated.

The vegetation composition of Koont is shown in Table 4 while Importance Value Indices (IVIs) are presented in Fig. 4. Six species of trees comprised the tree flora, occupying field boundaries of the site. The species were *Acacia modesta*, *Acacia nilotica*, *Eucalyptus camaldulensis*, *Ficus carica*, *Tamarix aphylla* and *Zizyphus mauritiana*.

The highest Summed Dominance Ratio (SDR) at site III was estimated for *Acacia modesta* and lowest for *Tamarix aphylla*. The shrub diversity was also low at this site and only four species recorded were; *Calotropis procera*, *Capparis aphylla*, *Grewia optiva* and *Ziziphus jujuba*. The highest SDR was of *Calotropis procera*, followed by *Ziziphus jujube*, *Capparis decidua* and *Grewia optiva*.

The herbaceous flora of this site comprised of ten species *viz*: *Aerva javanica*, *Chenopodium album*, *Cynodon dactylon*, *Datura stramonium*, *Heteropogon contortus*, *Parthenium hysterophorus*, *Saccharum bengalense*, *Setaria pumila*, *Tribulus terrestris* and *Withania somnifera*. Maximum SDR was calculated for *Setaria pumila* and minimum for *Withania somnifera*.

Table 4. Density, relative density (RD), relative frequency (RF), relative cover (RC) and Importance Value Index (IVI) of different floral species recorded at study site III (Koont) in agro-ecosystem of Pothwar plateau, Pakistan.

Tree species	Density/ha	RD	RF	RC	IVI
Acacia modesta	2.99	39.08	36.84	50	125.92
Acacia nilotica	1.87	24.44	18.44	21.11	63.99
Zizyphus mauritiana	1.7	22.22	24.98	3.21	50.41
Ficus carica	0.33	4.31	7.09	6.66	18.06
Eucalyptus camaldulensis	0.39	5.09	6.35	4.93	16.37
Tamarix aphylla	0.37	4.84	5.53	1.21	11.58
Shrubs species	**Density/4m^2**	**RD**	**RF**	**RC**	**IVI**
Calotropis procera	0.72	22.22	18.46	45	85.68
Ziziphus jujube	1.19	36.73	37.77	8.3	82.8
Capparis decidua	1	30.86	35.38	5.29	71.53
Grewia optiva	0.33	10.19	8.39	42	60.58
Herb/Grass species	**Density/1m^2**	**RD**	**RF**	**RC**	**IVI**
Setaria pumila	2.5	33.16	21.25	3.77	58.18
Cynodon dactylon	2.2	29.18	20.89	7.13	57.2
Saccharum bengalense	1.5	19.89	16.12	13.98	49.99
Parthenium hysterophorus	0.3	3.98	5.97	10.3	20.25
Heteropogon concortus	0.3	3.98	5.85	5.15	14.98
Tribulus terrestris	0.12	1.59	7.24	5.7	14.53
Chenopodium album	0.12	1.59	7.24	5.7	14.53
Aerva javanica	0.2	2.65	7.96	7.5	18.11
Datura stramonium	0.2	2.65	3.82	2.3	8.77
Withania somnifera	0.1	1.33	3.65	3	7.98

Table 5. Density, relative density (RD), relative frequency (RF), relative cover (RC) and Importance Value Index (IVI) of different floral species recorded at study site IV (Shah Syed Billu) in agro-ecosystem of Pothwar plateau, Pakistan.

Tree species	Density/ha	RD	RF	RC	IVI
Acacia nilotica	3.47	28.26	34.25	44.91	107.42
Zizyphus mauritiana	1.67	13.59	22.69	24.38	60.66
Acacia modesta	1.82	14.82	25.76	12.96	53.54
Olea ferruginea	3.96	32.25	6.47	7.21	45.93
Dalbergia sissoo	0.76	6.19	5.9	9.65	21.74
Tamarix aphylla	0.31	2.52	2.71	8.94	14.17
Capparis decidua	0.29	2.36	2.22	2.02	6.6
Shrubs species	**Density/4m^2**	**RD**	**RF**	**RC**	**IVI**
Dodonaea viscosa	1.83	43.26	25.57	6.9	75.73
Justicia adhatoda	1	23.64	25.92	15.62	65.18
Adhatoda vasica	0.65	15.37	17.05	26	58.42
Gymnosporia royleana	0.5	11.82	21.31	5.2	38.33
Ziziphus nummularia	0.25	5.91	10.14	12.5	28.55
Herb/Grass species	**Density/1m^2**	**RD**	**RF**	**RC**	**IVI**
Datura stramonium	2.3	21.95	18.13	79.99	120.07
Fumaria indica	2.1	20.04	16.29	66.67	103
Avera javanica	2.5	23.85	19.38	23.65	66.88
Carthamus oxycantha	0.72	6.87	10.86	27.75	45.48
Tribulus terrestris	1.5	14.31	13.63	17.11	45.05
Astragalus spinosus	0.66	6.29	10.86	16.25	33.4
Chenopodium album	0.5	4.77	7.24	5.7	17.71
Cannabis sativa	0.2	1.91	3.62	3.89	9.42

