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REVIEW

Anti-Viral Activity of Indian Plants

B. N. Dhawan

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Abstract Plants continue to be a major source for new chemical entities to develop novel therapeutic agents. Large number of plants has been shown to be active in vitro against a variety of human pathogenic viruses or their near congeners. In several cases the active compounds have been isolated and characterized. Very few of them, however, have been investigated in detail in vivo or taken to the clinic. Pure compounds like andrographolide, curcumin and glycyrrhizic acid as well as extracts of *Azadirachta indica* have shown activity against several viruses and should be investigated further for their therapeutic potential. An analysis of available data from several hundred species indicates that antiviral activity is more likely to be found in plants belonging to certain families. It is necessary to screen more plants of these families which are available in India to obtain further leads.

Keywords Antiviral activity · Indian plants · Herpes simplex · Viral hepatitis · Human immunodeficiency virus · Respiratory viruses · Interferon inducers

Introduction

Natural products have been, and continue to be, a major source of new chemical entities (NCE) for development of better therapeutic agents against infective and non-infective disorders. The bio-molecules are more stable, clinically more specific and available from renewable source [1]. Plants of Indian origin have provided several novel leads in the past [2] and are likely to yield more NCE in future also.

The contribution of natural products to anti-viral chemotherapy, however, has been more modest. Several factors have contributed to this scenario. Viral infections like the common cold are self limited and require only symptomatic treatment. Public health measures like vector control have succeeded in controlling vector transmitted infections. Similarly, development of effective vaccines has played a major role in eliminating diseases like small pox, near eradication of poliomyelitis and treatment of rabies. A major reason for limited input from Indian plants has been the non-availability of strict containment facility needed for such work at most institutions in the country. A large number of plants found in India have, therefore been investigated and found active in Japan, South Korea, US, etc. Data on all such plants also has been included in the present review along with analysis of data generated within the country. Plants active in viruses closely related to human virus [e.g. feline Human Immunodeficiency Virus (HIV) or duck hepatitis] have also been included. Maximum plants have been screened against Ranikhet disease (RNA) virus (RDV) and vaccinia (DNA virus) followed by herpes, HIV and hepatitis. The data in following sections has been arranged in the same order.

Most of the studies have used in vitro test systems and crude extracts of various parts of the plants. Pure compounds have been tested in some cases and in vivo procedures have been used in very few cases. In limited number of cases clinical studies also have been done. In several cases the name of the plant or family has been changed now. The name given in the original publication has been retained in the present review to avoid confusion but the names of family have been revised.

B. N. Dhawan (✉)
3, Rama Krishna Marg, Lucknow 226 007, India
e-mail: dhawanbn@gmail.com

Ranikhet Disease and Vaccinia Viruses

CSIR Central Drug Research Institute Lucknow (CDRI) has been the pioneer institute to undertake large scale screening of Indian plants for anti-microbial and other biological activities using about 80 in vitro and in vivo tests. The program has used 50% ethanolic extracts of botanically authenticated plant samples. The extracts have been screened in vitro against one RNA virus (Ranikhet disease virus) and one DNA virus (vaccinia virus). Some samples have also been screened against encephalomyocarditis (EMCV), Japanese Encephalitis B (JE) and Semliki Forest (SFV) viruses. Extracts showing high degree of activity were fractionated according to a standardized protocol to localize activity in one or more fractions. The results of testing 3,789 samples from 3,482 plants belonging to 233 families have been reported in a series of publications [3–14]. In addition, 967 of these plants were also tested for interferon-like activity against RD and vaccinia viruses [15]. A mid-term review of the work has also been published [16]. Antiviral activity was observed in 242 samples belonging to 96 families. The results have been summarized in Table 1. The plants have been listed under the appropriate families which have been arranged alphabetically. It also indicates plants where activity has been confirmed further in fractions or those exhibiting anticancer activity also.

Some of the active plants have been followed up at CDRI for isolation and characterization of the active constituents. The antiviral activity of (+) odorinol isolated from *Aglaia roxburghiana* has been reported by Joshi et al. [17]. Subsequently two new triterpinoids also have been isolated and characterized [18]. Lupeol has been identified as the active moiety of hexane fraction of *Vicoa indica*. It was effective against EMCV, RDV and SFV. Lupeol isolated from same fraction was active against RDV only [19]. Furomolligin isolated from *Rubia cardifolia* was active against EMCV [20].

