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COMMUNICATION

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COMMUNICATION

Floristic composition and distribution pattern of herbaceous plant diversity in fallow lands of the central districts of Punjab, India

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Abstract: This study explores the change in composition of herbaceous plants with change in season and site in the fallow lands of central districts of Punjab, India. Overall 41 plant species were reported from studied sites. Poaceae and Asteraceae were recorded as dominant families with seven and six plant species, respectively. Density and IVI values of perennial plant species were recorded to be the maximum from July to September and for annuals maximum values were from February to March and from July to September. Diversity indices like Shannon Wiener index, evenness index, Menhinick index, and Simpson diversity index values showed variation with season and site. Similarity index value between studied sites was recorded to be the minimum in July (0.45) which indicates a maximum value of dissimilarity index in this month. The information generated in this study can be exploited by researchers for conservation of natural plant diversity and timely assessments of such areas help to study climate change.

Keywords: Diversity, index, month, site, species, weeds.

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Competing interests: The authors declare no competing interests.

Author details: Jashanpreet Kaur was postgraduate student at Punjab Agricultural University, Ludhiana and she has great interest in plant diversity evaluation along with their taxonomy. She had done the detailed study on herbaceous plants in different landuse systems of Punjab during her masters. Dr. Rajni Sharma currently working as professor in department of botany of Punjab Agricultural University, Ludhiana and she has been working in research project of plant diversity evaluation of Punjab. Dr. Pushp Sharma is Physiologist of oilseeds at Punjab Agricultural University, Ludhiana and she is working in research fields of abiotic stresses.

Author contribution: JK conducted field trips, collected and compiled data related plant diversity. RS planned the outline of this research work and provides necessary guidelines for research. PS helped in statistical analysis.

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INTRODUCTION

India is one of the mega-diverse centers of the world. About 8.07% land in India and 61ha land in Punjab is reported as fallow lands in 2013–2014 according to a report prepared by the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare in 2016. Throughout the year, the fallow lands are covered with green herbaceous plants. Plant diversity is functional and a structural unit of biotic component of the ecosystem and subjected to change on interaction with a number of biotic and abiotic factors. The study of diversity of an area helps to assess ecosystem health as species distribution has both complementary and supplementary behavior. Naturally growing plants species in ecosystems are diverse to such an extent that most species are not documented till now and sometimes some species become extinct without being identified (Hubbell & Foster 1986). Losing even a few plant species in a diverse ecosystem can reduce the biomass production and impair regulatory, promoting and supporting services of the ecosystem. The concept of wild species evolved when humans started growing plants deliberately for food (Shah et al. 2006). Documentation of composition of the plant diversity of fallow lands and their economic importance has not been done systematically. Thus people are not aware about the economic value of herbaceous plants growing in fallow lands and they overlook them as weeds. So phytosociological surveys of these areas after regular intervals are important to document the variability of plant diversity. This helps in environmental monitoring as a small change in environmental conditions affect diversity of plant species because some plant species are unable to bear transformations. The distribution of plants depends on their genetic makeup and environmental factors such as light, temperature, and edaphic factors like soil composition, texture, and pH (Curtis 1959; Phillips 1959; Misra 1968). This paper focuses on naturally growing herbaceous plant diversity, composition, and their distribution pattern in fallow lands to draw attention of researchers so that they can explore the economic importance and conservation of these plant species. The documentation of plants diversity of the fallow lands of Punjab has not been done so far.

MATERIALS AND METHODS

Study site

The present study was carried throughout year (January–December 2017) in fallow lands of two central districts of Punjab, viz,. site 1 Ludhiana (30°54'14.886"N, 75°49'0.4836"E) and site 2 Sangrur (30°40'59.7504''N & 75°49' 41.1672''E) districts (Figure 1, Image 1). The distance between two districts (sites) was 30km. At each district about 10 fallow lands were explored. The fallow lands selected for the present investigation were with almost negligible anthropogenic disturbances.

The climate of both areas is typical subtropical with long dry season from end of September to early June and wet season from July to early September along with

Figure 1. Study site. (Source: Google)

Image 1. Study sites: A—Fallow land in July and August | B—Fallow land from December to March. © Jashanpreet Kaur.

hot desiccating winds. The average temperature ranged from 5°C to 35°C and maximum rainfall received during August was 131.4mm and 97mm for site 1 and site 2, respectively.

METHODS

Areas were explored by quadrat method. The size and number of quadrats to be laid down were determined by species area curve (Misra 1968). For the present investigation, 15 fixed quadrats (1mÎ1m) were laid randomly in three replications to study ground-level herbaceous vegetation at each study site. Areas were surveyed after 30 days throughout the year commencing from January to December 2017. Shrubs and herbs were documented in the present investigation. The documented plant species were grouped into dicots and monocots (Images 1–41).

A species composition study was carried out by computing various phytosociological characters for each month by standard formulae. Calculations were done using Microsoft Excel 7 and values were counter checked using Paleontological Software (PAST) version 3.

(i) Density / m^2 (Curtis 1959)

$$\text{Density} = \frac{\text{Total number of individuals of the plant species in all quadrats}}{\text{Total number of quadrats studied}}$$

(ii) IVI – Importance Value Index (Phillips 1959)

IVI = Relative density + Relative frequency + Relative Dominance

$$\text{Relative density} = \frac{\text{Density of individual plant species x 100}}{\text{Density of all the species}}$$

$$\text{Relative frequency} = \frac{\text{Frequency of individual plant species x 100}}{\text{Frequency of all the species}}$$

$$\text{Relative dominance} = \frac{\text{Basal area of plant species x 100}}{\text{Basal area of all the species}}$$

(Here Basal area = $\pi d^2/4$)

(iii) Shannon Wiener index (Shannon & Wiener 1963)

Shannon Wiener index (H) = $- \Sigma [P_i (\ln P_i)]$

$$\text{Here } P_i = \frac{\text{Number of individuals of one plant species}}{\text{Total number of all individuals of plant species}}$$

