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Flowering and Fruiting Dynamics of Medicinal Plants in Relation to Climatic Conditions

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ABSTRACT

We studied 159 medicinal plant species of 53 families, grown in nursery cafeteria for three consecutive years for their reproductive phonology. Plant species differed markedly in their response to monthly temperature, relative humidity and rainfall pattern of the area. An average 7.54% species bore regular flowering and fruiting throughout the year, 15.72% species experienced no flower, while 41.08% species were unable to form fruit. Peak flowering and fruiting was observed in August whereas in winter and summer months only few species enterd their reproductive phase. A significant positive correlation was found between reproductive phenology and rainfall, average low temperature and relative humidity while correlation between reproductive phase and average high temperature and the rate of evapotranspiration were not significant at $p \leq 0.05$. Average high temperature of 30 to 31°C and average low temperature around 24°C were found most suitable to induce flowering and fruiting in medicinal plants. Low average temperature below 14°C and high temperature above 36°C was found to be adverse to flowering and fruiting of medicinal plants under study.

Key Words: Phenology; Flowering; Fruiting; Rainfall; Temperature.

INTRODUCTION

Nature has already set for each species to have a definite period, month, season in a year for its seeding, germination and growth, flowering and fruiting. All stages in the life cycle of a plant species are influ-enced by a number of environmental factors. There is a synchronization of phenological behaviour of the species with various factors of the environment but its interactions with each species are different at different stages of their life cycle. Thus, the study of phenology of plant species is important as it provides the pattern of plant growth and inferences on the effect of environment on flowering and fruiting (Zhang et al. 2006). Moreover, phenological events are used variously for characteri-zation of vegetation type (Opler et al. 1980) and in the preparation of cultivation and management plans.

Different life forms such as shrubs and herbs have different patterns of flowering and fruiting phenology as herbaceous plants go through reproductive phase during the rainy season, whereas the same in woody plants is reported in dry season (Bhat and Murali 2001, Joshi and Janardanam 2004, Ramirez and Briceno 2011). Further, each plant life form shows particular association with particular climatic factor (Ramirez and Briceno 2011). Rate of plant growth and development depend upon the temperature and each species has a specific temperature range represented by a minimum, maximum and optimum (Hatfield and Prueger 2015). The phonological patterns change due to increased surface temperature (Rathcke and Lacey 1985) which leads to a shift in other phenological activities of the species (Linderholm 2006).

Plant species flower mostly either in response to dry season or change in temperature (Godoy 2009, Singh and Kushwaha 2006). Timing of fruiting is also well studied in relation with different abiotic factors, but the relationship with temperature and rainfall is scarcely attended. Temperature is one of the major factors affecting flowering and fruiting of a species. The climate change and global warming may force a shift in the length of growing period of various plant species (Singh and Kushwaha 2006). Although phenology of trees and shrubs has been studied extensively (Dahlgren et al. 2007, Gariglio et al. 2012, Kikim and Yadava 2001), phenology of medicinal herbs is not well studied, with a few exemptions (Kudo 1992, Risberg and Granstrom 2009).

Keeping this in mind, the present study aimed to evaluate flowering and fruiting response of 159 medicinal plant species grown in germplasm cafeteria-cum-conservatory, with reference to weather parameters over a three year period (2004-2006).

MATERIALS AND METHODS

The field study was carried out at the medicinal plant germplasm conservatory of Thakur Chhedilal Barrister College of Agriculture and Research Station, Bilaspur, Chhattisgarh, during 2004, 2005and 2006. The experimental area lies in 22° 9' 12" N and 82° 12' 12" E, at an altitude of 292 m.. The monthly mean temperature varies from 11.03 °C in December to 40.57°C in May. The average relative humidity ranges from 26.60% during May to above 93% during July-August. The annual rainfall is 1141.43mm, of which 82% is received during July to September. During the study period, average precipitation was 1139 mm, average low temperature 13°C in January and average high temperature 42°C in May (Table 1). Rainy season in the area is identified from July to September, winter season from December to 15th March and Summer from Aprilto June. Other climatological data viz. wind speed, sunshine, evapo-transpiration, etc. obtained from Meteorology Department of TCB College are summarized in Table 1.

The flowering (first flower date) and fruiting (first fruit date) was recorded for 159 medicinal plant species, collected from tropical forest of central India and grown in medicinal plant germplasm cafeteria cum ex-situ conservatory. Observations were made on flowering, and fruiting at one month interval from January 2004 to December 2006. For each species individual record of different reproductive phenophases were taken into consideration. Ten individuals of each species were randomly selected and tagged for perennials and annuals. In case of annuals, plants were re-tagged every year during the study period in the same cafeteria. Flowering was determined by first opened flower seen on any tagged plant and considered as the date of flowering while in case of fruiting, initiation of fruit on any tagged plant of the species was considered.

Table 1. Average weather conditions of Bilaspur, Chhattisgarh, India during the study period (2004-2006).

Month	Temperature		RH I	RH II	Wind Speed	Sunshine	ET	Rainfall	Rainy Days
	High	Low	%	%	km hr^{-1}	hr d^{-1}	mm d^{-1}	mm	
January	26.67	11.10	90.67	43.83	0.93	8.53	2.60	51.47	3.00
February	30.53	13.37	86.97	42.00	0.82	9.93	3.67	2.53	0.33
March	34.67	17.67	84.70	40.90	1.00	9.40	4.93	20.73	4.00
April	38.80	21.83	64.00	25.67	1.25	9.47	6.80	10.47	2.67
May	40.57	25.47	60.70	26.60	1.42	9.17	7.77	41.07	3.33
June	38.23	26.47	72.30	44.57	1.97	6.00	6.57	203.47	7.00
July	31.07	24.50	93.47	76.93	1.22	2.93	3.00	331.03	19.67
August	30.23	24.40	93.03	76.10	1.41	3.80	3.07	293.00	17.33
September	35.97	24.13	92.00	70.13	0.76	6.50	3.57	138.97	11.00
October	31.13	19.77	92.60	54.53	0.29	8.77	3.63	46.13	4.00
November	29.23	13.90	90.67	38.93	0.23	8.97	2.93	2.67	0.67
December	27.17	11.03	91.23	40.07	0.44	8.83	2.50	0.00	0.00
Average/ total	32.86	19.47	84.36	48.36	0.98	7.69	4.25	1141.53	73.00

For evaluating variation in phenology, simple measurements like average, minimum and maximum were obtained monthwise and yearwise using computer based program. Climate and data of mean flowering and fruiting in species were correlated on monthly basis. Percentage of species flowering and fruiting in a particular month was obtained and correlated with average low temperature, average high temperature and rainfall.