The interferon like activity of five plants (*Acacia auriculiformis*, *Cassia fistula*, *Olex polyama*, *Senecio tenuifolius* and *Zingiber capitatum*) has been investigated further. The classical fractionation failed to localize activity in a particular fraction. The activity could be localized in each case in non-dialyzable fraction. It was destroyed on treating the fraction with trypsin. These results suggest the presence of an interferon-like or interferon inducing substance in the non-dialyzable fraction [15].

CDRI has also tested plants used as hepato-protective agents in traditional systems of Indian medicine for their anti-hepatitis B virus surface antigen (HB_sAg) activity in serum of patients or carriers. Promising results were obtained with *Phyllanthus amarus* [21] and *Picrorhiza*

Table 1 Plants showing anti-viral activity in CDRI's biological screening program

No.	Family & plant	Part	Activity	References
	Acanthaceae			
1.	*Adhatoda vasica*	Rt	R	[3]
2.	*Barleria cuspidata*	Pl	R, r	[7, 15]
3.	*Niligirianthus ciliatus*	Px[a]	V	[12]
4.	*Strobilanthus wightianus*	Px	R, r	[7, 15]
	Anacardiaceae			
5.	*Cotinus coggygria*	Px	R	[3]
6.	*Pistacia integerrima*	Sb	R	[3]
7.	*Rhus parviflora*	Px	V, v, C	[5, 15]
8.	*Rhus succedanea*	Lf	R, r	[3, 15]
9.	*Rhus succedanea*	Px	R	[12]
	Annonaceae			
10.	*Miliusa macrocarpa*	Px	R	[12]
	Apiaceae			
11.	*Pimpinella diversifolia*	Pl	R	[3]
	Apocynaceae			
12.	*Ichnocarpus frutescens*	Pl	R	[3]
	Aquifoliaceae			
13.	Ilex *wightiana*	Px[a]	V	[12]
	Araliaceae			
14.	*Hedera colchica*	Px	R	[5]
15.	*Schefflera rostrata*	Lf, In	R	[12]
16.	*Schefflera wallichiana*	St	R	[12]
	Asclepiadeaceae			
17.	*Hemidesmus indicus*	Pl	R, r	[3, 15]
	Aspidiaceae			
18.	*Polystichum biaristatum*	Pl[a]	R	[12]
	Asteraceae			
19.	*Artemesia parviflora*	Pl	V	[6]
20.	*Cnicus walichii*	Pl	R	[3]
21.	*Conyza visicidula*	Pl	V,	[5]
22.	*Eclipta alba*	Pl	R	[3]
23.	*Lagascea molis*	Pl	r, V	[6, 15]
24.	*Laggera pierodanta*	Pl	R	[5]
25.	*Saussurea obvallata*	Fl	R	[11]
26.	*Siegesbeckia orientalis*	Pl	R, r	[3, 15]
27.	*Senecio tenuifolius*	Pl	R, r, v, C	[8, 15]
28.	*Tagetes erecta*	Pl	R	[4]
29.	*Tagetes minuta*	Pl	R, r	[4, 15]
30.	*Vernonia cineria*	Pl	R	[3]
31.	*Vittadinia australis*	Pl	V	[4]
	Berberidaceae			
32.	*Berberis lyceum*	Rt	R	[3]
	Betulaceae			
33.	*Alnus nepalensis*	Px	R	[12]
34.	*Alnus nitida*	Sb	R, V	[6]
	Bignoniaceae			