(iv) Menhinick index (Menhinick 1964)

Menhinick index = $S / \sqrt{n}$

S = Number of taxa

n = Number of individuals

(v) Evenness index (Pielou 1977)

Evenness index = H / ln S

Here H = Shannon wiener diversity index

S = Total number of species

(vi) Similarity index (Sorenson 1948)

Similarity index (S) = 2C/ (A+ B)

Here A = Number of species in one system

B = Number of species in another system

C = Number of species common in both systems

(vii) Dissimilarity index (Sorenson 1948)

Dissimilarity index = 1- S

Here S = Similarity index

(viii) Simpson diversity index (Simpson 1949)

Simpson diversity index = $\{1- \Sigma n_i (n_i -1)\} / N(N-1)$

Here N = Number of plants of the species

n_i = Number of plants of a species

Identification of plant species was done with the help of regional floras and taxonomists of the university. Statistical measures for mean and standard deviation was carried out using software SPSS version 16.

RESULTS

a) Species diversity and distribution

Overall 41 species belonging to 19 families were documented from both study sites; 32 were dicots whereas monocots were represented by only nine plant species (Table 1). The fallow land of site 2 was represented by 32 plant species and site 1 by 31 plant species. Twenty-two plant species were common to both sites and 10 plant species were confined to site 2 while nine were confined only to site 1. *Artemisia scoparia*, *Conyza bonariensis*, *Croton bonplandianus*, *Euphorbia hirta*, *Ipomoea pestigridis*, *Gnaphalium purpureum*, *Polygonum plebeium*, *Stellaria media*, and *Xanthium strumarium* were confined to site 1; *Abutilon indicum*, *Cenchrus biflorus*, *C. catharticus*, *C. setiger*, *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Poa annua*, *Sida cordifolia*, *Sesamum indicum*, and *Tribulus terestris* were confined to site 2; however, the rest of the plant species were common at both locations. Poaceae (Table 2) with seven plant species was dominant at site 2 while Asteraceae dominated with six plant species at site 1.

b) Density and IVI at two locations

Density values on both study sites were recorded between 0.07–10.5. In the case of perennial plant species, the maximum value (10.5) was observed for *Parthenium hysterophorus* in September at site 2. At site 1, however, the value of this species varied between 1.00–3.53. At site 1, the maximum density was for *Chenopodium album* (7.6) in August. Among annuals, the maximum value was observed for *Anagallis arvensis* (2.13) in March at site 2 and for *Coronopus didymus* (3.26) in April at site 1. For species that are confined to a particular study site, maximum density values were recorded for *Artemisia scoparia* (2.67) in site 1 and *Digitaria sangunalis* (2.93) in site 2 (Appendix 1).

Importance Value Index (IVI) values of the two study sites ranged from 0.26 to 106. Among perennials, *Chenopodium album* (106) showed a maximum value in site 2 while in site 1 values of this index for *C. album* was below 50. Similarly for site 1, *Achyranthes aspera* showed maximum values, i.e., 82.9 while in Site 2 values of IVI for this species were below 50. Among annuals, a maximum value of 71.4 was observed at site 2 for *Anagallis arvensis* in January. *Malva parviflora* was recorded to have maximum IVI, i.e., 11.2 at site 1 in January. *Artemisia scoparia* which was confined to site 1 showed maximum density (27) in September while *Cenchrus biflorus* recorded only at site 2 showed a maximum density, i.e., 8.03 in November (Appendix 2).

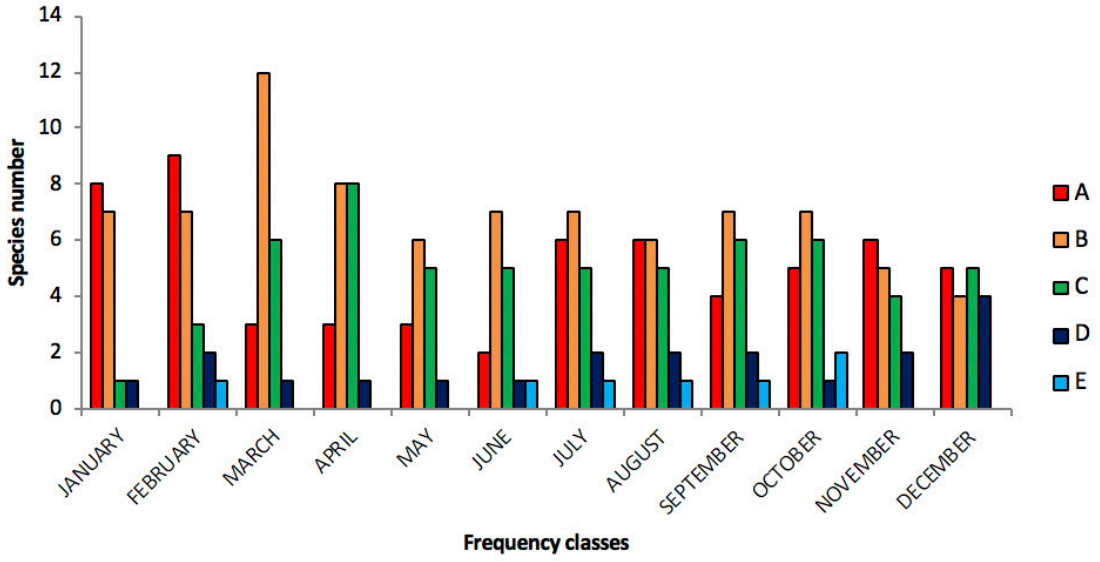

Figure 2. Raunkiaer's frequency class distribution in fallow land of Ludhiana, Punjab, India.

Table 1. Floristic composition of fallow lands of two locations (Ludhiana and Sangrur) in Punjab.