RESULTS AND DISCUSSION

After observation a record of time period of flowering and fruiting were done for all the 159 species of medicinal plants from 53 families. These species consisted 16% of Fabaceae, 6.9 % Liliaceae, 6.28% Zingiberaceae, 4.40% Araceae and 64.5% from other plant families (Appendix 1). *Aerva lanata*, *Bacopa monnieri*, *Barleria prionitis*, *Catharanthus pusillus*, *Catharanthus roseus*, *Centella asiatica*, *Eclipta prostrata*, *Operculina turpethum*, *Phyllanthus amarus*, *Rauvolfia serpentina*, *Solanum torvum* and *Wedelia chinensis* flowered and fruited round the year (Appendix 1) whereas no flowering was observed in 10.69%, 4.40% and 32.07% species during 2004, 2005 and 2006, respectively. Pooled analysis of data exhibited the 7.54% species bore flower and fruit round the year, and 15.72% species exhibited no flower while 41.08% plant species could not form fruit during study (Figure1). Overall the highest flowering 15.51% occurred in August month and the lowest 1.88% in February, whereas in case of fruiting of species was concerned, it was highest in August (10.68%) and the lowest during February to March (1.04%).

Data on flowering and fruiting behaviour of medicinal plants under study reveals that different species showed monthly variation in flowering and fruiting (Figures 2 and 3). The peak period of flowering and fruiting can be distinguished for majority of the species during monsoon (July to August) with temperature range of 30 to 31ºC (Figure 5) and at average low temperature about 24 ºC (Figure 6). Though the species showed variation in flowering and fruiting on the basis of specific environmental factors, 22.01% species flowered in August 2004, 16.35% in July 2005 and only 8.80% in August 2006 (Figure 2). The number of plant species flowering in winter months (December to March) was the lowest: only 2.03%, 3.45% and 2.35% species flowered during winter of 2004, 2005 and 2006, respectively. Similarly, the species fruiting was highest in August (14.46%, 11.32% and 6.28% in 2004, 2005 and 2006) and lowest in February (1.25%, 0.63% and 1.25% in 2004, 2005 and 2006 respectively) (Figure 3). Average high temperature in summer (April to June) had a negative effect on flowering, it resulted in 2.30, 6.07 and 6.91% species flowering in 2004, 2005 and 2006, respectively. Similarly only 2.37% species bore fruit in summer season (April to June) compared to the rainy season where majority of the species produced fruits (Figure 4). A low temperature during winter season also decreased fruiting: only 2.93%, 2.3% and 1.04% species exhibited fruiting in 2004, 2005 and 2006 respectively (Figure 5 and 6).

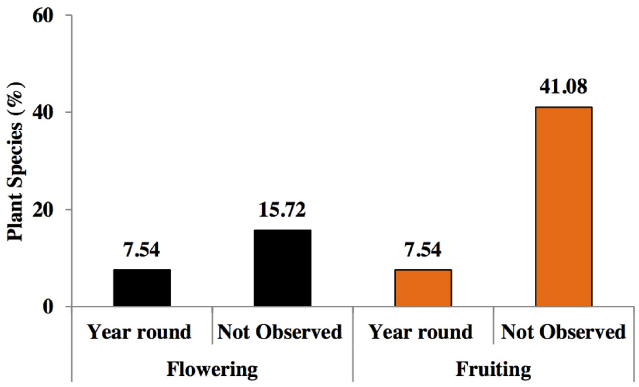

Figure 1. Species (% of total examined) with year round and no flowering and fruiting.

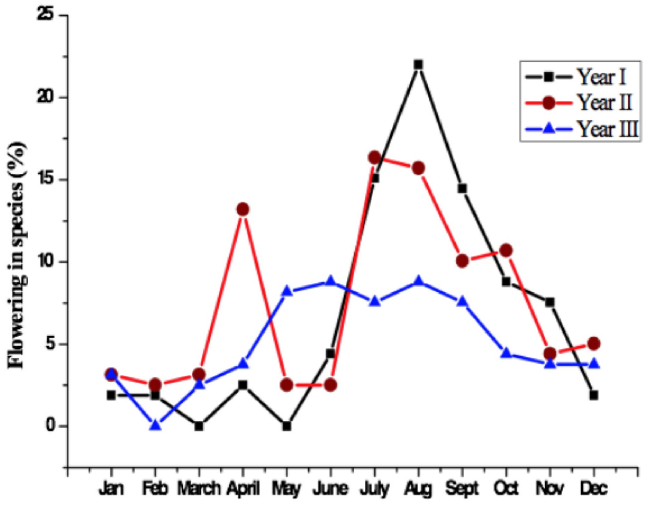

Figure 2. Monthly variation in flowering behaviour of medicinal plants.