Table 1 continued

No.	Family & plant	Part	Activity	References
35.	*Heterophragma adenophyllum*	Px	V	[5]
36.	*Stereospermum suaveolens*	Rt	R, r, C	[3, 15]
	Bixaceae			
37.	*Bixa orellana*	Fr[a]	V	[12]
	Bombacaceae			
38.	*Salmalia malabarica*	Fl	R, r	[3, 15]
	Brassicaceae			
39.	*Descurainia sophia*	Pl	R	[10]
	Caesalpiniaceae			
40.	*Caesalpinia bonducella*	Rt	V	[3]
41.	*Cassia auriculata*	Px[a]	R, r	[3, 15]
42.	*Cassia auriculata*	Rt	V, v	[3, 15]
43.	*Cassia fistula*	Sb[a]	R, r, v, C	[3, 15]
44.	*Cassia fistula*	Pd[a]	R, V	[3]
45.	*Cassia tora*	Pl	R	[3]
46.	*Caesalpinia sepiaria*	Rt	R,V	[4]
47.	*Hardwickia binata*	Pl	R, r, v	[5, 15]
48.	*Tamarindus indica*	Fl	R	[3]
	Capparaceae			
49.	*Capparis multiflora*	Px	R	[12]
50.	*Capparis longispina*	Px	R	[3]
	Caprifoliaceae			
51.	*Lonicera leschenaultii*	Px	R	[11]
	Celastraceae			
52.	*Euonymus angulatus*	Px[a]	R	[13]
53.	*Salacia roxburghii*	Px	R, r	[6, 15]
	Combretaceae			
54.	*Terminalia chebula*	Fr	R	[3]
55.	*Terminalia chebula*	Lf	R	[11]
56.	*Terminalia chebula*	Sw	R, r	[11, 15]
57.	*Terminalia paniculata*	Px[a]	R, C	[12]
	Connaraceae			
58.	*Connarus wighti*	Px	R	[6]
	Convolvulaceae			
59.	*Cuscuta reflexa*	Px	R, r	[4, 15]
	Cucurbitaceae			
60.	*Cucumis callosus*	Px	R,V	[12]
	Cupressaceae			
61.	*Cupressus torulosa*	Px	R,	[7]
	Cyperaceae			
62.	*Carex obscura*	Pl	R	[10]
63.	*Cyperus niveus*	Pl	R, r	[3, 15]
64.	*Cyperus pangorei*	Pl[a]	V	[12]
	Dilleniaceae			
65.	*Dillenia pentagyna*	Sb[a]	R	[14]
	Dipterocarpaceae			
66.	*Shorea robusta*	Px[a]	R	[10]
	Ebenaceae			

Table 1 continued

No.	Family & plant	Part	Activity	References
67.	*Diospyros chloroxylon*	Px	R	[6]
68.	*Diospyros marmorata*	Px[a]	R	[13]
69.	*Diospyros peregrina*	Sb	R, r	[3, 15]
70.	*Maba nigrescens*	Px	R, r, V, v	[6, 15]
	Elaeagnaceae			
71.	*Hippophae salicifolia*	Sb[a]	R	[11]
	Elaeocarpaceae			
72.	*Elaeocarpus tectorius*	Lf[a]	R, V	[11]
73.	*Elaeocarpus glandulosus*	Px	R, C	[12]
	Ericaceae			
74.	*Agapetes odonalocera*	Tu[a]	R	[12]
75.	*Rhododendron arboreum*	Px[a]	R	[14]
	Euphorbiaceae			
76.	*Aporosa villosula*	Px	R	[13]
77.	*Baccaurea ramiflora*	Fr	S	[14]
78.	*Bridelia retusa*	Sb[a]	R, r, C	[5, 15]
79.	*Bridelia squamosa*	Px	R	[6]
80.	*Euphorbia prolifera*	Pl	R, C	[3]
81.	*Euphorbia royleana*	St	R	[3]
82.	*Glochidion hohenackerii*	Px	R	[3]
83.	*Glochidion subsessile*	Px	R	[12]
84.	*Glochidion zeylanicum*	Px[a]	R	[12]
85.	*Jatropha glandulifera*	Px	R, r	[10, 15]
86.	*Kirganelia reticulata*	Px	R	[3]
87.	*Kirganelia tanarius*	Px	R,V	[12]
88.	*Mallotus resinosus*	Px	R,V	[12]
89.	*Margaritaria indica*	Px	V	[12]
90.	*Ricinus communis*	Lf	V	[3]
91.	*Emblica officinalis*	Fr	R	[3]
	Fabaceae			
92.	*Crotolaria semperflorens*	Px	R	[11]
93.	*Dunbaria ferruginea*	Px[a]	R	[12]
94.	*Indigofera pulchella*	Rt	V	[3]
95.	*Indigofera cassioides*	Px[a]	R	[12]
96.	*Mundulea sericeae*	Px	R, r	[6, 15]
97.	*Ougeinia oojeinensis*	Sb	R	[3]
98.	*Phaseolus trilobus*	Pl	V	[5]
99.	*Sesbania procumbens*	Px	R	[14]
100.	*Sesbania sesban*	Px	R	[6]
101.	*Sophora glauca*	Px	R	[7]
102.	*Uraria lagopoides*	Pl	R, r	[4, 15]
103.	*Wisteria chinensis*	Px	R	[12]
	Fagaceae			
104.	*Castanea sativa*	Sb	R	[3]
105.	*Castanopsis indica*	Sb	R, r, C	[7, 15]
106.	*Fagus sylvatica*	Px	r, V	[5, 15]
107.	*Lithocarpus dealbatus*	Sb	R	[11]
108.	*Lithocarpus dealbatus*	Fr	R	[11]