Plant species	Family	Group	Site 1	Site 2
Abutilon indicum (L.) Sweet	Malvaceae	Dicot	-	+
Achyranthes aspera L.	Amaranthaceae	Dicot	+	+
Ageratum conyzoides L.	Asteraceae	Dicot	+	+
Anagallis arvensis L.	Primulaceae	Dicot	+	+
Artemisia scoparia Waldst. & Kit.	Asteraceae	Dicot	+	-
Boerhavia diffusa L.	Nyctaginaceae	Dicot	+	+
Calotropis procera (Aiton) W.T.Aiton	Apocynaceae	Dicot	+	+
Cannabis sativa L.	Malvaceae	Dicot	+	+
Senna occidentalis (L.) Link	Fabaceae	Dicot	+	+
Cenchrus biflorus Roxb.	Poaceae	Monocot	-	+
Cenchrus catharticus Delile	Poaceae	Monocot	-	+
Cenchrus setiger Vahl	Poaceae	Monocot	-	+
Chenopodium album L.	Chenopodiacae	Dicot	+	+
Conyza bonariensis (L.) Cronquist	Asteraceae	Dicot	+	-
Coronopus didymus (L.) Sm.	Brassicaceae	Dicot	+	+
Croton bonplandianus Baill.	Euphorbiaceae	Dicot	+	-
Cynodon dactylon (L.) Pers.	Poaceae	Monocot	+	+
Dactyloctenium aegyptium (L.) Willd.	Poaceae	Monocot	-	+
Dicliptera brachiata (Pursh) Spreng.	Acanthaceae	Dicot	+	+
Digitaria sanguinalis (L.) Scop.	Poaceae	Monocot	-	+
Euphorbia hirta L.	Euphorbiaceae	Dicot	+	-
Gnaphalium purpureum L.	Asteraceae	Dicot	+	-
Indigofera linifolia (L.f.) Retz.	Fabaceae	Dicot	+	+
Ipomoea pes-tigridis L.	Convolvulaceae	Dicot	+	-
Malva parviflora L.	Malvaceae	Dicot	+	+
Medicago polymorpha L.	Fabaceae	Dicot	+	+
Parthenium hysterophorus L.	Asteraceae	Dicot	+	+
Poa annua L.	Poaceae	Monocot	-	+
Polygonum plebeium R.Br	Polygonaceae	Monocot	+	-
Sesamum indicum L.	Pedaliaceae	Dicot	-	+
Sida acuta Burm.f.	Malvaceae	Dicot	+	+
Sida cordifolia L.	Malvaceae	Dicot	-	+
Sisymbrium irio L.	Brassicaceae	Dicot	+	+
Spergula arvensis L.	Caryophyllaceae	Monocot	+	+
Stellaria media (L.) Vill.	Caryophyllaceae	Dicot	+	-
Tephrosia purpurea (L.) Pers..	Fabaceae	Dicot	+	+
Trianthema portulacastrum L.	Aizoaceae	Dicot	+	+
Tribulus terrestris L.	Zagophyllaceae	Dicot	-	+
Urena lobata L.	Malvaceae	Dicot	+	+
Veronica agrestris L.	Plantginaceae	Dicot	+	+
Xanthium strumarium L.	Asteraceae	Dicot	+	-

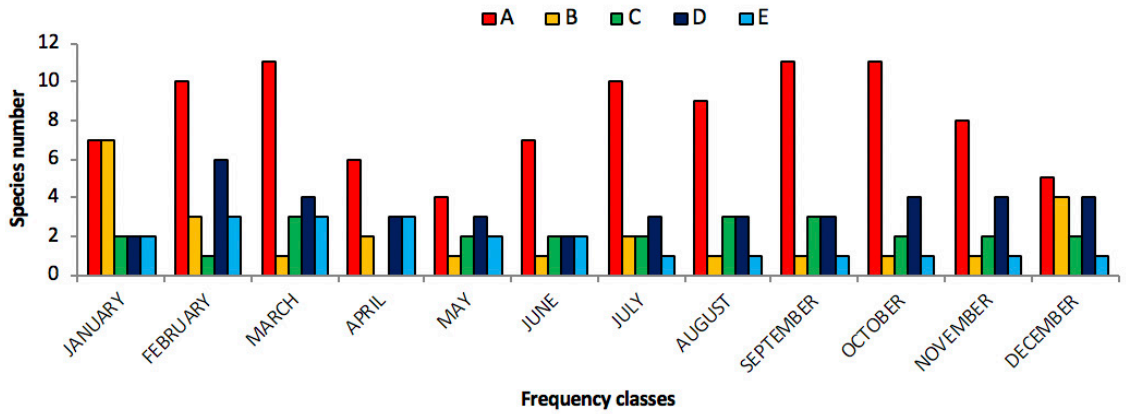

Figure 3. Raunkiaer's frequency class distribution in fallow land of Sangrur, Punjab, India.

Table 2. Distribution of number of plant species among families in fallow lands of Ludhiana and Sangrur in Punjab.

	Family	Site 1	Site 2
1	Asteraceae	6	2
2	Poaceae	1	7
3	Malvaceae	4	6
4	Fabaceae	4	4
5	Brassicaceae	2	2
6	Caryophyllaceae	2	1
7	Amaranthaceae	1	1
8	Primulaceae	1	1
9	Nyctaginaceae	1	1
10	Apocynaceae	1	1
11	Chenopodiaceae	1	1
12	Acanthaceae	1	1
13	Aizoacae	1	1
14	Plantaginaceae	1	1
15	Euphorbiaceae	2	0
16	Convolvulaceae	1	0
17	Polygonaceae	1	0
18	Pedalliaceae	0	1
19	Zagophyllaceae	0	1

c) Raunkiaer's frequency distribution classes

In Raunkiaer's frequency distribution classes curve for site 1 (Figure 2), a number of plant species included in class A decreased up to June followed by an increase in the number of species with a slight decrease in the month of September and October. In frequency distribution class B maximum number of species were recorded in March (12 species) and after March, the species number started decreasing. For class C maximum numbers of plant species were recorded; eight in April with a slight decrease thereafter. For class D the maximum number of plant species was four, recorded in the month of December and in the rest of the months, the number of species for this class distribution was between 1 and 0. Very less number of plant species was recorded for class E. In January, March–May and November–December no plant species were recorded in this category.

