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RESEARCH PAPER

TITLE:

PHENOLOGICAL STUDY OF FLORA OF DISTRICT SWABI, KHYBER PAKHTUNKHWA (PAKISTAN)

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ABSTRACT

This study was conducted in District Swabi in eight selected sites/stands during 2019-2020. A total of 237 plant species were studied in these sites/stands. Phenological behavior of each plant species was observed in field and recorded every month of the year. The result revealed that maximum number of species (20.2%) were recorded in vegetative stage in February, in flowering stage (28.2%) in March, in fruiting stage (28.2%) in April and in post reproductive stage (27%) in June. Least number of species (1 species; 0.4%) were found in vegetative stage in September, in flowering stage (1 species; 0.4%) in December, in fruiting stage (1 species; 0.4%) in January and in post reproductive stage (2 species; 0.8%) in April. There were 83 species found in vegetative stage in spring followed by 82 species in winter, 67 species in summer and 5 species in autumn. In flowering stage, 121 species were recorded in spring followed by 63 species in summer, 46 species in autumn and 7 species in winter. In fruiting stage, 88 species were recorded in spring followed by 72 species each in summer and autumn and 5 species in winter. Similarly, 91 species were found in post reproductive stage in summer followed by 82 species in autumn, 56 species in winter and 8 species in spring. It was observed that spring was the peak flowering season followed by summer while spring was the peak fruiting season followed by summer and autumn.

Keywords: Flora, Phenology, Seasons, Stands, Swabi, Pakistan

1. INTRODUCTION

The diversity and ecological characteristics of the plants of a particular area depend upon environmental conditions, including altitude, seasonal variation, edaphic factors and climate. The ecological characteristics of flora particularly phenological pattern, can be used as indicator of prevailing environmental conditions. Flora refers to all plant life occurring in any particular geographic region at a specific geological period and includes the number of species. In simple words, flora represent particularly to species composition. The word "Phenology" is derived from Greek word "phainomai" meaning to appear or come into view **(Vashistha *et al*., 2009)**. Phenology referred to the seasonal timing of life cycle events such as dormancy, seedling, flowering and fruiting **(Rathcke and Lacey, 1985)**. It refers to the relationship between plant growth phases and solar year calendar dates. The timing of periodic biological events among plant species phases provides the framework for collecting and synthesizing extensive quantitative data on plant community rhythms **(Dar and Malik, 2009)**. It is a periodic phenomenon in plants that are tied to periodic environmental changes **(Schwartz, 2003)**.

Phenology is the study of response of plants towards environmental changes. Abiotic environmental factors such as variation in

light and temperature, rain, presence or absence of pollinators, herbivores and competitors have been shown to play an important role in time of various phenological events. Phenological studies are also important in understanding species inter-relationship and their interaction with the environment **(Kaur *et al*., 2013)**. These studies prove valuable to assess the reproductive cyclic changes of the plant species and pattern of climate. Plant phenological variations in response to climate are the most responsive and easily observable factors **(Badeck *et al*., 2004)**. According to **Yadav and Yadav (2008)**, the interrelationship of phenological events and climate can reveal the potential impacts of upcoming climate changes. These events are associated to periodic weather and edaphic changes **(Rathcke and Lacey, 1985; Schwartz, 2003)**. Phenological studies prove useful to evaluate the pattern of climate and reproductive cyclic changes of the plant species. The present study aimed to explore the phenological pattern of flora of plain areas of district Swabi. This study is vital for the conservation of natural resources and might be supportive for future ecological studies.

2. MATERIALS AND METHODS

2.1. Study Area

District Swabi situated between the Indus River and Kabul River in the Khyber Pakhtunkhwa province of Pakistan. It was upgraded and declared to the status of district in 1988. Geographically the research area located between 72°-13' and 72°-49' East longitude and 33°-55' and 34°-23' North latitude. It is bounded on east by Haripur, on north by Buner, on south by Attock and west by Mardan and Nowshera (Figure 1). It has a total area of 1,543 km^2, which may be divided into two geographical regions; hilly areas and plains. The hilly areas mostly lies in the north while plain areas lies in south. The soil of the research area is fertile and it shows great variation in texture and color. It is used for general cropping of pulses, vegetables, and cereals. Swabi has extreme and harsh climate, experiences a cold winter and a scorching summer (Table 1). Temperature rise steeply from May onward and gradually decreased from October onward. June, July and August are hottest months while January is the coldest month. July and August (monsoon) received maximum rainfalls during which humidity increase and weather becomes hot **(Anwar *et al*., 2015)**.

2.2. Field survey and Plants collection and identification

This study was conducted in District Swabi in eight selected sites/stands during 2019-2020. These stands/sites were selected on basis of physiognomic contrast, floristic composition and edaphic factors for phenological study (Table 2). Field trips were made in each month/season for collection of plants. The collected plants were dried in papers and attached on Herbarium sheets. The "Flora of Pakistan" **(Ali and Nasir 1989-1991; Nasir and Ali 1970-1989)** was used to identify each of these plants. Tropicos-Project (www.tropicos.org/Project/Pakistan) the online Flora of Pakistan, The Plant List (http://www.theplantlist.org/), and World Flora Online (https://www.worldfloraonline.org) were then used to confirm the identification. The identified plant specimens were numbered and deposited in the Herbarium of

Department of Botany at Islamia College Peshawar for future references.

2.3. Phenological data collection

Microsoft excel sheet was used for data collection and documentation. Phenological behavior of each plant species was observed in field and recorded every month of the year and then converted into four seasons; spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). Plant species were then classified into following phonological stages;

I. Pre-reproductive/Vegetative (leaves stage and pre-flowering stage)
II. Reproductive (flowering stage and fruiting stage)
III. Post-reproductive (dormant stage and drying stage).