Table 1 continued

No.	Family & plant	Part	Activity	References
109.	*Lithocarpus dealbatus*	Lf, Tw	R	[11]
110.	*Quercus himalayana*	Px	V	[11]
111.	*Quercus lamellosa*	Sb	R, r, V, v	[3, 15]
112.	*Quercus lanceafolia*	Sb	R, r, V, v	[3, 15]
113.	*Quercus lineata*	Sb	R	[3]
114.	*Quercus pachyphylla*	Sb	R	[3]
115.	*Quercus thomsonii*	Px[a]	R	[12]
	Gentianaceae			
116.	*Canscora diffusa*	Pl	R	[4]
	Guttiferae			
117.	*Garcinia talbotii*	Pl	r, V	[5, 15]
	Hippocrateaceae			
118.	*Loeseneriella arnottiana*	Px[a]	R	[13]
	Juglandaceae			
119.	*Juglans regia*	Lf	V	[6]
	Lamiaceae			
120.	*Leonurus sibiricus*	Pl	V	[5]
121.	*Leucas prostrata*	Pl[a]	V	[12]
122.	*Rabdosia coetsa*	Px	R	[11]
123.	*Teucrium quadrifarium*	Pl	r, V	[6, 15]
124.	*Teucrium royleanum*	Pl	R	[10]
	Lauraceae			
125.	*Cinnamomum iners*	Px	R, r	[6, 15]
126.	*Lindera pulcherrima*	Px	R	[9]
127.	*Litsea coriacea*	Px	R	[13]
128.	*Machilus gamblei*	Lf	R	[3]
	Liliaceae			
129.	*Scilla hyacinthiana*	Bu	S	[14]
	Loranthaceae			
130.	*Dendrophthoe falcata*	Px	R, r	[4, 15]
131.	*Dendrophthoe falcata*	Px	V	[5]
132.	*Helixanthera wallichiana*	Px[a]	R, V	[13]
	Lythraceae			
133.	*Lagerstroemia speciosa*	Px	R	[4]
134.	*Wodfordia fruticosa*	Pl	R	[3]
	Malvaceae			
135.	*Thespesia populnea*	Fr	R, r, C	[3, 15]
	Melastomataceae			
136.	*Melastoma normale*	Pl	r, V	[4, 15]
137.	*Memecylon umbellatum*	Lf	R, C	[3]
	Meliaceae			
138.	*Aglaia anamallayana*	Px[a]	R	[13]
139.	*Amoora wallichi*	St	R, r, V, v	[3, 15]
140.	*Melia azaderach*	Sb	R, r	[4, 15]
	Menispermaceae			
141.	*Cocculus pendulus*	Px	R, C	[4]
142.	*Tinospora cardifolia*	St	R	[3]
	Mimosaceae			