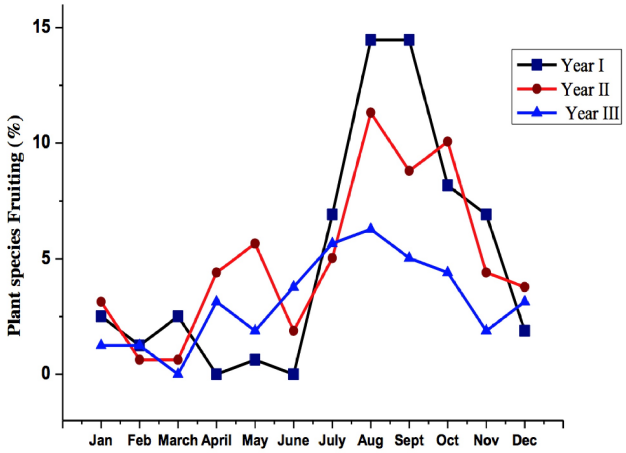

Figure 3. Monthly variation in fruiting behaviour of medicinal plants

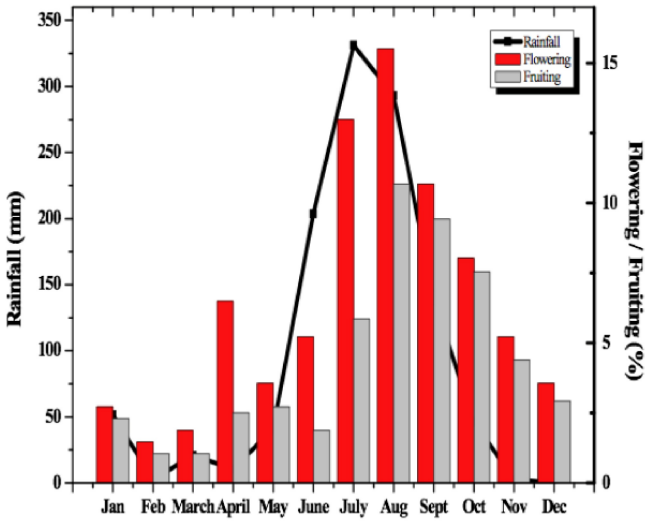

Figure 4. Impact of rainfall on flowering and fruiting of medicinal plants.

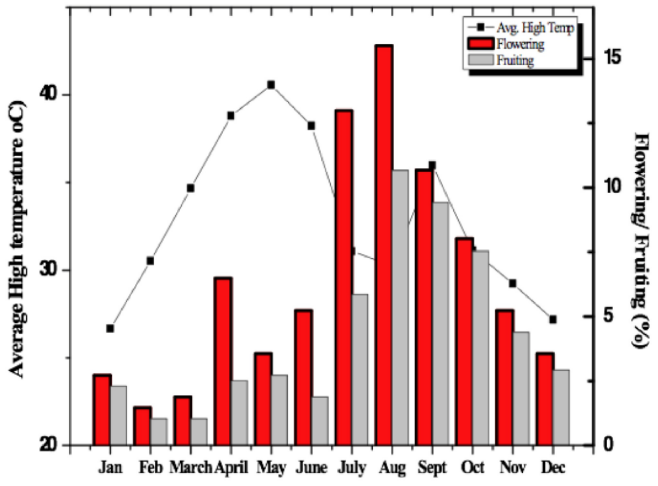

Figure 5.Impact of average high temperature on flowering and fruiting

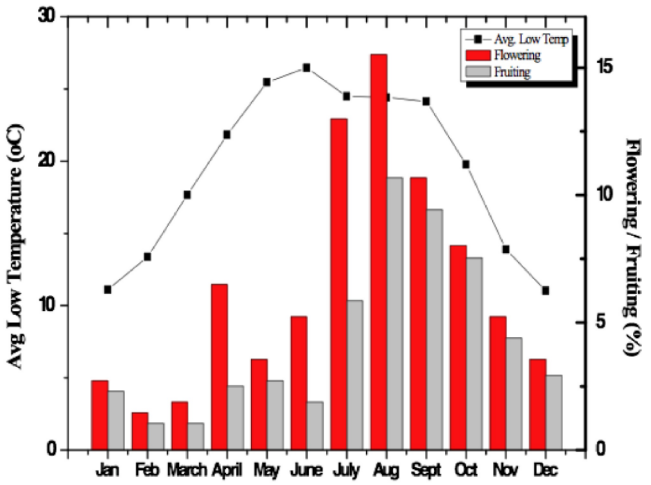

Figure 6.Impact of average low temperature on flowering and fruiting

A significant positive correlation was found between average low temperature and flowering (r^2 = 0.355) and between rainfall and flowering (r^2 = 0.668) (Figure 7A and C due to high relative humidity during July to August which also supported flowering (Figure 7D and E) (r^2 = 0.115 and r^2 = 0.693 for average low RH and average high RH respectively). Similarly, correlation between average low temperature, rainfall, relative humidity and pooled mean percent of species in fruiting was significantly positive ($p \leq 0.05$) (Figure 8A, C, D and E) while correlation was not significant between average high temperature and fruiting (r^2= 0.019, Figure 8B) and between evapotranspiration and fruiting (r^2 = 0.015, Figure 8 F). This indicated that temperature around 24°C helped greater proportion of species for fruiting that might be due to minimum diurnal temperature, whereas when average high temperature reached beyond 36°C along with high evaporation caused reduction in fruiting of plant species that might be due to considerable dropping of flowers. Our observations are in agreement with those of researchers elsewhere (Hatfield and Prueger 2015, Barlow et al. 2015). They have shown that the yield responses to temperature vary among species based on the their cardinal temperature requirements and any shift from the optimum temperature range impacts adversely on the reproductive stage of development and results in reduced fruiting. Khah and Passam (1992) reported the low temperature below 14 °C to be detrimental for the function of female flower enhancing the chance of sterility and abortion of formed grain. We also found a non-significant correlation between average high temperature and flowering (r^2 = 0, Figure 7) and evapo-