The percentage of each phonological stage within each month was calculated by applying the following formula;

Phenological stage (%) = (Number of species found in each phenological stage within a particular month ÷ Total number of species) × 100

3. RESULTS AND DISCUSSION

Phenology is the study of response of plants towards environmental changes. It is a periodic phenomenon in plants. Abiotic environmental factors such as variation in light and temperature, rain, presence or absence of pollinators, herbivores and competitors have been shown to play an important role in time of various phenological events. Phenological studies are also important in understanding species inter-relationship and their interaction with the environment **(Kaur *et al.*, 2013)**. Phenological variations are the indicator of climatic changes especially in temperature and humidity. **Shaheen *et al.* (2016)** stated that at different altitude and growing seasons, each species shows different phenological aspects such as flowering, fruiting, appearance and disappearance. Temperature, rainfalls and day length are all related to the phenological period and climate of any given area **(Marqueus *et al.*, 2004; Shaheen *et al.*, 2016)**.

The phenological data was recorded in the field during each month of the year. Monthly phenological behavior showed that maximum number of species (48 species; 20.2%) were recorded in vegetative stage in February, in flowering stage (67 species; 28.2%) in March, in fruiting stage (67 species; 28.2%) in April and in post reproductive stage (64 species; 27%) in June. Least number of species (1 species; 0.4%) were found in vegetative stage in September, in flowering stage (1 species; 0.4%) in December, in fruiting stage (1 species; 0.4%) in January and in post reproductive stage (2 species; 0.8%) in April (Table 3; Table 4; Figure 2).

The monthly phenological data was converted to the four seasons of the year. The present study revealed that during spring (March-May) 83 species were found in vegetative condition including 60 (72.3%) herbs, 10 (12.0%) shrubs and 13 (15.7%) trees, 121 species in flowering condition including 101 (83.4%) herbs, 10 (8.3%) shrubs and 10 (8.3%) trees, 88 species were found in fruiting stage including 85 (96.6%) herbs and 3 (3.4%) trees while 8 species were found in post reproductive stage including 7 (87.5%) herbs and 1 (12.5%) shrub. In

summer (June-August) 67 species were recorded in vegetative stage including 63 (94.0%) herbs, 3 (4.5%) shrubs and 1 (1.5%) tree. There were 63 species in flowering stage including 53 (84.1%) herbs, 6 (9.5%) shrubs and 4 (6.4%) trees. Similarly, 72 species were found in fruiting condition including 50 (69.5%) herbs, 13 (18.0%) shrubs and 9 (12.5%) trees, while 91 species were recorded in post reproductive stage including 86 (94.5%) herbs, 2 (2.2%) shrubs and 3 (3.3%) trees. During autumn (September-November) 5 species was found in vegetative stage including all herbs, 46 species were found in flowering stage including 45 (97.8%) herbs and 1 (2.2%) shrub. Similarly, 72 species were found in fruiting condition including 67 (93.0%) herbs, 3 (4.2%) shrubs and 2 (2.8%) trees while 82 species in post reproductive stage including 61 (74.4%) herbs, 11 (13.4%) shrubs and 10 (12.2%) trees. During winter season (December-February) 82 species were found in vegetative condition including 78 (95.1%) herbs and 4 (4.9%) shrubs, 7 species in flowering condition including all herbs. Similarly, 5 species were found in fruiting stage including 4 (80.0%) herbs and 1 (20.0%) shrubs while 56 species were found in post reproductive stage including 52 (92.8%) herbs, 3 (5.4%) shrubs and 1 (1.8%) tree (Table 3; Table 5; Figure 3).

In the present investigation, the flowering phenology showed that spring marked the peak of flowering season followed by summer. Our results are in line with **Farooq *et al*. (2018)** who recorded maximum plants in flowering condition during spring season, while studying the phenology of tree flora of upper Tanawal, district Mansehra, Khyber Pakhtunkhwa, Pakistan. Our findings are disagreed with the results of **Dar and Malik (2009), Kaur *et al*. (2013), Shaheen *et al*. (2016), Amjad *et al*. (2017), Khan *et al*. (2018)** and **Rahman *et al*. (2018)** who recorded maximum number of plants in flowering condition during summer from their respective study areas. This disagreement is due to altitudinal range, climatic condition, variation in light and habitat diversity. During March maximum number of species were found in flowering stage. Our results are in line with **Khan *et al*. (2015), Amjad *et al*. (2017)** and **Farooq *et al*. (2018)** who recorded maximum plants in flowering condition in the month of March and April, while studying the phenology of flora in different parts of Pakistan. **Khan *et al*. (2015)** stated that moderate atmospheric temperature, increased light duration and increased population of pollinators may play vital role in flowering peak during spring season (March and April). During the months of December and January, the least number of species were found in both flowering and fruiting stages. Similar results were also made by other workers **(Khan *et al*., 2015; Amjad *et al*., 2017; Farooq *et al*., 2018; Khan *et al*., 2018; Rahman *et al*., 2018)**. **Godoy *et al*. (2009)** stated that flowering phenology is mediated by the interaction of internal factors with external environmental signals such as day length, drought or temperature. Flowering at the optimum time ensures richness and good development of fruits and seeds. The fruiting phenology indicated that spring was the peak fruiting season followed by autumn. Similar result was made by **Kaur *et al*. (2013)** while studying the phenology of phanerogams of

Northwestern Punjab, India. Our findings are disagreed with the results of **Amjad *et al*. (2013)** and **Farooq *et al*. (2018)** who recorded maximum number of plants in fruiting stage during summer. This disagreement is due to altitudinal range, climatic condition and variation in light. Minimum number of species were found in fruiting stage in the month of March, February, December and January. Similar result was obtained by **Rahman *et al*. (2018)** while studying the phenology of flora of Manoor Valley, Pakistan. Maximum number of species were recorded in fruiting stage in the month of April followed by October. Our results are in line with **Kaur *et al*. (2013)** who recorded maximum number of species in fruiting stage during March, April and May, while studying the phenology of phanerogams of Northwestern Punjab, India.