Table 1 continued

No.	Family & plant	Part	Activity	References
143.	*Abarema ungulata*	Px	R	[13]
144.	*Acacia auriculiformis*	Px, Sb	r, v	[15]
145.	*Acacia catechu*	St	R	[3]
146.	*Acacia raddiana*	Px	R	[11]
147.	*Albizzia procera*	Px	r, V, C	[5, 15]
148.	*Mimosa pudica*	Pl	r, V	[4, 15]
	Moraceae			
149.	*Ficus hirta*	Px[a]	V	[12]
150.	*Ficus religiosa*	Sb	R, r	[3, 15]
	Moringaceae			
151.	*Moringa oleifera*	Fr	V	[3]
	Myricaceae			
152.	*Myrica nagi*	Sb	R	[3]
	Myristicaceae			
153.	*Knema linifolia*	Sb	R	[14]
	Myrsinaceae			
154.	*Maesa chisea*	Px	R	[7]
155.	*Maesa indica*	Px	V, v	[4, 15]
	Myrtaceae			
156.	*Eugenia codyensis*	Px[a]	R	[12]
157.	*Eugenia mangifolia*	Px	R	[11]
158.	*Eugenia thwaitesii*	Px[a]	R	[12]
159.	*Syzygium densiflorum*	Px	R	[11]
160.	*Syzygium kurzii*	Px[a]	S	[14]
161.	*Syzygium occidentalis*	Px	R	[12]
162.	*Syzygium samarangense*	Px	R,V	[12]
163.	*Syzygium tetragonum*	Px	R	[11]
	Ochnaceae			
164.	*Ochna integerrima*	Px	R	[14]
	Oleaceae			
165.	*Olea polygama*	Px	r, v	[17]
166.	*Nyctanthes arbor-tristis*	Fr	E	[14]
167.	*Ximenia americana*	Px	R	[6]
	Onagraceae			
168.	*Jussiaea suffruticosa*	Pl	R, r, C	[7, 15]
169.	*Ludwiga perensis*	Pl	R, r	[4, 15]
	Orchidaceae			
170.	*Vanda spathulata*	Pl	R, r	[7, 15]
	Papavaraceae			
171.	*Argemone mexicana*	Pl	R	[3]
	Passifloraceae			
172.	*Passiflora mollissima*	Px	R	[11]
	Pinaceae			
173.	*Cryptomeria japonica*	Px	V	[4]
	Pittosporaceae			
174.	*Pittosporum tetraspermum*	Px	R	[12]
	Plumbaginaceae			
175.	*Vogelia indica*	Pl	R	[4]

Table 1 continued

No.	Family & plant	Part	Activity	References
	Poaceae			
176.	*Cynodon dactylon*	Px[a]	V	[3]
177.	*Hordeum vulgare*	Sd	R, r	[3, 15]
178.	*Imperata cylindrica*	Px	R, r	[5, 15]
179.	*Isachne kunthiana*	Pl	R	[12]
180.	*Saccharum species*	Lf	R	[11]
	Polygonaceae			
181.	*Polygonum glabrum*	Px	R, r	[4, 15]
	Polypodiaceae			
182.	*Adiantum caudatum*	Pl	R	[3]
183.	*Asplenium nidus*	Px	R, V	[12]
184.	*Pseudodrynaria coronans*	Rh[a]	R	[12]
	Primulaceae			
185.	*Anagallis arvensis*	Pl	R, r	[5, 15]
	Proteaceae			
186.	*Hakea saligna*	Px	R	[7]
	Ranunculaceae			
187.	*Clematis buchanana*	Px	V	[4]
188.	*Clematis gouriyana*	Px	R	[3]
	Rhamnaceae			
189.	*Scutia myrtima*	Px	R, V	[3]
190.	*Zizyphus glaberrima*	Px	R, r	[6, 15]
191.	*Zizyphus rugosa*	Px[a]	R	[13]
	Rosaceae			
192.	*Cotoneaster bacillaris*	Px	R, r, V, v	[6, 15]
193.	*Photinia integrifolia*	Px	r, V	[5, 15]
194.	*Prunus cornuta*	Px	R, r	[6, 15]
195.	*Rosa leschenaultii*	Px	R	[11]
196.	*Rubus hexagonus*	Px	R	[11]
	Rubiaceae			
197.	*Cinchona ledgeriana*	Lf	V, v	[6, 15]
198.	*Gardenia jasminoides*	Px	R, r	[4, 15]
199.	*Gardenia turgida*	Fr	R, C	[3]
200.	*Ixora arborea*	Px	r, V	[5, 15]
201.	*Ixora nigricans*	Px	R	[5]
202.	*Psychotria truncata*	Px	R, r,	[6, 15]
203.	*Randia dumetorum*	Sb	R	[3]
204.	*Uncaria pilosa*	Px	R	[12]
	Rutaceae			
205.	*Atalantia racemosa*	Px	R, r	[5, 15]
206.	*Evodia lunu-ankenda*	Sb	R, r,	[7, 15]
207.	*Paramignya monophylla*	Px	R, C	[12]
	Sabiaceae			
208.	*Meliosma simplicifolia*	Px	R	[11]
	Salicaceae			
209.	*Salix alba*	Sb	R	[6]
210.	*Salix babylonica*	Pl	r, V	[4, 15]