Habitat Evaluation and Vegetation of Shah Syed Billu (Site IV): Similar to site-III the substrate of this site was made of hard clay without any water access point. The site is located in area of village Shah Syed Billu, tehsil Choa Saden Shah of district Chakwal. Sixty percent of the area was under cultivation dominated by wheat- groundnut cropping system. There was high human disturbance due to human habitation in the area (Table 1).

A total of seven tree species were recorded at this site, namely *Acacia modesta*, *Acacia nilotica*, *Capparis decidua*, *Dalbergia sissoo*, *Olea ferruginea*, *Tamarix aphylla* and *Zizyphus mauritiana*. Second layer of vegetation was represented by five species of shrubs comprising of *Adhatoda vasica*, *Dodonaea viscosa*, *Gymnosporia royleana*, *Justicia adhatoda* and *Ziziphus nummularia* (Table 5).

The herbaceous flora consisted of eight species; *Astragalus spinosus*, *Aerva javanica*, *Cannabis sativa*, *Carthamus oxycantha*, *Chenopodium album*, *Datura stramonium*, *Fumaria indica* and *Tribulus terrestris*. The highest Summed Dominance Ratio (SDR) for trees, shrubs and grasses/herbs were calculated for *Acacia nilotica*, *Dodonaea viscosa* and *Datura stramonium* respectively and the minimum value of SDR was caluculated for *Capparis deciduas* (tree), *Ziziphus nummularia* (shrub) and *Cannabis sativa* (grass) (Fig. 5).

Vegetation comparison of four study sites: The sampling quadrat was used as the replicate to see if there was difference in vegetation based on the study (Table 6). In total, 12 tree species were recorded. *Acacia modesta* and *Zizyphus mauritiana* were present in all the study sites. Tree density did not differ significantly across the four sites ($F_{3, 68} = 1.12$, $P = 0.35$, $p>0.05$).

Vegetation stratum categorized as shrubs at all four study sites was represented by 14 species. The shrub densities did not differ significantly among the study sites when quadrat is the replicate ($F_{3, 68} = 0.78$, $P = 0.51$, $p>0.05$). Relatively drier sites represented by wheat-groundnut cropping system and devoid of any water source had higher ($t_2 = 4.39$, $P = 0.048$, $p<0.05$) populations diversity of shrubs as compared to the sites bearing wheat-maize/millet cropping system and having water resources (comparing mean values for these two sites to the mean values for the other two sites).

Twenty five species of grasses/herbs were recorded across the study sites. Density of these species significantly differed across the study sites ($F_{3, 68} = 2.90$, $P = 0.04$) and herbs present at site III were different from other sites but there was no clear association of herb density with cropping practice ($t_2 = 0.71$, $P = 0.55$). Instead the sites in district Chakwal had fewer herbs than the other districts. In summary there appear to be more shrubs in the drier sites than the wetter ones that could be due to rain fall and soil type of the latter locations, but the difference is marginal.

Discussion

This study recorded 51 species of plants associated with crop field boundary vegetation in two different cropping systems of Pothwar plateau which shows that the plateau has good agricultural flora. It was found that grasses and forbs pre-dominate the area. These results are in concordance with other studies conducted on wild flora in different areas of Pothwar plateau (Hasnain, 1985; Jabeen & Ahmad, 2009).

Two tree species namely *Acacia modesta* and *Zizyphus mauritiana* were common at all study sites indicating their widespread presence in the area. These results are supported by findings of Ahmed (2002) and Sher *et al.* (2012) in different valleys of this region. Hussain (2003) found that *Olea ferruginea* was also a very important dominant species of Pothwar region; however, this was not true for agro-ecosystem of Pothwar. *Acacia nilotica* and *Tamarix aphylla* were common trees at sites III and IV that were generally dry. These results are in agreement with other authors, e.g., Bargali & Bargali (2009) reported that *Acacia nilotica* is widespread across the arid and semi-arid regions of the world while Joseph & Tomaso (1998) and Tellman (2002) reported that colonization of *Tamarix aphylla* was closely associated with farming.