4. CONCLUSIONS AND RECOMMENDATIONS

The current understanding of phenology is important to help people understand how plants respond to climate change. Several aspects of phenology such as seedling, flowering, fruiting and dormancy of different plant species varied during twelve months of the study period, with much of the variation controlled by the amount and timing of precipitation, light and temperature. It was observed that spring was the peak flowering season followed by summer while spring was the peak fruiting season followed by summer and autumn. It is further suggested that there is a need to assess some ethno-medicinal and palatable forage plants for their mineral and nutritional status at different phenological stages in the research area.

5. ACKNOWLEDGEMENTS

The authors express special appreciation to those who helped us in the field survey, plants collection in the research sites and plants identification.

Table 1: Climatic data of District Swabi Khyber Pakhtunkhwa, Pakistan.

Months	Temperature (°C)			Precipitation (mm)	Average humidity (%)
	Maximum	Minimum	Average		
January	17.7	2.8	10.2	55	27
February	19.4	6	12.7	58	41
March	24.4	10.6	17.5	69	38
April	30.1	15.3	22.7	47	34
May	36.1	20	28	23	25
June	41	24.9	32.9	25	24
July	38	25.7	31.8	110	44
August	36	24.8	30.4	137	51
September	35	21.9	28.4	58	43
October	31.7	15.1	23.4	14	29
November	25.5	8.3	16.9	12	29
December	19.7	3.8	11.7	31	24
Annual	**29.5**	**14.9**	**22.2**	**53.2**	**34.0**

Source: Climate data. org., 2018

Table 2: Characteristics of representative stands in district Swabi, Pakistan.

Sites/Stands	Habitats	Code	Altitude (m)	Latitude N°	Longitude E°
Swabi-1	Stream bank	SB	310	34.08668	72.47401
Swabi-2	Dry stream bed	DSB	340	34.07617	72.60456
Swabi-3	Undulating land	UL	348	34.24140	72.32543
Swabi-4	Fallow land	FL	321	34.22003	72.28960
Swabi-5	Cultivated lands	CL	320	34.22035	72.28867
Swabi-6	Road side	RS	317	34.21448	72.28004
Swabi-7	Grassland	GL	340	34.11330	72.29683
Swabi-8	Sandy land	SL	357	34.08475	72.33185

Table 3: Phenological behavior of flora of district Swabi Khyber Pakhtunkhwa, Pakistan.

Sr. No.	Plant Name	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Herb layer													
1	*Achyranthes aspera* L.	-	PR	-	-	-	VG	-	FL	-	-	FR	-
2	*Aerva javanica* (Burm.f.) Juss.ex Schult.	-	-	-	-	VG	FL	-	FR	-	-	PR	-
3	*Aerva sanguinolenta* (L.) Blume	-	-	PR	-	-	-	-	VG	FL	-	FR	-
4	*Ajuga bracteosa* Wall.ex Benth.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
5	*Allium griffithianum* Boiss.	-	VG	FL	-	FR	-	PR	-	-	-	-	-
6	*Alternanthera pungens* Kunth	-	-	-	-	-	-	-	VG	FL	FR	-	PR
7	*Alternanthera philoxeroides* (Mart.) Griseb.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
8	*Alternanthera sessilis* (L.) R. Br. ex DC.	-	-	-	-	-	VG	FL	-	FR	-	PR	-
9	*Alysicarpus ovalifolius* (Schumach.) J. Léonard	-	-	-	-	-	-	-	VG	FL	FR	-	PR
10	*Amaranthus graecizans* Cutanda	-	-	-	-	-	VG	FL	FR	-	PR	-	-
11	*Amaranthus tenuifolius* Wall.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
12	*Amaranthus viridis* L.	-	-	-	-	VG	-	FL	FR	-	PR	-	-
13	*Anagallis arvensis* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
14	*Anisomeles indica* (L.) Kuntze	-	-	-	-	-	-	-	VG	FL	FR	-	PR
15	*Apluda mutica* L.	PR	-	-	-	-	-	-	VG	FL	-	FR	-
16	*Arachis hypogaea* L.	-	-	-	-	VG	-	FL	-	FR	-	PR	-
17	*Arenaria serpyllifolia* Bourg.ex Willk. and Lange	VG	-	FL	FR	-	PR	-	-	-	-	-	-
18	*Aristida adscensionis* L.	-	VG	-	FL	-	-	-	FR	-	-	-	PR
19	*Aristida cyanantha* Nees	-	-	VG	-	FL	-	FR	-	-	PR	-	-
20	*Arundo donax* L.	PR	-	-	VG	-	-	-	-	FL	-	FR	-
21	*Asparagus officinalis* L.	-	-	-	VG	FL	-	FR	-	-	PR	-	-