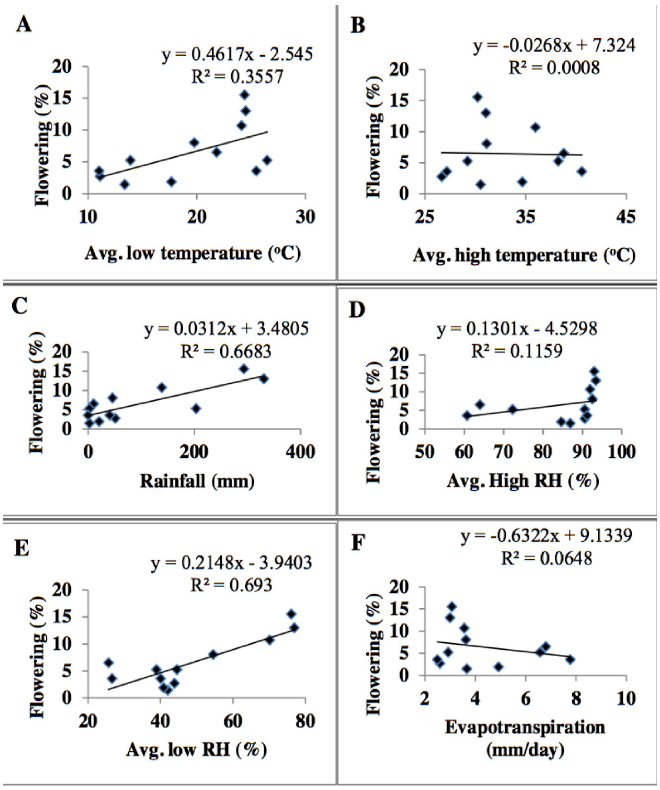

Figure 7. Correlations between: A. Average low temperature and flowering; B. Average high temperature and flowering; C. Rainfall and flowering; D. Average high relative humidity and flowering; E. Average low relative humidity and flowering; and F. Evapotranspiration and flowering.

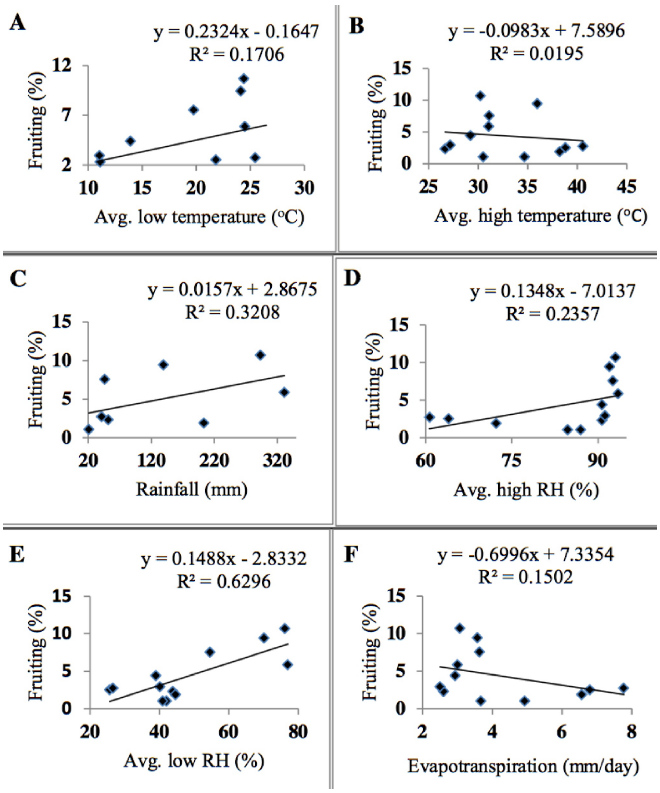

Figure 8. Correlations between: A. Average low temperature and fruiting; B. Average high temperature and fruiting; C. Rainfall and fruiting; D. Average high relative humidity and fruiting; E. Average low relative humidity and fruiting; and F. Evapotranspiration and fruiting.

transpiration and flowering ($r^2 = 0.064$, Figure 7F) which reflects the adversity of these attributes on flowering of plant species under study. Similarly Barlow et al. (2015) also proved that the excessive heat causes reduction in grain number and reduces duration of the grain filling period in Wheat crop.Our results was also concord with the findings of Joshi and Janardanam (2004) Duraisamy and Paulsamy (2010) in which they found that herbs flower mostly during August followed by fruiting in the same month due to congenial environmental factors for plant reproduction phases.The timing of phonological events did not show much variation where mean highest flowering was observed during August which wasvery soon replaced by fruiting for whole 3 years study as also ascribed by Nakar and Jadeja (2015).Rainfall also to have positive effects on fruiting as similar to flowering which was found highest in August (Figure 2, 8C) due to highest relative humidity ($r^2$0.115 and r^2 0.693, Figure 8D and E for average low RH and high RH respectively) with minimum diurnal temperature gradients, as reported by Khah and Passam 1992). In these months, the temperature range was quite optimum with high quantity of moisture both in soil and in atmosphere,formed congenial environment for reproductive phase, high viability of pollen grain, fertilization and fruitformation (Hatfield and Pruger 2015).Krishnan (2002) also accentuated our results indicating a positive correlation between fruiting and rainfall.Phenology of flowering and fruiting in shrubs and herbs was also reported mostly during August in Girnar reserve forest, Gujarat (Nakar and Jadeja 2015) and of Eastern Ghats, Southern India (Shivaraj and Krishnamurthy1989 and 1992).