Same was true for *Calotropis procera* and *Ziziphus nummularia* as these shrubs were found at three out of four sites. Nawaz *et al.* (2012) also found them to be the abundant species of the area. Bastin *et al*. (2003) found that *Calotropis procera* is toxic and thus unpalatable to livestock but it is symptomatic of general habitat disturbance. However, *Ziziphus nummularia* is excellent fodder for livestock and is commonly found along farmlands of the world (Hocking, 1993; Orwa *et al*., 2009). *Cannabis sativa* and *Lantana camara* were found at sites I and II. These species are common invasive species in agricultural landscapes and ruderal habitats (Cooper, 2009; Berry *et al*., 2011). The presence of *Justicia adhatoda* and *Dodonaea viscosa* confirms that livestock grazing is common in agro ecosystems of this area since these are the indicator species of grazing (Ahmad *et al*., 2008b).

Among herbs and grasses *Abutilon indicum*, *Amaranthus* spp., *Cyperus rotundus* and *Eragrostis poroles* were common at sites I and II. *Amaranthus* spp., *Cyperus rotundus* and *Eragrostis poroles* favor the soil with moderate to high moisture and are common in cultivated areas, disturbed landscapes and gardens (Parsons & Cuthbertson, 2001; Ilyas *et al*., 2015). *Amaranthus hybridus* commonly called chalwera is a weed of wheat and cornfields throughout Punjab and Kyber Pakhtunkhuwa (Marwat *et al.,* 2010). Selvam *et al*., (2012) reported that *Abutilon indicum* was present in both dry and wet soils and hilly areas but in this study this species was found only in sites with nearby water access points. *Chenopodium album*, *Datura stramonium* and *Tribulus terrestris* were common at sites III and IV. Hussain *et al*., (2009) and Nawaz *et al.,* (2012) reported that dry climate and slightly acidic soils favoured these species which was true in this study.

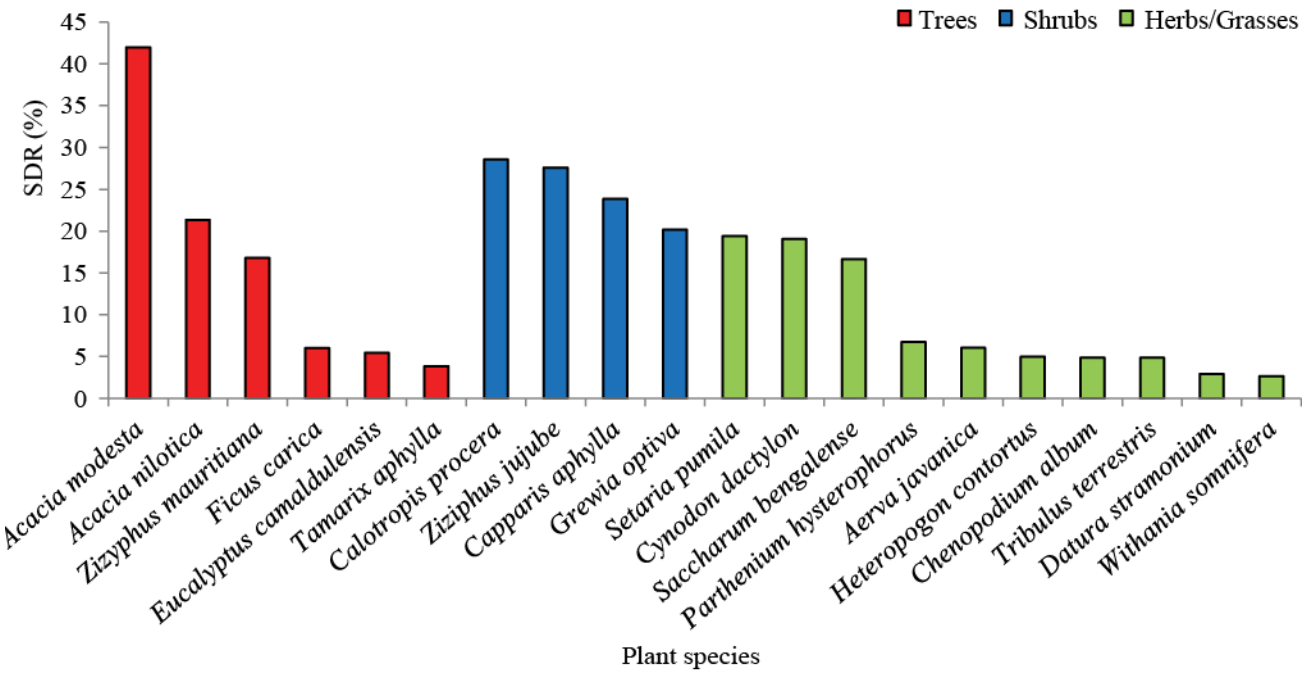

Fig. 4. Summed Dominance Ratio (SDR) of the plant species observed at study Site III (Koont) in agro-ecosystem of Pothwar plateau, Pakistan.