In Raunkiaer's frequency distribution classes curve for site 2 (Figure 3), the maximum species were recorded in class A and B. In class A the maximum number of plant species was eleven each recorded in March, September and October. In class B, a maximum number of plant species, i.e., seven were recorded in January after that the number of individuals having frequency in this range decreased with a slight increase in December (4). For frequency class C the number of plant species recorded were 2 or 3 and in April no plant species were recorded for this class. In frequency class D, the maximum number of plant species was six in February. In frequency class E the number of plant species decreased from March to December.

d) Diversity Indices

Values of all diversity indices showed variation for each month (Figure 4). Shannon Wiener index represents entropy in plant community. The values recorded for this index were between 1.73–2.69 at both studied locations. The highest value of this index was reported in March (2.47) from site 1 while in December (2.69) from site 2.

Simpson Diversity index (Table 3) measures diversity of community by taking into consideration dominant taxa. This index values recorded between 0.81–0.93 from both study sites. From site 1 the highest value (0.91) was recorded in January and February, however, from site 2 the highest value (0.93) was recorded in February only.

Evenness index indicated evenness of plant species

Table 3. Monthly Community characteristics of fallow lands at both sites.

Parameter / Month	Fallow land (Site 1)				Fallow land (Site 2)			
	Shannon Wiener index	Simpson diversity index	Evenness index	Menhinick index	Shannon Wiener index	Simpson diversity index	Evenness index	Menhinick index
January	2.33±0.35	0.91±0.01	0.77±0.11	1.71±0.15	2.13±0.2	0.85±0.59	0.56±0.11	1.95±0.21
February	2.46±0.12	0.91±0.01	0.81±0.04	1.47±0.15	2.68±0.18	0.93±0.02	0.70±0.07	1.77±0.06
March	2.47±0.12	0.89±0.01	0.80±0.04	1.47±0.11	2.56±0.27	0.90±0.04	0.65±0.12	1.52 ±0.15
April	2.03±0.10	0.86±0.02	0.77±0.34	1.08±0.22	2.45±0.23	0.88±0.05	0.63±0.13	1.34±0.09
May	1.73 ±0.7	0.81±0.12	0.81±0.21	1.11±0.16	2.09 ±0.22	0.85±0.04	0.64±0.04	1.24 ±0.16
June	1.86 ±0.15	0.82±0.02	0.72±0.06	1.20 ±0.22	2.02±0.18	0.82 ±0.05	0.52 ±0.09	1.10 ±0.16
July	2.02±0.04	0.85±0.13	0.67±0.15	1.38±0.30	1.73±0.23	0.85 ±0.05	0.50±0.11	1.32 ±0.14
August	2.04±0.12	0.86±0.00	0.75 ±0.06	1.30±0.24	2.16±0.45	0.85±0.05	0.52 ±0.11	1.23±0.12
September	2.11±0.06	0.87±0.00	0.73±0.02	1.41 ±0.05	2.34±0.26	0.87±0.04	0.55 ±0.12	1.23 ±0.09
October	2.22±0.09	0.87±0.00	0.77 ±0.04	0.82±0.02	2.49±0.41	0.89±0.03	0.59 ±0.07	1.41 ±0.03
November	2.08±0.11	0.87±0.00	0.77±0.04	0.83±0.00	2.28±0.18	0.88±0.02	0.63 ±0.07	0.83 ±0.04
December	2.34±0.09	0.89±0.00	0.88±0.02	1.46±0.07	2.69±0.16	0.91±0.00	0.70±0.04	1.64 ±0.09
Mean	2.14±0.25	0.87±0.32	0.77±0.90	1.27±0.30	2.30±0.36	0.87±0.05	0.60±0.10	1.38±0.31

(Mean ± Standard deviation).

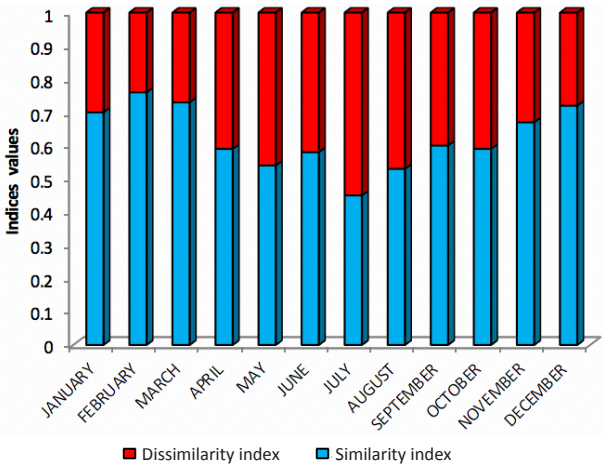

Figure 4. Monthly similarity and dissimilarity indices values between both study sites.

in particular community. The values for this index was recorded as highest in December at both site 2 (0.88) and site 1 (0.70). In site 2 the highest value of 0.70 was also recorded in the month of February.

Species Richness index (Menhinick index) value was recorded between 0.82–1.95 and maximum value of this index was recorded in January for both Site 2 (1.95) and Site 1 (1.75).

Sorenson similarity index predicts similarity between study sites (Figure 3). The highest values of this index were recorded (0.76) in February then values started decreasing and became the lowest in July (0.45) after which value of this index started increasing. Dissimilarity index value was recorded to be the highest in July (0.55).

DISCUSSION

In the present investigation, the difference in the number of individuals between systems, confinement of plant species to particular systems and difference in dominance of plant species may be due to environment, mainly edaphic or some other factors. Literature studies by many workers on a number of plant species and dominant families in different land use systems like Hailu (2017) recorded 58 plant species in rangelands of Ethiopia and 70 plant species (herbs, shrubs, and trees) were recorded by Kaur (2015) in the wasteland of Amritsar. Kaur et al. (2017) reported Asteraceae as the dominant family in Doaba region of Punjab while Poaceae was reported as the dominant family in the wasteland of Amritsar by Kaur (2015).