Conclusively, it was found that each species has its specific range of temperature requirement for fruiting and flowering of medicinal plant species under studied. The majority of plant species exhibited flowering and fruiting during August month because of the optimum temperature range (24°C to 30°C). Rainfall and relative humidity also supported reproductive phenology of the plants as it was positively correlated with these attri-

butes. But high rate of evapotranspiration and average high temperature over 36ºC have adverse effects on reproductive phases of medicinal plants. Some plants (7.54%) exhibited regular flowering and fruiting in all the years while some more species did not flower and fruit which may be employed for vegetative means of propagation. The findings of the study may be useful for considering modules for cultivation technology of medicinal plants to benefit the farmer's.

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Appendix 1. Flowering and fruiting behavior of medicinal plants.

S.N.	Species	Local Name	Family	Flowering			Fruiting		
				2004	2005	2006	2004	2005	2006
1	*Abelmoschus manihot* L.	Vanbhindi,	Malvaceae	16/8	17/4, 15/8	15/8	26/8	29/4, 18/9	27/8
2	*Abelmoschus moschatus* L.	Kasturibhindi	Malvaceae	9/9	8/9	12/9	25/9	3/10	2/10
3	*Aborma augusta* L.	Ulatkambal	Malvaceae	31/8	9/7	15/5	12/9	9/8	13/6
4	*Abrus precatorius* L.	Rattigunja	Fabaceae	18/8	17/8	18/6	3/09	12/9	10/7
5	*Abutilon indicum* L.	Sweet Kanghi	Malvaceae	16/10	26/9	21/10	26/10	- -	2/11
6	*Achyranthes bidentata* Blume	Apamarg Neela	Amaranthaceae	8/8	22/7	16/5	23/8	20/8	12/6
7	*Acorus calamus* L.	Sweet flag	Araceae	19/09	25/9	21/9	- -	- -	2/10
8	*Adhatoda vasica*P. Miller. Nees	Adusa	Acanthaceae	06/12	31/12	25/12	- -	- -	- -
9	*Adiantum philippense* L.	Mamira	Polypodiaceae	4/7	21/7	28/5	16/7	30/7	12/6
10	*Adina cordifolia* (Roxb) Ridsdale	Kadwapatta	Rubiaceae	15/08	10/08	20/7	- -	- -	- -
11	*Alliumam peloprasum* L.	Van Lahsun	Liliaceae	08/08	30/3, 3/08	14/3, 5/08	25/08	08/04, 24/8	23/4, 20/8
12	*Aloe vera* (L.) Burm f.	Gwarpatha	Liliaceae	- -	- -	29/9	- -	- -	- -
13	*Alpinia galangal* L.	Bendrakela	Zingiberaceae	16/08	20/06	21/6	5/09	25/07	5/7
14	*Amorphophallus campanulatus* (Roxb) Bl.	Van Suran	Araceae	8/7	15/7	17/6	- -	- -	- -
15	*Amorphophallus* sp. (Roxb) Blume	Chandalkanda	Araceae	27/6	30/6	- -	8/9	13/9	- -
16	*Andrographis paniculata* (Burm f.) Wall &Nees	Kalmegh	Acanthaceae	26/08	03/10	20/8	15/09	19/10	9/9
17	*Antidesma diandrum* Roxb	Amti	Euphorbiaceae	23/09	22/7	20/4	03/10	17/8	3/5
18	*Ardisia solanacea* Roxb	Rakatphad	Myrsinaceae	03/10	26/02	3/9	- -	04/4	20/12
19	*Argemone mexicana* L.	Peelikateli	Papaveraceae	03/09	15/09	25/01	13/09	- -	- -
20	*Argyreia nervosa* Sweet	Samandarka pat	Convolvulaceae	27/09	5/10	- -	- -	- -	- -
21	*Argyreia speciosa* Burm f.	Samudrapalak	Convolvulaceae	04/08	02/09	- -	24/08	- -	- -
22	*Arisaema tortuosum* (Wallich.) Schott	Amari	Araceae	11/10	17/08	- -	- -	- -	- -
23	*Aristolochia indica* L.	Ishwarmool	Aristolochiaceae	04/07	07/07	20/9	24/07	20/7	3/10
24	*Aerva lanata* (L.) Juss	Gorukhganja	Amaranthaceae	*	*	*	*	*	*
25	*Alangium atrifolium* L. f.	Ankol	Alangiaceae	- -	- -	21/7	- -	- -	25/7
26	*Asparagus racemosus* Willd	Satavar	Liliaceae	03/10	10/11	21/11	13/10	25/11	5/12
27	*Baliospermum montanum* (Willd) Muell.	Chitawar	Euphorbiaceae	25/10	18/04	15/5	10/11	10/5	2/6
28	*Barleria prionitis* L.	Katsaraeya	Acanthaceae	*	*	*	*	*	*
29	*Bauhinia variegata* L.	Safedkachnar	Fabaceae	15/10	28/9	- -	1/11	- -	- -
30	*Bacopa monnieri* (L.) Pennell	Bramhi	Scrophulariaceae	*	*	*	*	*	*
31	*Bixa orellana* L.	Sinduri	Bixaceae	20/08	28/09	30/9	5/09	18/10	16/10
32	*Canavalia gladiata* (Jacq.) DC	Bansem	Fabaceae	15/07	27/08	23/08	25/9	3/9	5/09
33	*Caesalpinia bonducella* (L) Roxb.Fleming	Gataran	Fabaceae	- -	- -	27/7	- -	- -	10/8
34	*Cassia hirsuta* L.	Jangalikasondi	Fabaceae	5/11	13/11	22/10	1/12	13/12	30/10
35	*Cassia glauca* L.	Agaltara	Fabaceae	20/8	25/8	22/8	3/9	5/9	2/9
36	*Cassia occidentalis* L.	Kasoundi	Fabaceae	3/8	17/8	15/6	18/8	19/9	27/6
37	*Catharanthus pusillus* (Murr.) *G.*	Sadabahar	Apocynaceae	*	*	*	*	*	*
38	*Catharanthus roseus* (L.) G.	Sadabahar	Apocynaceae	*	*	*	*	*	*
39	*Celastrus paniculatus* Willd.	Malkangni	Celastraceae	15/4	25/3	18/4	- -	- -	15/5
40	*Centella asiatica* (L.) Urb.	Mandookparni	Apiaceae	*	*	*	*	*	*
41	*Centratherum anthelminticum* (L.) Kuntze	Vanjeera	Asteraceae	8/8	26/10	28/10	23/8	7/11	10/11
42	*Chlorophytum arundinaceum* Baker	Safedmusli	Liliaceae	25/8	25/7	28/6	- -	- -	10/7
43	*Chlorophytum tuberosum* Sant. et.al.	Safedmusli	Liliaceae	30/7	28/7	3/8	- -	5/12	29/8
44	*Cissus quadrangularis* L.	Hathjod	Vitaceae	11/11	25/10	21/11	- -	- -	- -
45	*Citrullus colocynthis* (L.) Schrader.	Indryan	Cucurbitaceae	8/8	10/8	12/8	12/9	15/9	2/9
46	*Clematis smilacifolia* Wall.	Morwah	Ranunculaceae	15/10	28/10	12/10	12/11	10/11	10/11
47	*Cleome viscosa* L.	Hurhur	Ranunculaceae	25/8	17/8	6/9	8/10	20/10	2/10
48	*Clerodendrum indicum* (L.) Kuntze	Bharangi	Verbenaceae	4/7	8/4	10/5	20/7	3/6	5/6
49	*Clerodendrum serratum* (L.) Moon	Bharang	Verbenaceae	13/8	8/4, 22/7	11/7	23/8	15/5,30/8	23/7
50	*Clitoria ternatea* L.	Aprajita	Fabaceae	16/8	17/8	11/8	25/9	28/9	29/8