22	*Aster subulatus* (Michx.) Hort. ex Michx.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
23	*Avena fatua* L.	-	VG	FL	FR	-	-	PR	-	-	-	-	-
24	*Bidens pilosa* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
25	*Boerhavia diffusa* L.	-	-	VG	FL	-	-	FR	-	PR	-	-	-
26	*Boerhavia procumbens* Banks ex Roxb.	-	-	-	-	-	-	VG	FL	-	FR	-	PR
27	*Bothriospermum tenellum* (Hornem.) Fisch. and C.A.Mey.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
28	*Brachiaria ramosa* (L.) Stapf	-	-	-	-	-	VG	-	FL	FR	-	PR	-
29	*Brassica rapa subsp. campestris* (L.) Clapham	-	-	FL	FR	-	PR	-	-	-	-	-	VG
30	*Bromus pectinatus* Thunb.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
31	*Buglossoides arvensis* (L.) Johnst.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
32	*Calendula arvensis* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
33	*Cannabis sativa* L.	-	-	VG	-	FL	-	FR	-	PR	-	-	-
34	*Capsella bursa-pastoris* (L.) Medik.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
35	*Cardaria draba* (L.) Desv.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
36	*Carthamus lanatus* L.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
37	*Carthamus oxyacantha* M.Bieb.	-	-	-	-	VG	FL	FR	-	PR	-	-	-
38	*Cenchrus biflorus* Roxb.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
39	*Cenchrus ciliaris* L.	FL	FR	-	PR	-	-	-	-	-	-	-	VG
40	*Centaurea iberica* Trevir.ex Spreng.	-	-	VG	FL	-	FR	-	-	PR	-	-	-
41	*Centaurea benedicta* (L.) L.	-	VG	-	FL	FR	-	PR	-	-	-	-	-
42	*Centaurium pulchellum* (Sw.) Druce	-	-	VG	FL	FR	-	PR	-	-	-	-	-
43	*Cerastium dichotomum* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
44	*Chenopodium album* L.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
45	*Chenopodium ambrosioides* L.	-	-	-	-	VG	FL	FR	-	-	PR	-	-
46	*Chenopodium botrys* L.	-	-	-	-	-	VG	FL	FR	-	PR	-	-
47	*Chenopodium murale* L.	-	VG	FL	FR	-	-	PR	-	-	-	-	-
48	*Chenopodium strictum* Roth	-	-	-	-	-	VG	-	-	FL	FR	-	PR
49	*Chrozophora tinctoria* (L.) Raf.	-	-	-	-	VG	FL	FR	-	PR	-	-	-
50	*Chrysopogon aucheri* (Boiss.) Stapf	-	-	-	-	-	-	VG	-	FL	FR	-	PR
51	*Cichorium intybus* L.	-	-	VG	FL	-	FR	PR	-	-	-	-	-
52	*Cirsium arvense* (L.) Scop.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
53	*Cleome scaposa* DC.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
54	*Cleome viscosa* L.	-	-	-	-	-	VG	FL	FR	-	PR	-	-
55	*Commelina benghalensis* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
56	*Convolvulus arvensis* L.	-	-	VG	FL	FR	-	-	PR	-	-	-	-
57	*Corchorus olitorius* L.	-	-	-	-	-	-	VG	FL	FR	-	PR	-
58	*Corchorus tridens* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
59	*Coriandrum sativum* L.	-	-	FL	FR	-	PR	-	-	-	-	-	VG
60	*Coronopus didymus* (L.) Sm.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
61	*Crotalaria juncea* L.	-	-	-	-	-	VG	-	FL	-	FR	-	PR
62	*Cucumis melo subsp.agrestis* (Naudin) Pangalo	-	-	-	-	-	-	-	VG	FL	FR	-	PR
63	*Cucurbita moschata* Duchesne	-	-	-	VG	FL	FR	-	-	PR	-	-	-
64	*Cuscuta reflexa* Roxb.	FL	-	-	FR	-	-	-	PR	-	-	VG	-
65	*Cyanthillium cinereum* (L.) H.Rob.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
66	*Cymbopogon jwarancusa* Schult.	-	-	-	-	-	-	VG	-	FL	FR	-	PR

67	*Cynodon dactylon* (L.) Pers.	-	VG	-	FL	-	-	-	FR	-	-	PR	-
68	*Cynoglossum lanceolatum* Forssk.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
69	*Cyperus compressus* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
70	*Cyperus rotundus* L.	-	-	-	-	-	-	VG	-	FL	FR	-	PR
71	*Dactyloctenium aegyptium* (L.) Willd.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
72	*Datura innoxia* Mill.	-	-	-	-	VG	-	FL	-	FR	-	PR	-
73	*Desmostachya bipinnata* (L.) Stapf	-	VG	-	-	-	FL	-	FR	-	-	PR	-
74	*Diarthron vesiculosum* (Fisch. and C.A. Mey. Ex Kar. and Kir.) C.A. Mey.	-	-	-	VG	FL	FR	-	PR	-	-	-	-
75	*Dichanthium annulatum* (Forssk.) Stapf	-	-	-	VG	-	-	-	FL	FR	-	PR	-
76	*Dicliptera bupleuroides* Nees	PR	-	-	-	-	-	-	VG	FL	-	FR	-
77	*Dicliptera paniculata* (Forssk.) I.Darbysh.	-	PR	-	-	-	-	VG	-	-	FL	FR	-
78	*Digera muricata* (L.) Mart.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
79	*Digitaria sanguinalis* (L.) Scop.	-	-	-	-	-	VG	FL	-	FR	-	PR	-
80	*Digitaria ciliaris* (Retz.) Koeler	-	-	-	-	-	VG	FL	-	FR	-	PR	-
81	*Echinochloa colona* (L.) Link	-	-	-	-	-	VG	FL	-	FR	-	PR	-
82	*Echinops echinatus* Roxb.	-	-	-	FL	-	FR	-	PR	-	-	VG	-
83	*Eleusine indica* (L.) Gaertn.	-	-	-	-	-	VG	FL	FR	-	PR	-	-
84	*Emex spinosa* (L.) Campd.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
85	*Eragrostis minor* Host	-	-	-	-	-	VG	FL	FR	-	PR	-	-
86	*Erigeron canadensis* L.	-	-	-	VG	-	FL	-	FR	-	-	PR	-
87	*Erigeron sumatrensis* Retz.	-	-	-	VG	-	-	FL	FR	-	PR	-	-
88	*Eruca sativa* Mill.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
89	*Eryngium coeruleum* M. Bieb.	-	-	-	VG	-	FL	FR	-	PR	-	-	-
90	*Euphorbia hirta* L.	-	PR	-	-	-	VG	FL	-	-	FR	-	-
91	*Euphorbia esula* L.	-	-	VG	FL	FR	-	-	PR	-	-	-	-
92	*Euphorbia helioscopia* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
93	*Euphorbia indica* Lam.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
94	*Euphorbia prostrata* Aiton	-	-	-	VG	-	FL	-	FR	-	PR	-	-
95	*Filago hurdwarica* (Wall.ex DC.) Wagenitz	-	-	VG	-	FL	FR	-	-	PR	-	-	-
96	*Fimbristylis cymosa* R. Br.	-	-	-	-	-	VG	FL	FR	-	PR	-	-
97	*Foeniculum vulgare* Mill.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
98	*Fumaria indica* Pugsley	VG	-	FL	FR	-	PR	-	-	-	-	-	-
99	*Galium aparine* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
100	*Gamochaeta pensylvanica* (Willd.) Cabrera	-	-	VG	FL	FR	-	PR	-	-	-	-	-
101	*Geranium rotundifolium* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
102	*Goldbachia laevigata* (M. Bieb.) DC.	FR	-	PR	-	-	-	-	-	-	-	VG	FL
103	*Heliotropium europaeum* L.	-	-	-	-	VG	FL	FR	-	PR	-	-	-
104	*Heliotropium strigosum* Willd. subsp. *strigosum*	-	-	-	-	VG	FL	-	-	FR	-	PR	-
105	*Herniaria cinerea* DC.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
106	*Heteropogon contortus* (L.) P. Beauv.	-	-	-	-	VG	FL	-	-	FR	-	PR	-
107	*Imperata cylindrica* (L.) Raeusch.	-	-	-	-	VG	-	FL	-	FR	-	PR	-
108	*Indigofera astragalina* DC.	-	-	-	-	-	VG	FL	FR	-	-	PR	-