Among the perennials, density values were a maximum up to 10.5 in September at site 2 while at site 1, the maximum values were up to 7.6 recorded in August. The density values for annuals were below three at both studied locations. Higher density values at site 2 might be due to difference in fertility of soil or other environmental factors.

Analysis of IVI indicated status and pattern of variation of dominant plant species. *Chenopodium album* at site

2 and *Achyranthes aspera* at site 1 were identified as important species throughout the year because their IVI values were higher than 50. Differences in IVI values of two study sites might be due to changes in surrounding conditions and anthropogenic activities. Similarly, Hailu (2017) worked out the IVI values of rangelands with two different management practices and concluded 75.29 as maximum IVI value for the herbaceous species named *Eragrostis aspera*.

In Raunkiaer's frequency distribution classes, there was absence of frequency class E at site 1 in January, March, April, May, November, and December whereas at site 2 class C was non-existent in April. Missing of classes indicates the heterogeneity in species diversity of study sites which might be due to biotic factors (Iqbal 2008). Raunkiaer's frequency classes were also used by Mishra et al. (2004) to study effects of anthropogenic disturbances on plant diversity and community structures in Meghalaya, India.

Shannon Wiener index typical values lies between 0 to 3.5. In the present study, the index value ranged from 1.73 to 2.69. Higher values were recorded at site 2 fallow land which indicated higher number of plant species. Pramanik & Das (2015) calculated Shannon Wiener index to study vegetation of Buxa Tiger Reserve, Gorumara national parks and recorded variation in values from 1.40 to 0.009.

Simpson diversity index indicates diversity of dominant plant species. As values in the present study were less than 1 so we can conclude study sites were not dominated by single plant species. Index values were maximum in month of January (0.91) and February (0.91) at site 1 whereas in February (0.93) at site 2. Iqbal (2008) computed this index for urban localities of Krachi with values from 1.36 to 4.54.

Overall mean values of Evenness index were maximum at site 2 revealing evenness in distribution of individuals of species. With respect to months, species were evenly distributed in February at site 2 and in December at site 1. Similarly, Ismail et al. (2015) used evenness index for herbaceous vegetation of two localities Rashad and Alabassia of Sudan and values reported by him ranged from 1.11 to 1.35.

From Menhinick index values, it is concluded highest species richness was present at site 2. Maximum species richness was recorded in January at both sites in Punjab.

CONCLUSIONS

The present documentation of species suggests that fallow lands which are considered as waste lands have enormous economic plant wealth. Punjab being an agrarian state more stress is laid on use of land for cultivation purposes but there is dire need to explore and document rich plant wealth in fallow lands for medicinal or other economic values. By consulting the literature of medicinal plants, it was concluded that all the plants documented in the study possess medicinal values but due to a lack of awareness and research on these plant species they are considered of no use.

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Image 1. *Abutilon indicum* (L.) Sweet

Image 2. *Achyranthes aspera* L.

Image 3. *Ageratum conyzoides* L.

Image 4. *Anagallis arvensis* L.

Image 5. *Artemisia scoparia* Waldst. & Kit.

Image 6. *Boerhaavia diffusa* L.

Image 7. *Calotropis procera* (Aiton)W.T. Aiton

Image 8. *Cannabis sativa* L.

Image 9. *Senna occidentalis* (L.) Link

Image 10. *Cenchrus biflorus* Roxb

Image 11. *Cenchrus catharticus* Delile

Image 12. *Cenchrus setiger* Vahl

Image 13. *Chenopodium album* L

Image 14. *Conyza bonariensis* (L.) Cronquist

Image 15. *Coronopus didymus* (L.) Sm

Image 16. *Croton bonplandianus* Baill

Image 17. *Cynodon dactylon* (L.) Pers

Image 18. *Dactyloctenium aegyptium* (L.) Willd

Image 19. *Dicliptera brachiata* (Pursh) Spreng

Image 20. *Digitaria saguinalis* (L.)

Image 21. *Euphorbia hirta* (L.)