Appendix 1. (Continued)

S.N.	Species	Local Name	Family	Flowering			Fruiting		
				2004	2005	2006	2004	2005	2006
51	*Coleus forskahlii* Briq.	Pashanbhed	Lamiaceae	15/9	3/10	17/9	25/9	7/12	28/9
52	*Colocasia esculenta* L.	Junglikuchai	Araceae	15/7	12/8	- -	- -	- -	- -
53	*Colocasia* sp. L.	Bramharakas	Araceae	24/06	11/7	- -	- -	- -	- -
54	*Colocasia*sp. L.	Dhobasadu	Araceae	- -	15/8	- -	- -	- -	- -
55	*Costus speciosus* (J. Kpoenig.) Sm	Keokand	Zingiberaceae	3/8	7/ 7	18/6	20/8	15/8	4/7
56	*Crinum asiaticum* L.	Sudarshan	Liliaceae	26/7	20/7	29/6	17/8	18/8	20/7
57	*Crinum defixum* Ker-Gawl	Bajarkand	Liliaceae	- -	25/4	- -	- -	18/05	- -
58	*Crinum latifolium* L.	Giloch	Liliaceae	22/9	26/2	15/6	- -	- -	- -
59	*Crotolaria sericea* Roth.	Jangali san	Fabaceae	11/11	28/11	10/10	21/11	20/12	21/10
60	*Cryptolepis buchananii* Roen. &Schult.	Nagbel	Asclepiadaceae	25/10	6/4	28/6	- -	3/9	- -
61	*Curculigo orchoides* Gaertn.	Kali musli	Hypoxidaceae	20/7	20/6	26/6	- -	- -	- -
62	*Curcuma amada Roxb.*	DaruHaldi	Zingiberaceae	27/6	- -	- -	- -	- -	- -
63	*Curcuma angustifolia* Roxb.	Tikhur	Zingiberaceae	28/6	5/4	12/6	- -	- -	- -
64	*Curcuma aromatic* Salisb.	Janglihaldi	Zingiberaceae	15/7	22/7	18/7	- -	- -	- -
65	*Curcuma caesia* Roxb.	Kali haldi	Zingiberaceae	15/6	11/4	16/5	- -	- -	- -
66	*Curcuma zeodaria* Roxb.	Narkachoor	Zingiberaceae	9/9	3/9	14/9	- -	- -	- -
67	*Cymbopogon flexuous* Steud.	Lemon grass	Poaceae	10/10	28/10	11/10	30/10	25/11	28/10
68	*Cymbopogon martini* (Roxb.) Wats.	Pamarosa grass	Poaceae	7/9	13/05	- -	23/9	1/6	- -
69	*Cymbopogon winterianus* Jowitt.	Citronella grass	Poaceae	- -	15/2	- -	10/3	- -	- -
70	*Cynoglossum lanceolatum* Forssk.	Bhograj	Boranginaceae	15/4,	22/4	13/4	- -	5/5	22/4
71	*Datura stramonium* L.	Dhatura	Solanaceae	- -	22/9	27/7	- -	5/10	07/8
72	*Desmodium gangeticum* (L.) DC.	Shalparni	Fabaceae	17/7	25/8	24/7	10/8	- -	- -
73	*Desmodium heterocarpon* (L.) DC.	Mohini	Fabaceae	15/9	20/9	12/9	28/9	- -	- -
74	*Desmodiuml axiflorum*.DC.	Kariaokhad	Fabaceae	26/8	3/9	- -	15/9	24/9	- -
75	*Desmodium motorium* (Houtt.) Merr.	Telegraph plant	Fabaceae	17/9	3/10	- -	19/10	25/10	- -
76	*Desmodium pulchellum* (L.) Benth.	Katla	Fabaceae	3/10	20/8	- -	17/10	- -	- -
77	*Dioscorea hispida* Dennst.	Bechandi	Dioscoreaceae	10/8	20/7	- -	25/8	12/8	- -
78	*Dioscorea pentaphylla* (L.)	Barahakanda	Dioscoreaceae	5/8	26/7	- -	25/8	15/8	- -
79	*Diplocyclos palmatus* Jeff.	Bundela	Cucurbitaceae	- -	- -	3/12	- -	- -	18/12
80	*Eclipta prostrate* L.	Bhringra	Asteraceae	*	*	*	*	*	*
81	*Elephantopus scaber L.*	Sahastramool	Asteraceae	7/8	19/8	5/8	25/8	5/9	20/8
82	*Elettaria cardemomum* (L.) Maton.	Chhotiilaychi	Zingiberaceae	6/7	31/3	- -	25/8	12/8	- -
83	*Eryngium foetidum L.*	Jangalidhania	Apiaceae	15/10	3/1, 15/10	10/1, 24/10	- -	23/1, - -	- -
84	*Flemingia bracteata*	Galfulli	Fabaceae	25/10	20/8	23/9	15/11	- -	- -
85	*Flemingia nana* Roxb.	Balraj	Fabaceae	11/11	25/12	- -	7/12	- -	- -
86	*Flemingia praecox* Clarke	Chhotasavar	Fabaceae	3/2	27/12	- -	27/3	19/3	- -
87	*Flemingia* sp.L.	Vanchana	Fabaceae	3/10	10/10	- -	- -	- -	- -
88	*Gardenia gummifera L.*	Dikamali	Rubiaceae	-	-	15/12	- -	- -	- -
89	*Globba racemosa* Sm.	Jhoolbhazi	Zingiberaceae	4/7	17/7	- -	- -	- -	- -
90	*Gloriosa superba L.*	Kalihari	Liliaceae	4/8	03/10	5/7	20/8	- -	-
91	*Grewia hirsute* Vahl.	Gudsakari	Tiliaceae	10/7	15/7	- -	3/11	10/1	- -
92	*Gymnema sylvaestre* (Retx.) R. Br.	Gudmar	Asclepiadaceae	26/8	27/7	25/7	20/9	- -	- -
93	*Hedychium coronarium* J. Koenig.	Gulbakawali	Zingiberaceae	25/7	30/10	21/11	- -	- -	- -
94	*Helicteres isora L.*	Marodphalli	Sterculiaceae	8/8	25/7	21/8	20/8	16/10	8/9
95	*Hibiscus vitifolius L.*	JungliKapas	Malvaceae	26/8	25/9	10/6	10/9	19/10	27/7
96	*Hiptagema dablota* Gaertn.	Batterey	Malpighiaceae	30/11	31/3	5/12	18/12	2/5	28/12
97	*Holostemma annulare* (Roxb.) K. Schum.	Khudhur	Asclepiadaceae	10/8	- -	- -	30/8	- -	- -
98	*Hygrophila auriculata* (Schum.) Heine	Talmakhana	Acanthaceae	20/11	15/11	- -	- -	- -	- -
99	*Hyptis suaveolens* (L.) Poit.	Van Tulsa	Lamiaceae	15/9	25/9	- -	5/10	15/10	- -
100	*Ipomoea mauritiana* Jacq.	Bedarikanda	Convolvulaceae	15/7	20/7	17/8	28/7	30/7	25/8
101	*Jasminum grandiflorum L.*	Vanmongra	Oleaceae	15/12	03/4	21/12	22/1	13/5	- -