109	*Indigofera linifolia* (L.f.) Retz.	-	-	-	-	VG	FL	-	-	FR	-	PR	-
110	*Ipomoea pes-tigridis* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
111	*Juncus bufonius* L.	FL	FR	-	PR	-	-	-	-	-	-	VG	-
112	*Lactuca dissecta* D.Don	-	VG	FL	FR	-	PR	-		-	-	-	-
113	*Lathyrus aphaca* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
114	*Launaea nudicaulis* (L.) Hook.f.	-	-	-	-	VG	FL	-	FR	-	PR	-	-
115	*Launaea procumbens* (Roxb.) Ramayya and Rajagopal	-	-	-	-	VG	FL	-	FR	-	PR	-	-
116	*Lepidium pinnatifidum* Ledeb.	-	-	VG	FL	FR	-	-	PR	-	-	-	-
117	*Leptochloa panicea* (Retz.) Ohwi	-	-	-	-	-	-	VG	FL	FR	-	PR	-
118	*Leucas nutans* (Roth) Spreng.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
119	*Lindenbergia indica* Vatke	-	-	-	-	-	-	-	VG	FL	FR	-	PR
120	*Linum corymbulosum* Rchb.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
121	*Lycopersicon esculentum* Mill.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
122	*Malcolmia africana* (L.) W.T. Aiton var. *africana*	-	VG	FL	FR	-	PR	-	-	-	-	-	-
123	*Malva neglecta* Wallr.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
124	*Malvastrum coromendelianum* (Linn.) Garcke	-	-	-	VG	-	FL	-	FR	-	PR	-	-
125	*Martynia annua* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
126	*Mazus pumilus* (Burm.f.) Steenis	VG	-	FL	FR	-	PR	-	-	-	-	-	-
127	*Medicago lupulina* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
128	*Medicago minima* (L.) L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
129	*Medicago polymorpha* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
130	*Medicago sativa* L.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
131	*Melilotus indica* (L.) All.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
132	*Mentha longifolia* (L.) L.	-	-	-	VG	-	FL	-	FR	-	PR	-	-
133	*Micromeria biflora* (Buch.-Ham. ex D. Don) Benth.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
134	*Mirabilis jalapa* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
135	*Misopates orontium* (L.) Raf.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
136	*Mollugo nudicaulis* Lam.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
137	*Nanorrhinum ramosissimum* (Wall.) Betsche	-	-	-	-	VG	FL	-	FR	-	-	PR	-
138	*Nasturtium officinale* W.T. Aiton	-	VG	FL	FR	-	PR	-	-	-	-	-	-
139	*Neslia apiculata* Fisch., C.A. Mey. and Avé-Lall.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
140	*Nonea echioides* (L.) Roem. and Schult.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
141	*Nonea edgeworthii* A. DC.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
142	*Oenothera rosea* L'Hér. ex Aiton	-	-	-	VG	FL	FR	-	PR	-	-	-	-
143	*Oxalis corniculata* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
144	*Oxalis pes-caprae* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
145	*Papaver hybridum* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
146	*Papaver rhoeas* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
147	*Parthenium hysterophorus* L.	VG	-	-	FL	-	-	FR	-	-	PR	-	-
148	*Paspalum paspalodes* (Michx.) Scribn.	-	-	-	-	VG	-	FL	-	FR	-	PR	-
149	*Perotis hordeiformis* Nees	-	-	-	-	-	-	-	VG	FL	FR	-	PR
150	*Persicaria barbata* var. *gracilis* (Danser) H. Hara	-	-	-	-	VG	FL	-	FR	-	PR	-	-