Image 22. *Gnaphalium purpureum* L

Image 23. *Indigofera linifolia* (L.f.) Retz

Image 24. *Ipomoea pes-tigridis* L

Image 25. *Malva parviflora* L

Image 26. *Medicago polymorpha* L

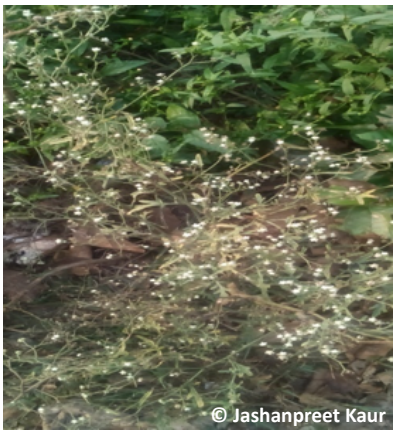

Image 27. *Parthenium hysterophorus* L

Image 28. *Poa annua* L

Image 29. *Polygonum plebeium* R.Br

Image 30. *Sesamum indicum* L

Image 31. *Sida acuta* Burm.f

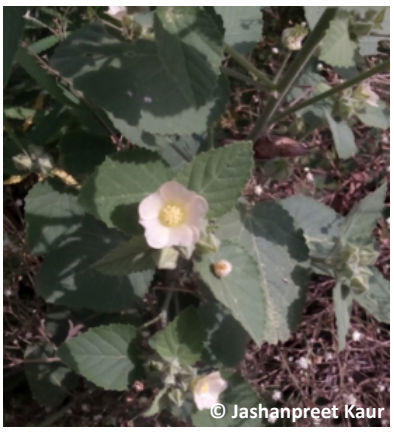

Image 32. *Sida cordifolia* L

Image 33. *Sisymbrium irio* L

Image 34. *Spergula arvensis* L

Image 35. *Stellaria media* (L.) Vill

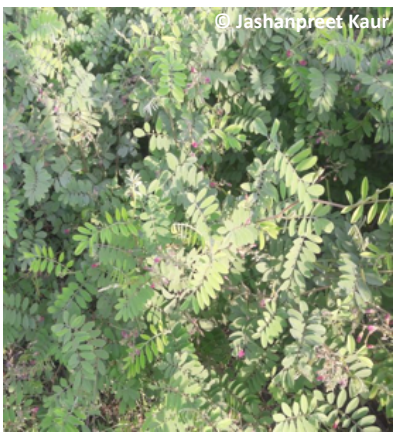

Image 36. *Tephrosia pupurea* (L.) Pers

Image 37. *Trianthema portulacastrum* L

Image 38. *Tribulus terrestris* L

Image 39. *Urena lobata* L

Image 40. *Veronica agrestis* L

Image 41. *Xanthium strumarium* L

Appendix 1. Variation in monthly density of plant species in fallow land at site 1 (L) and site 2 (Sangrur) from January–December 2017: L—Site 1 | S—Site 2 | *—indicates absence of plant species | 0—indicates completion of life-cycle of plant | L—Ludhiana | S—Sangrur.

	Month	Jan		Feb		March		April		May		June		July		Aug		Sept		Oct		Nov		Dec	
	Plant species	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S
1	*Abutilon Indicum* (L.) Sweet	*	1.4	*	1.4	*	0.8	*	0.8	*	0.8	*	1	*	1.4	*	1.4	*	1.4	*	1.4	*	1.4	*	1.4
2	*Achyranthes aspera* L.	1.86	4.34	2.53	2.67	2.53	2.07	1.93	1.4	1.8	1.6	1.8	1.07	0	0.87	0	0.87	0	1.87	0	2.07	0	1.87	0	1.8
3	*Ageratum conyzoides* L.	0.8	0.27	0.8	0.6	0.8	0.73	0.53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	*Anagallis arvensis* L.	1.07	1	1.67	1.07	1.53	2.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	*Artemisia scoparia* Waldst. & Kit.	0	*	0	*	0	*	0	*	1.67	*	1.67	*	1.87	*	2.33	*	2.27	*	1.31	*	2.27	*	2.67	*
6	*Boerhavia diffusa* L.	0	0	0	0	0	0	0	0	0	0	0.67	0.6	0.67	0.6	0.67	0.87	0.67	0.87	0.67	0.8	0.67	0.73	0	0
7	*Calotropis procera* (Aiton) W.T. Aiton	0.13	0.27	0.13	0.27	0.13	0.73	0.13	0.73	0.13	0.87	0.13	1.13	0.13	0.27	0.27	0.27	0.27	0.27	0.23	0.27	0.27	0.27	0.27	0.27
8	*Cannabis sativa* L.	1.8	0.8	6	2.2	6	6.27	3.87	1	3.4	3.47	3.4	0.53	3	6.07	3	6.07	2.73	6.07	2.03	3.53	2.73	3.53	2.06	1.27
9	*Senna occidentalis* (L.) Link	1.2	0.87	1.2	0.6	1.2	1	2.47	0	0.87	0.67	0.87	0.8	0.87	1.93	0.87	1.93	0.93	2.8	0.75	2.8	0.93	2.6	0.93	2.53
10	*Cenchrus biflorus* Roxb.	*	0.74	*	0	*	0	*	0	*	0	*	4.67	*	0.8	*	0.8	*	0.87	*	0.87	*	0.87	*	1.33
11	*Cenchrus catharticus* Delile	*	0.54	*	0.74	*	0	*	2.07	*	0	*	1.8	*	0.27	*	0.27	*	0.33	*	0.33	*	0.4	*	0.4
12	*Cenchrus setiger* Vahl	*	0	*	1.06	*	1.87	*	2.6	*	0.8	*	0	*	0	*	0	*	0	*	0	*	0	*	0
13	*Chenopodium album* L.	0.33	0	1.2	2.07	1.2	1.07	1.13	1.73	0	3.13	0	5.27	1.33	7.6	1.33	7.6	1.2	7.6	1	5.33	1.13	0	1	0
14	*Conyza Bonariensis* (L.) Cronquist	0	*	0	*	0	*	0	*	0	*	0.07	*	0.07	*	0.07	*	0.07	*	0.08	*	0.07	*	0	*
15	*Coronopus didymus* (L.) Sm.	0.53	0.2	1.8	0.74	1.8	1.93	3.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.87
16	*Croton bonplandianus* Baill.	0	*	0	*	0	*	0	*	0	*	0	*	0.07	*	0.2	*	0.03	*	0.23	*	0.33	*	0	*
17	*Cynodon dactylon* (L.) Pers.	4	1.8	4	2.13	4.67	2.27	4.67	2.87	4.67	1.8	4.67	1.93	0.67	1.8	4.67	1.8	4.67	1.8	4.67	1.8	4.67	1.8	4.67	1.8
18	*Dactyloctenium aegyptium* (L.) Willd.	*	0	*	0	*	0	*	0	*	0	*	0	*	0.53	*	0.53	*	0.53	*	0.53	*	0.2	*	0
19	*Dicliptera brachiata* (Pursh) Spreng.	0.27	0.33	0.27	0.34	0.27	0.33	0	0	0	0	0	0	0	0	0	0	0.33	0	0.28	0.4	0.33	0.4	0.34	0.4
20	*Digitaria sanguinalis* (L.) Scop.	*	0	*	0	*	0	*	0	*	0	*		*	2.93	*	2.93	*	2.93	*	2.8	*	0	*	0
21	*Euphorbia hirta* L.	0	*	0	*	0	*	0	*	0	*	0	*	0.13	*	0.13	*	0.13	*	0.16	*	0	*	0	*
22	*Gnaphalium purpureum* L.	0.13	*	0.2	*	0.2	*	0.2	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*
23	*Indigofera linifolia* (L.f.) Retz.	0	0	0.2	0.4	0.2	0.67	0.2	1	0.2	0.47	0.2	0.47	0.2	0.4	0	0	0	0	0	0	0	0	0	0