Appendix 1. (Continued)

S.N.	Species	Local Name	Family	Flowering			Fruiting		
				2004	2005	2006	2004	2005	2006
102	*Jatropha curcas L.*	Bagranda	Euphorbiaceae	8/8	1/8	15/5	28/8	25/8	- -
103	*Jatropha gossypifolia L.*	Ratanjot	Euphorbiaceae	23/6	21/4	12/4	1/7	8/5	30/4
104	*Kalanchoe heterophylla* Prain.	Bhasampatti	Crassulaceae	25/11	4/10	- -	- -	- -	- -
105	*Kalanchoe pinnata* (Lamk.) Pers.	Vidhara	Crassulaceae	3/10	12/10	- -	11/11	- -	- -
106	*Leea asiatica* Edgew.	Hansiadafar	Leeaceae	15/7	17/ 8	15/5	25/7	10/8	- -
107	*Leea macrophylla* Roxb.	Hansraj	Leeaceae	27/6	3/5	24/4	5/7	7/8	- -
108	*Leea robusta* Roxb.	Hansrajbada	Leeaceae	4/7	15/7	19/5	20/8	17/8	- -
109	*Leonotis nepetifolia* (L.) R.Br.	Jungligenda	Lamiaceae	20/10	25/12	- -	30/10	- -	- -
110	*Lippia javanica* (Burm. f.) Spreng.	Hanuman sand	Brassicaceae	10/9	28/1	- -	- -	- -	- -
111	*Malaxis latifolia* Sm.	Rajmohini	Orchidaceae	- -	01/4	- -	-	20/4	- -
112	*Marsdenia tenacissima* (Roxb.) Moon	Dudhiyalata	Asclepiadaceae	4/7	14/8	- -	25/7	,28/9	- -
113	*Millingtonia hortensis* L.f.	Akashneem	Bignoniaceae	3/11	20/11	- -	- -	- -	- -
114	*Mimosa pudica* L.	Lajwanti	Mimosaceae	6/9	2/7	15/3	20/9	5/10	- -
115	*Mucuna pruriens* (L.) DC.	Kewanch	Fabaceae	3/9	20/9	- -	15/10	6/10	- -
116	*Murraya paniculata* (L.) Jacq.	Hathul	Rutaceae	- -	1/11	- -	- -	10/11	- -
117	*Nelsonia canescens* (Lam.) Spreng	BaidJadi	Acanthaceae	25/1	18/1	20/12	- -	- -	- -
118	*Nervilia aragoana* Gaud.	Bhimalathi	Orchidaceae	4/7	12/7	3/7	24/7	28/7	21/7
119	*Nordostachys jatamansi* (D. Don) DC	Jatamasi	Caprifoliaceae	- -	3/3	- -	31/3	- -	- -
120	*Nyctanthes arbortrsitis* L.	Harsingar	Oleaceae	3/8	20/8	23/9	30/11	29/10	30/9
121	*Ocimum basilicum* L.	Dauna	Lamiaceae	8/11	3/9	30/7	25/11	22/9	- -
122	*Ocimum gratssimum* L.	Ram Tulsi	Lamiaceae	7/9	8/4	- -	27/9	24/4	- -
123	*Operculina turpethum* (L.) Silva Manso.	Nisodh	Convolvulaceae	*	*	*	*	*	*
124	*Phyllanthus amarus* Schum et Thonn	Bhuianwla	Euphorbiaceae	*	*	*	*	*	*
125	*Pimpinella bracteata* Haines.	Badatejraj	Apiaceae	15/9	20/8	- -	5/11	- -	- -
126	*Piper longum* L.	Pipali	Piperaceae	4/7	31/10	24/6	12/7	7/12	- -
127	*Plumbago zeylanica* L.	Chitrak	Plumbaginaceae	20/9	28/8	21/8	13/10	20/9	28/8
128	*Polygala crotalarioides* Buch -Ham ex DC	Tejraj	Polygalaceae	5/12	12/12	- -	- -	- -	- -
129	*Psoralea corylifolia* L.	Bawchi	Fabaceae	20/8	7/9	15/8	5/9	19/10	24/8
130	*Pueraria tuberosa* (Roxb. ex. Willd) DC	Patalkumhada	Fabaceae	25/4	5/5	- -	- -	- -	- -