151	*Persicaria hydropiper* (L.) Delarbre	-	-	VG	-	FL	-	FR	-	-	PR		-
152	*Phalaris minor* Retz.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
153	*Physalis minima* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
154	*Poa annua* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
155	*Polygonum plebeium* R.Br.	-	-	VG	FL	-	FR	-	-	PR	-	-	-
156	*Polypogon monspeliensis* (L.) Desf.	-	VG	FL	FR		PR	-	-	-	-	-	-
157	*Portulaca oleracea* L.	-	-	-	-	VG	FL	FR	-	PR	-	-	-
158	*Portulaca pilosa* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
159	*Pulicaria vulgaris* Gaertn.	-	-	-	-	VG	FL	FR	-	PR	-	-	-
160	*Ranunculus muricatus* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
161	*Ranunculus sceleratus* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
162	*Rhynchosia capitata* (B. Heyne ex Roth) DC.	-	-	-	-	-	VG	FL	FR	-	-	PR	-
163	*Rhynchosia minima* (L.) DC.	-	-	-	-	-	-	VG	FL	FR	-	-	PR
164	*Rorippa islandica* (Oeder ex Murray) Borbás	-	-	VG	FL	-	FR	-	-	PR	-	-	-
165	*Rostraria cristata* (L.) Tzvelev	-	VG	FL	FR	-	PR	-	-	-	-	-	-
166	*Rumex dentatus* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
167	*Saccharum bengalense* Retz.	-	PR	-	-	VG	-	-	-	-	FL	-	FR
168	*Saccharum spontaneum* L.	-	-	-	-	VG	-	FL	-	FR	-	PR	-
169	*Salvia plebeia* R. Br.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
170	*Scandix pecten-veneris* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
171	*Setaria pumila* (Poir.) Roem. and Schult.	PR	-	-	-	-	-	-	-	VG	FL	FR	-
172	*Setaria viridis* (L.) P. Beauv.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
173	*Sida cordata* (Burm.f.) Borss. Waalk. var. *cordata*	-	-	-	-	-	-	-	VG	FL	FR	-	PR
174	*Silene conoidea* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
175	*Silybum marianum* (L.) Gaertn.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
176	*Sisymbrium irio* L.	VG	FL	FR	-	PR	-	-	-	-	-	-	-
177	*Solanum nigrum* L.	-	-	VG	FL	FR	-	-	-	-	PR	-	-
178	*Solanum surattense* Burm. F.	-	-	-	-	VG	FL	-	FR	-	-	-	PR
179	*Sonchus arvensis* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
180	*Sonchus asper* (L.) Hill	-	VG	FL	FR	-	PR	-	-	-	-	-	-
181	*Sonchus oleraceus* (L.) L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
182	*Sorghum halepense* (L.) Pers.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
183	*Spergula arvensis* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
184	*Stellaria media* (L.) Vill.	VG	FL	FR	-	PR	-	-	-	-	-	-	-
185	*Tagetes erecta* L.	-	-	-	VG	FL	-	-	FR	-	PR	-	-
186	*Taraxacum officinale* (L.) Weber ex F.H.Wigg.	VG	FL	FR	-	PR	-	-	-	-	-	-	-
187	*Torilis leptophylla* (L.) Rchb.f.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
188	*Trianthema portulacastrum* L.	-	-	-	-	-	-	VG	FL	FR	-	PR	-
189	*Tribulus terrestris* L.	-	-	-	-	VG	FL	-	FR	-	PR	-	-
190	*Trichodesma indicum* (L.) Lehm.	-	-	-	-	-	VG	FL	-	FR	-	-	PR
191	*Trifolium repens* L.	-	-	-	FL	-	FR	PR	-	-	-	-	VG
192	*Trifolium resupinatum* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
193	*Trigonella monantha* C.A. Mey.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
194	*Triticum aestivum* L.	-	-	FL	FR	-	PR	-	-	-	-	-	VG
195	*Triumfetta pentandra* A.Rich.	-	-	-	-	-	-	-	VG	FL	FR	-	PR

196	*Urtica dioica* L.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
197	*Verbascum thapsus* L.		-	VG	FL	-	FR	-	-	PR	-	-	-
198	*Verbena officinalis* L.	-	-	-	-	VG	FL	FR	-	PR	-	-	-
199	*Veronica anagallis-aquatica* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
200	*Veronica persica* Poir.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
201	*Vicia hirsuta* (L.) Gray	-	VG	FL	FR	-	PR	-	-	-	-	-	-
202	*Vicia monantha* Desf.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
203	*Vicia peregrina* L.	-	VG	FL	FR	-	PR	-	-	-	-	-	-
204	*Vicia sativa* L.	VG	-	FL	FR	-	PR	-	-	-	-	-	-
205	*Xanthium strumarium* L.	-	-	-	VG	-	-	-	-	FL	FR	-	PR
206	*Zea mays* L.	-	-	-	-	-	-	-	VG	FL	FR	-	PR
	B. Shrub layer												
207	*Acacia farnesiana* (L.) Willd.	-	-	VG	FL	-	-	FR	-	-	-	PR	-
208	*Berberis lycium* Royle	-	VG	-	-	FL	-	FR	-	PR	-	-	-
209	*Cajanus cajan* (L.) Huth	-	-	-	-	-	VG	-	FL	-	FR	-	PR
210	*Calotropis procera subsp. hamiltonii* (Wight)	-	-	VG	-	FL	-	-	FR	-	PR	-	-
211	*Cassia occidentalis* L.	-	-	-	-	VG	FL	-	FR	-	-	PR	-
212	*Ficus palmata* Forssk.	-	-	VG	-	FL	-	FR	-	-	-	PR	-
213	*Ipomoea cornea ssp. fistulosa* (Mart.ex Choisy) D. Austin	-	-	VG	-	FL	-	FR	-	-	PR	-	-
214	*Lantana camara* L.	-	VG	-	FL	-	-	-	FR	-	-	PR	-
215	*Opuntia dillenii* (Ker Gawl.) Haw.	-	-	-	VG	-	FL	-	-	FR	-	-	PR
216	*Plumbago zeylanica* L.	-	-	-	-	VG	-	FL	-	-	FR	-	PR
217	*Ricinus communis* L.	-	-	VG	FL	-	FR	-	PR	-	-	-	-
218	*Rosa chinensis* Jacq	-	VG	-	FL	-	FR	-	PR	-	-	-	-
219	*Sesbania concolor* J.B. Gillett	-	-	-	-	-	VG	FL	FR	-	PR	-	-
220	*Sida cordifolia* L.	-	-	PR	-	-	-	-	VG	-	FL	-	FR
221	*Vitex negundo* L.	-	-	-	VG	-	FL	-	FR	-	-	PR	-
222	*Withania coagulans* (Stocks) Dunal	-	-	-	FL	-	FR	-	-	PR	-	-	VG
223	*Ziziphus nummularia* (Burm. F.) Wight and Arn.	-	VG	-	FL	-	FR	-	-	-	-	PR	-
	C. Tree layer												
224	*Acacia modesta* Wall.	-	-	-	VG	FL	FR	-	-	-	PR	-	-
225	*Acacia nilotica* (L.) Willd. ex Delile	-	-	-	-	VG	-	-	FL	FR	-	PR	-
226	*Ailanthus altissima* (Mill.) Swingle	-	-	-	VG	FL	FR	-	-	-	PR	-	-
227	*Albizia lebbeck* (L.) Benth.	-	-	-	VG	-	FL	-	FR	-	-	PR	-
228	*Broussonetia papyrifera* (L.) L'Hér.ex Vent.	-	-	VG	-	FL	-	FR	-	PR	-	-	-
229	*Callistemon citrinus* (Curtis) Skeels	-	-	VG	FL	-	FR	-	-	-	PR	-	-
230	*Dalbergia sissoo* Roxb. Ex DC.	-	-	VG	-	FL	FR	-	-	-	PR	-	-
231	*Eucalyptus globulus* Labill.	-	-	VG	-	FL	-	FR	-	-	-	PR	-
232	*Leucaena leucocephala* (Lam.) de Wit	-	-	-	-	VG	FL	FR	-	-	-	-	PR
233	*Melia azedarach* L.	-	-	VG	FL	-	FR	-	-	-	-	PR	-
234	*Morus alba* L.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
235	*Morus macroura* Miq.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
236	*Morus nigra* L.	-	-	VG	FL	FR	-	PR	-	-	-	-	-
237	*Sesbania sesban* (L.) Merr. Var. *sesban*	-	-	-	-	-	VG	-	FL	FR	-	PR	-