	Month	Jan		Feb		March		April		May		June		July		Aug		Sept		Oct		Nov		Dec	
24	*Ipomoea pes-tigridis* L.	0	*	0	*	0	*	0	*	0	*	0.33	*	0.33	*	0.33	*	0.67	*	0	*	0	*	0	*
25	*Malva Parviflora* L.	0.93	0.27	1.33	0.8	1.53	0.53	0	0.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.87	1.54
26	*Medicago polymorpha* **L.**	0.4	0.34	0.47	0.4	0.27	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	*Parthenium hysterophorus* L.	1	0.74	1	2.73	1	3.53	1	3.53	1	1.4	1	6.07	2.33	10.5	2.33	10.5	2.47	10.5	1.23	7.53	1.73	3.6	1.73	3.2
28	*Poa annua* L.	*	0	*	0.4	*	1.27	*	1.27	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0
29	*Polygonum plebeium* R.Br	0	*	0.07	*	0.07	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*
30	*Sesamum Indicum* L.	*	0	*	0	*	0	*		*	0.33	*	0.33	*	0.33	*	0.33	*	0.33	*	0.33	*	0.33	*	0.27
31	*Sida acuta* Burm.f.	2.13	0	2.13	1.93	2.13	1.93	2.27	1.93	1.13	0.33	1.13	0.2	1.33	2.6	1.33	2.6	1.27	2.6	1	2.67	1.53	1.33	1.53	1.33
32	*Sida Cordifolia* L.	*	0	*	0	*	0	*	0	*	0	*	0	*	0.27	*	0.27	*	0.87	*	0.87	*	0.53	*	0.53
33	*Sisymbrium irio* L.	0.2	0.4	0.33	1.87	0.33	1.73	0.33	1.73	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	1.2	1.6
34	*Spergula arvensis* L.	1	0	1	1.07	1.13	1.2	0	1.2	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	1	1.2
35	*Stellaria media* (L.) Vill.	0.8	*	1.6	*	0.8	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0.27	*
36	*Tephrosia purpurea* (L.) Pers..	0	0	0	0	0	1	0	1	0.13	0.6	0.13	0.6	0.13	0.73	0.13	0.73	0.13	0.73	0.13	0.73	0.13	0.73	0.13	0
37	*Trianthema portulacastrum*L.	0	0	0	0	0	0	0	0	0	0	0	1.07	0.47	0.6	0	0.6	0.13	1	0.13	1	0.13	0	0	0
38	*Tribulus terrestris* L.	*	0	*	0	*	0	*	0	*	0	*	0.33	*	0.8	*	0.8	*	0.93	*	0.93	*	0	*	0
39	*Urena lobata* L.	0.13	0.67	0.13	0.4	0.13	0.67	0.13	0.73	0.27	0.8	0.27	0.33	0.27	0.47	0.27	0.2	0.13	0.6	0.13	0.53	0.13	0.33	0.13	0.33
40	*Veronica agrestris* L.	0.4	0.8	1.06	0.8	1.07	0.4	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	*Xanthium strumarium* L.	0	*	0	*	0	*	0	*	0	*	0	*	0.2	*	0.2	*	0.2	*	0.67	*	0	*	0	*

Appendix 2. Variation in monthly Importance Value Index(IVI) of plant species in fallow land at Site 1(L) and Site 2(S), January–December 2017.

	Month	Jan		Feb		March		April		May		June		July		August		September		October		November		December	
	Plant species	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S
1	*Abutilon Indicum* (L.) Sweet	*	86.2	*	42.6	*	44.5	*	35.1	*	30.8	*	25	*	24.3	*	23.7	*	22.9	*	26.3	*	67.2	*	48.6
2	*Achyranthes aspera* L.	82.9	52.2	72.9	23.1	71.6	15	70.4	13.9	5.35	18.1	5.26	11.7	43.7	8.6	57.4	8.91	58.8	11.2	64.7	10.4	63.1	18.5	69.4	16.5
3	*Ageratum conyzoides* L.	6.96	5.06	4.27	6.01	4.22	4.63	3.46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	*Anagallis arvensis* L.	13.3	71.4	13.9	28.5	11.4	14.4	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	*Artemisia scoparia* Waldst. & Kit.	0	*	0	*	0	*	0	*	12	*	11.9	*	24.1	*	27.4	*	27	*	26.1	*	22.9	*	24.5	*
6	*Boerhavia diffusa* L.	0	0	0	0	0	0	0	0	0	0	0.43	8.81	1.68	5.57	1.5	6.58	1.59	6.18	1.53	7.23	1.61	10.1	0	0
7	*Calotropis procera* (Aiton) W.T. Aiton	8.95	15.8	6.14	8.74	6.06	14.3	7.52	10.8	26.2	11.3	25.6	9.61	9.51	5.94	16.3	5.99	16.7	5.81	15.6	6.97	15.4	13.3	15.3	2.94
8	*Cannabis sativa* L.	19.4	13.1	33.5	15.2	31.6	30.9	34.7	36.1	13.5	29.5	13.3	25.4	30.9	23.3	28.8	23.8	26.4	21.6	25.7	17.4	21	31.3	20	63.2
9	*Senna occidentalis* (L.) Link	18.8	18.7	14.2	5.77	12	10.5	28.7	10.3	12	10.3	11.9	8.27	20.1	12.9	18.5	13.1	17.9	14.9	17.2	16.8	16	31.8	16	19.3
10	*Cenchrus biflorus* Roxb.	*	10.4	*	0	*	0	*	0	*	0	*	0	*	5	*	5.13	*	4.89	*	5.09	*	8.03	*	7.1
11	*Cenchrus catharticus* Delile	*	12.7	*	5.62	*	0	*	0	*	0	*	5.28	*	3.11	*	3.23	*	3.73	*	3.77	*	6.71	*	5.18
12	*Cenchrus setiger* Vahl	*	0	*	7.17	*	9.76	*	9.34	*	3.17	*	0	*	0	*	0	*	0	*	0	*	0	*	0
13	*Chenopodium album* L.	13.9	0	28.5	61.3	28.3	44.5	33	68.5	0	106	0	102	54	99.5	45	100	42.3	7.17	39.5	88	37	0	31.8	0
14	*Conyza Bonariensis* (L.) Cronquist	0	*	0	*	0	*	0	*	0	*	0.61	*	1.62	*	1.56	*	1.62	*	1.55	*	1.28	*	0	*
15	*Coronopus didymus* (L.) Sm.	5.94	5.5	15.4	7.88	13.3	11.8	26.9	11.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.91
16	*Croton bonplandianus* Baill.	0	*	0	*	0	*	0	*	0	*	0	*	1.68	*	3.43	*	3.84	*	5.24	*	4.82	*	0	*
17	*Cynodon dactylon* (L.) Pers.	33.7	15.5	24.3	12.2	24.1	11	36.1	11.6	3.02	10.9	2.98	9.07	42.9	6.47	40.4	6.64	40.7	6.19	39.9	6.94	33.8	11	36.5	9.91
18	*Dactyloctenium aegyptium* (L.) Willd.	*	0	*	0	*	0	*	0	*	0	*	0	*	4.62	*	4.71	*	4.29	*	4.37	*	3.16	*	0
19	*Dicliptera brachiata* (Pursh) Spreng.	4.32	7.39	3.33	4.28	2.77	6.14	0	0	0	0	0	0	0	0	0	0	5.45	0	5.29	3.63	5.18	5.87	4.82	4.57