131	*Rauvolfia serpentina* (L.) Benth ex Kurz	Sarpgandha	Apocynaceae	*	*	*	*	*	*
132	*Rubia cordifolia* L. (Roxb.)	Manjista	Rubiaceae	- -	26/12	- -	- -	- -	- -
133	*Ruta graveolens* L.	Sitab	Rutaceae	1/1	2/1	16/1	18/1	19/1	7/2
134	*Salvia plebeja* R. Br.	Memri	Lamiaceae	15/9	3/7	- -	5/10	18/7	- -
135	*Sansevieria cylindrica* Thunb nom. cons.	Janglimunga	Agavaceae	11/11	22/12	15/11	3/2	-	20/01
136	*Scoparia dulcis* L.	Hajardana	Scrophulariaceae	15/9	22/7	18/5	- -	17/8	- -
137	*Smilax macrophylla* L.	Ramdatun	Smilaceae	- -	- -	- -	- -	- -	- -
138	*Smilax perfoliata*Lour	Jalraj	Smilaceae	4/7	16/7	- -	18/7	1/8	- -
139	*Solanum incanum* L.	Bhantaki	Solanaceae	- -	- -	21/11	- -	- -	2/12
140	*Solanum torvum* S.W.	Chhotikaheri	Solanaceae	*	*	*	*	*	*
141	*Solanum violaceum* Ortega.	Vanbhata	Solanaceae	- -	3/5	- -	- -	7/7	- -
142	*Spilanthus oleracea* (DC.) Clarke.	Akarkara	Asteraceae	8/2	10/10	- -	25/2	15/11	- -
143	*Stachytarpheta jamaicensis* (L.) Vahl.	ApamargSafed	Verbenaceae	10/8	1/8	15/4	25/8	17/8	24/4
144	*Stephania hirnaundifolia* Vahl	Hirankhuri	Menispermaceae	3/9	25/4	- -	- -	- -	- -
145	*Stephania herandifolia* (Willd.) Walp.	Hirankhuri	Menispermaceae	2/7	12/8	- -	- -	- -	- -
146	*Strobilanthes asperrimus* Nees.	- -	Acanthaceae	- -	12/4	- -	- -	3/6	- -
147	*Tephrosia purpurea* (L.) Pers.	Sarphonka	Fabaceae	25/9	3/10	25/5	1/10	19/10	27/5
148	*Uraria picta* (Jacq.) Desv.	Prishtthaparni	Fabaceae	30/8	25/4,	15/6	15/9	7/5	- -
149	*Urena lobata* L.	Latangari	Malvaceae	5/11	8/4,	1/5	20/1	3/5	- -
150	*Urginea indica* (Roxb.) Kunth..	Junglipyaz	Liliaceae	10/7	25/6	30/3	5/8	15/7	24/4
151	*Uraria alopecuroides* (Roxb.) Wight.	Jogilat	Fabaceae	10/8	4/4,	- -	20/8	25/4	- -
152	*Vernonia divergens* (Roxb.) Edgew.	Kodgi	Asteraceae	16/11	23/11	6/11	25/11	10/12	- -

Appendix 1. (Continued)

S.N.	Species	Local Name	Family	Flowering			Fruiting		
				2004	2005	2006	2004	2005	2006
153	*Vigna* sp. L.	Jangalibarbate	Fabaceae	15/9	20/9	- -	24/9	5/10	- -
154	*Vitex leucoxylon* L.	Mayurpankh	Verbenaceae	- -	03/4	14/3	- -	28/4	- -
155	*Vitex negundo* L.	Nirgundi	Verbenaceae	11/4	20/4	10/5, 22/7	5/5	10/5	- -
156	*Wedelia chinensis* (Osbeck.) Merr.	Bhringraj	Asteraceae	*	*	*	*	*	*
157	*Withania somnifera* (L.) Dunal.	Ashwagandha	Solanaceae	5/1	31/12	10/01	30/1	10/01	30/1
158	*Woodfordia fruticosa* L. Kurz.	Dhavai	Lythraceae	15/2	12/1	25/01	10/3	15/2	10/2
159	*Zingiber roseum* (Roxb.) Roscoe	JangliAdrak	Zingiberaceae	8/8	3/10	19/8	28/8	29/11	7/9