Legend: PR- Post Reproductive; **FR-** Fruiting; **FL-** Following; **VG-** Vegetative

Table 4: Monthly summary of phenological stages of flora of District Swabi, Pakistan.

Sr. No.	Months	Phenological stages							
		Vegetative	%	Flowering	%	Fruiting	%	Post Reproductive	%
1	January	28	11.8	3	1.3	1	0.4	4	1.7
2	February	48	20.2	3	1.3	2	0.8	4	1.7
3	March	36	15.2	67	28.2	3	1.3	3	1.3
4	April	19	8.0	36	15.2	67	28.2	2	0.8
5	May	28	11.8	18	7.6	18	7.6	3	1.3
6	June	21	8.9	28	11.8	20	8.5	64	27
7	July	9	3.8	23	9.7	21	8.9	18	7.6
8	August	37	15.6	12	5.0	31	13.1	9	3.8
9	September	1	0.4	42	17.8	22	9.3	18	7.6
10	October	0	0	4	1.7	43	18.2	29	12.2
11	November	4	1.7	0	0	7	2.9	35	14.8
12	December	6	2.6	1	0.4	2	0.8	48	20.2
Total/Annual		**237**	**100**	**237**	**100**	**237**	**100**	**237**	**100**

Table 5: Seasonally summary of phenological stages of flora of District Swabi, Pakistan. (All figures are number of species)

Sr. No.	Phenological stage	Seasons				Total/ Annual
		Spring (Mar-May)	Summer (Jun-Aug)	Autumn (Sep-Nov)	Winter (Dec-Feb)	
1	Vegetative	83	67	5	82	**237**
2	Flowering	121	63	46	7	**237**
3	Fruiting	88	72	72	5	**237**
4	Post Reproductive	8	91	82	56	**237**