	Month	Jan		Feb		March		April		May		June		July		August		September		October		November		December	
20	*Digitaria sanguinalis* (L.) Scop.	*	0	*	0	*	0	*	0	*	0	*	0	*	13.2	*	13.4	*	12.3	*	12.8	*	0	*	0
21	*Euphorbia hirta* L.	0	*	0	*	0	*	0	*	0	*	0	*	1.8	*	1.74	*	1.81	*	1.76	*	0	*	0	*
22	*Gnaphalium purpureum* L.	2.75	*	2.37	*	1.8	*	2.17	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*
23	*Indigofera linifolia* (L.f.) Retz.	0	0	2.25	5.64	2.19	4.71	3.09	6.76	1.25	11.4	1.23	9.4	4.84	4.58	0	0	0	0	0	0	0	0	0	0
24	*Ipomoea pes-tigridis* L.	0	*	0	*	0	*	0	*	0	*	0.61	*	4.13	*	3.97	*	1.55	*	3.21	*	0	*	0	*
25	*Malva Parviflora* L.	11.2	6.57	9.95	8.23	10.6	6.86	0	5.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.73	15
26	*Medicago polymorpha* **L.**	6.09	11.6	4.42	19.7	2.99	24.6	0	24	0	15.4	0	0	0	0	0	0	0	0	0	0	0	31.4	0	24.5
27	*Parthenium hysterophorus* L.	7.97	8.13	5.66	3.09	4.82	4.27	11.1	3.98	1.71	15.41	1.7	36.29	24.4	36.67	22.8	37.22	24.7	34.44	20	31.2	18.6	31.86	18.3	24.5
28	*Poa annua* L.	*	0	*	5.41	*	8.78	*	8.39	*	0	*	0	*	0	*	0	*	0	*	0		0	*	0
29	*Polygonum plebeium* R.Br	0	*	1.01	*	0.94	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*
30	*Sesamum Indicum* L.	*	0	*	0	*	0	*	0	*	0	*	0	*	3.36	*	3.48	*	3.24	*	3.32		5.08	*	3.88
31	*Sida acuta* Burm.f.	33.6	0	24.1	26.2	21.5	7.67	32.9	6.77	23.3	7.56	22.8	26.3	25.1	20	22	20.5	21.4	19.3	23.5	21.8	23.3	29.1	22.4	21
32	*Sida Cordifolia* L.	*	0	*	0	*	0	*	0	*	0	*	0	*	3.12	*	3.4	*	5.96	*	6.2		8.02	*	6.83
33	*Sisymbrium irio* L.	3.02	7.19	2.78	15.2	1.83	13.5	5.86	12.9	0	10.6	0	0	0	0	0	0	0	0	0	0	0	0	11.9	15.8
34	*Spergula arvensis* L.	10.5	0	8.41	6.96	7.33	11.4	0	11.1	0	16.6	0	0	0	0	0	0	0	0	0	0	0	0	11	11.1
35	*Stellaria media* (L.) Vill.	9.56	*	13	*	6.76	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	0	*	4.16	*
36	*Tephrosia purpurea* (L.) Pers..	0	0	0	0	0	5.91	0	5.72	0.26	7.51	0.26	5.63	2.03	5.72	1.88	5.91	1.76	5.53	1.7	5.76	1.8	6.89	0	0
37	*Trianthema portulacastrum* L.	0	0	0	0	0	0	0	0	0	0	0	9.49	0	5.14	0	5.27	1.75	5.83	1.69	6.07	1.79	0	1.66	0
38	*Tribulus terrestris* L.	*	0	*	0	*	0	*	0	*	0	*	4.34	*	6.15	*	6.24	*	7.07	*	7.23		0	*	0
39	*Urena lobata* L.	1.54	10.4	1.22	4.59	1.24	4.83	1.75	5.44	1.44	10.9	1.4	3.68	4.12	2.98	3.89	1.67	2.06	4.03	2	4.08	2.08	6.33	1.75	4.93
40	*Veronica agrestris* L.	5.48	71.4	9.57	5.73	8.84	3.7	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	*Xanthium strumarium* L.	0	*	0	*	0	*	0	*	0	*	0	*	3.76	*	3.46	*	3.4	*	3.27	*	0	*	0	*

Ludhiana—Site 1 | Sangrur—Site 2 | *—indicates absence of plant species | 0—indicates completion of life-cycle of plant.

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