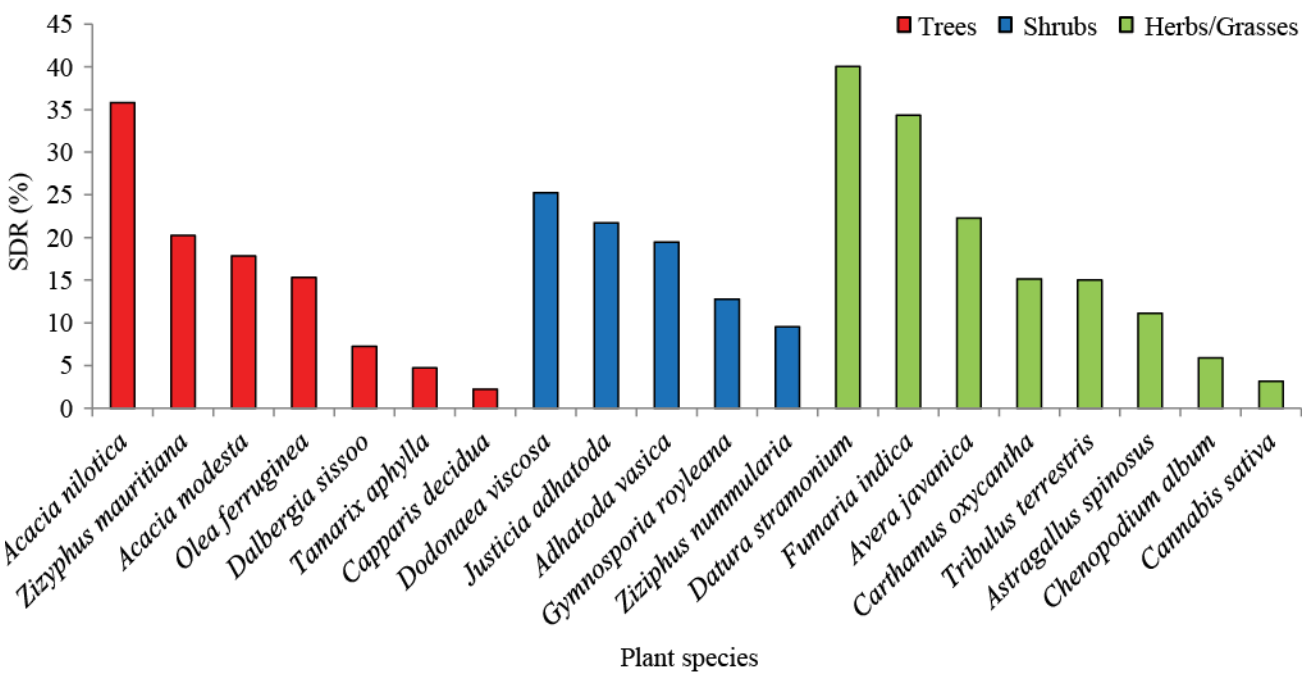

Fig. 5. Summed Dominance Ratio (SDR) of the plant species observed at study Site IV (Shah Syed Billu) in agro-ecosystem of Pothwar plateau, Pakistan.

Table 6. Mean density (± SD) of trees, shrubs and grasses/herbs at four study sites in agro-ecosystem of Pothwar plateau, Pakistan.

Sites	Trees (D/ha)	Shrubs (D/4m^2)	Herbs (D/1m^2)
Site I	1.21 ± 0.35^a	0.71 ± 0.17^b	0.65 ± 0.21^c
Site II	1.15 ± 0.42^a	0.66 ± 0.14^b	0.94 ± 0.26^c
Site III	1.28 ± 0.45^a	0.81 ± 0.19^b	0.75 ± 0.29^d
Site IV	1.75 ± 0.55^a	0.85 ± 0.27^b	1.31 ± 0.32^c
ANOVA*	$F_{3,68}$= 1.12, P=0.35	$F_{3,68}$=0.78, P=0.51	$F_{3,68}$=2.90, P=0.04

*ANOVAs were calculated using quadrate as replicate
Mean values denoted by common letter were not significantly different from each other

Conclusion

Agro-ecosystems of Pothwar plateau have good wild flora across the field borders and in total 51 species were recorded in this study. The dominant trees with widespread presence in the area were *Acacia modesta* and *Zizyphus mauritiana* while shrubs and grasses characteristic of scrub forest were abundant in the study sites.

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