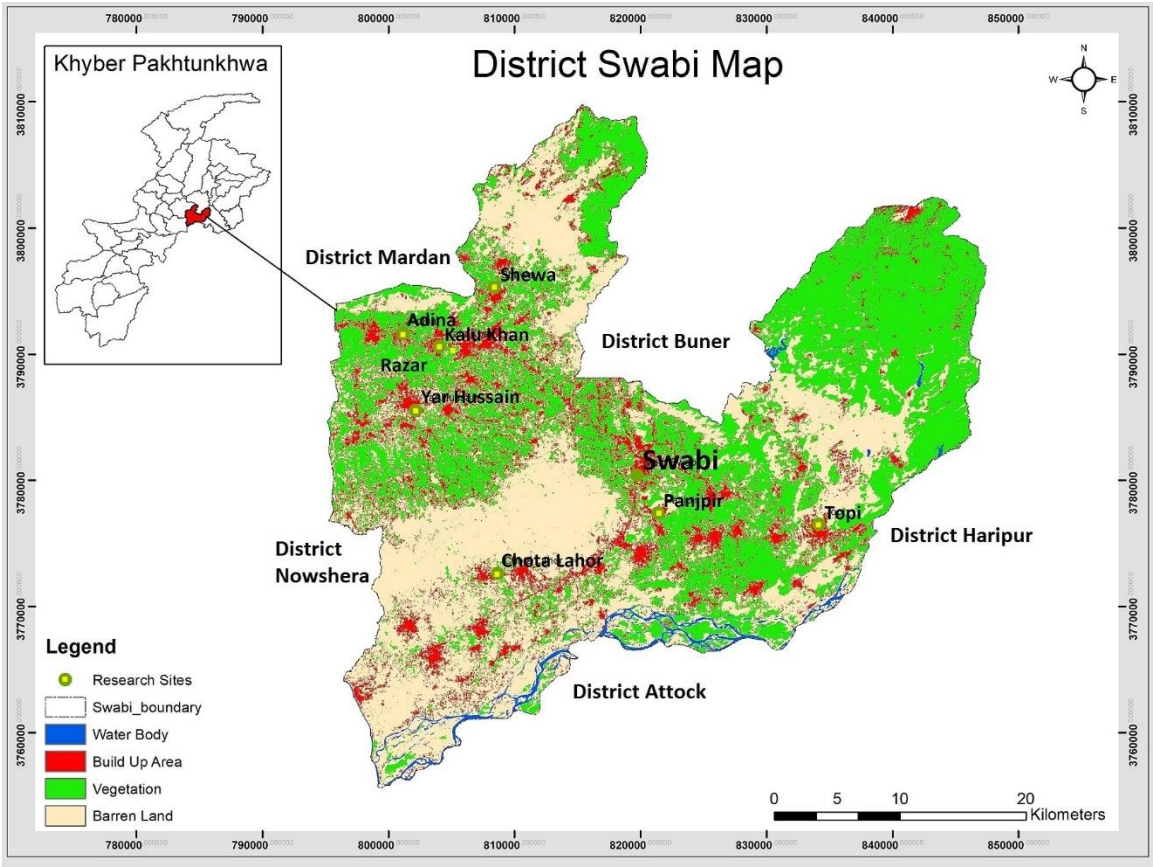

Figure 1: Map of District Swabi showing research sites.

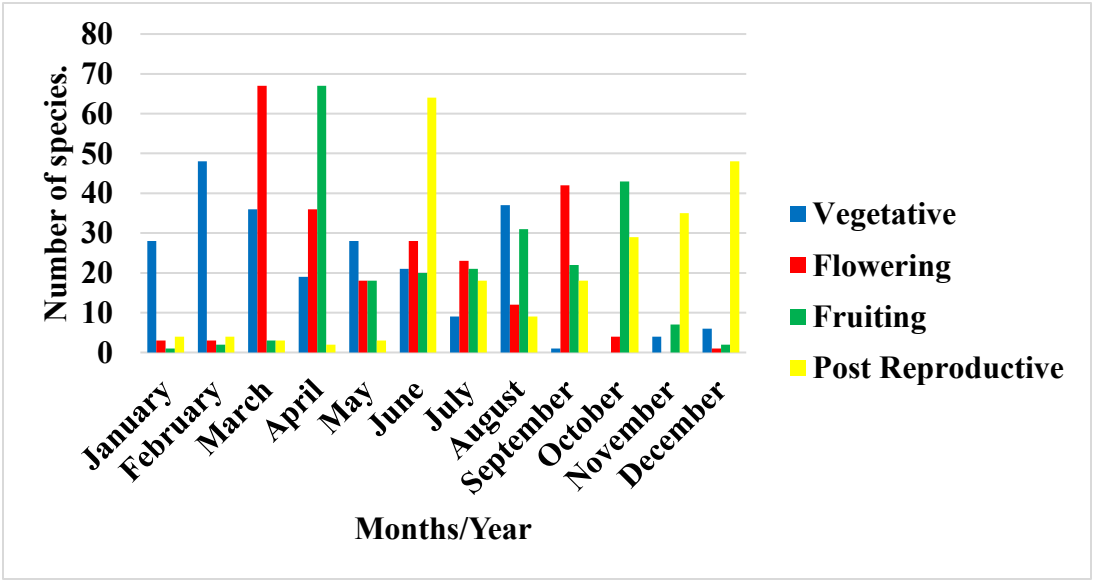

Figure 2: Monthly summary of phenological stages of flora of District Swabi.

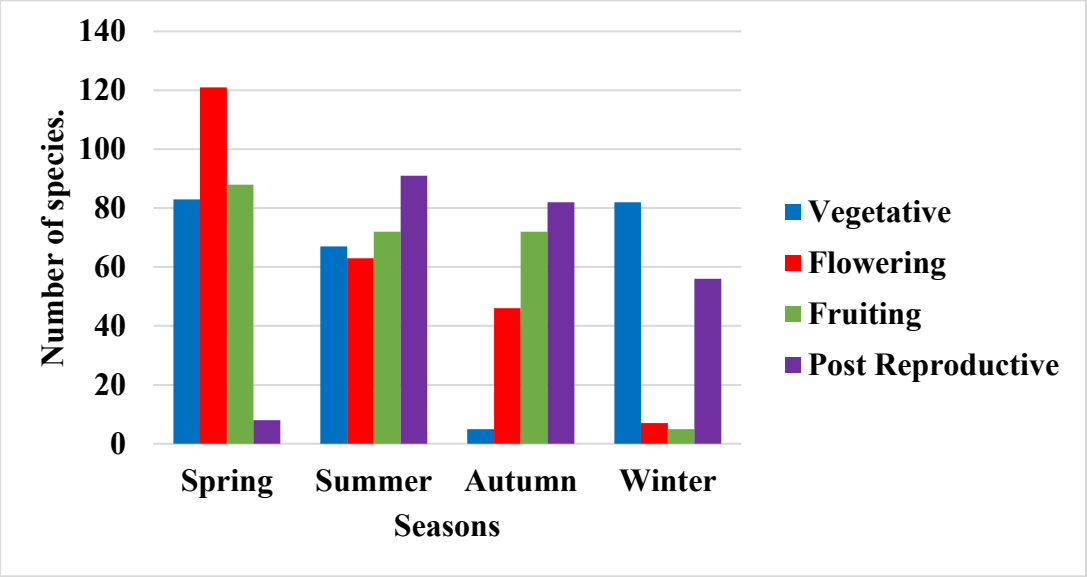

Figure 3: Seasonally summary of phenological stages of flora of District Swabi.

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