Table 1 continued

No.	Family & plant	Part	Activity	References
	Samydaceae			
211.	*Casearia tomentosa*	Px	R	[4]
	Santalaceae			
212.	*Osyris arborea*	Lf	R	[3]
	Sapindaceae			
213.	*Allophylus serratus*	Px	R, r	[6, 15]
	Sarauiaceae			
214.	*Saurauia roxburghii*	Px	R	[7]
	Saxifragaceae			
215.	*Bergenia ligulata*	Rh	R	[11]
	Scrophulariaceae			
216.	*Celsia coromandeliana*	Pl	V, C	[4]
217.	*Limnophila racemosa*	Pl	V	[4]
	Solanaceae			
218.	*Atropa belladonna*	Lf	R, r	[3, 15]
219.	*Nicotiana plumbaginifolia*	Pl	R, r, C	[4, 15]
220.	*Solanum xanthocarpum*	Pl	R, r, C	[3, 15]
221.	*Withania somnifera*	Pl	R, V	[3]
	Staphyleaceae			
222.	*Turpinea pomifera*	Sb[a]	J	[14]
	Sterculiaceae			
223.	*Byttneria grandifolia*	Px[a]	R	[14]
	Symplocaceae			
224.	*Symplocos paniculata*	Lf	R, r	[3, 15]
	Theaceae			
225.	*Camellia japonica*	Px[a]	R	[12]
	Thymelaeaceae			
226.	*Lasiosiphon eriocephalus*	St	R	[3]
	Tiliaceae			
227.	*Erinocarpus nimmonii*	Lf	R, v	[11, 15]
228.	*Grewia hirsuta*	Px	R	[5]
229.	*Grewia latifolia*	Px	R, r	[4, 15]
230.	*Tilia europaea*	Px	R, r, C	[5, 15]
	Ulmaceae			
231.	*Ulmus wallichiana*	Sb	R, r	[6, 15]
	Urticaceae			
232.	*Urtica dioica*	Pl	R,	[10]
	Verbenaceae			
233.	*Gmelina arborea*	Sb	R	[3]
234.	*Vitex diversifolia*	Px	R	[12]
	Vitaceae			
235.	*Cayratia auriculata*	Fr	R	[12]
236.	*Lea indica*	Lf	R, r	[3, 15]
237.	*Lea macrophylla*	Px	V	[10]
	Zingiberaceae			
238.	*Cautleya spicata*	Rt, Rh	R	[3]
239.	*Costus speciosus*	Pl	R, r, V, v	[6, 15]

Table 1 continued

No.	Family & plant	Part	Activity	References
240.	*Zingiber capitatum*	Pl	r, v	[15]
241.	*Zingiber zerumbet*	Rh	R	[11]
	Zygophyllaceae			
242.	*Fagonia critica*	Px	R	[3]

Part used: *Bu* bulb, *Fl* flower, *Fr* fruit, *Lf* leaf, *In* inflorescence, *Pd* pod, *Pl* plant, *Px* plant without root, *Rh* rhizome, *Rt* root, *Sb* stem bark, *St* stem, *Sw* stem wood, *Tu* tuber, *Tw* twig

Activity: *E* encephalomyocarditis virus, *J* Japanese B encephalitis virus, *R* Ranikhet disease virus, *r* interferon induction, *S* semliki forest virus, *V* vaccinia virus, *v* interferon induction, *C* anticancer

[a] Activity confirmed in fractions

kurroa [22–26]. These have been reviewed in the section on hepatitis virus.

Herpes Virus

Activity against herpes virus has been reported in 49 Indian plants. These have been listed in Table 2. The activity is distributed widely and the plants belong to 34 families. Most of them have been reported active against herpes-1 virus though a few are active against both herpes-1 and 2. In 12 cases the strain used has not been mentioned. Only four publications have reported in vivo activity. Pure isolated compounds have been tested in 26 cases. Two of the compounds glycyrrhizin and lupeol are active against other human viruses also and this has been indicated at appropriate places in this review. Unfortunately none of them appear to have been followed up further. The results have been published in 43 papers and only 9 of them are from Indian laboratories. Table 2 includes only those plants from foreign publications which are found in India.

Human Immunodeficiency Virus

Large number of papers has been published in recent years reporting anti-HIV activity in numerous natural products, partly because of the large screening program of US National Cancer Institute. Activity has been reported only in 38 Indian plants in 32 papers. These have been shown in Table 3 and belong to 28 families. Data on 41 materials has been reported and 24 of them are pure compounds. Most investigators (26) have studied the activity on HIV-1 and in 10 cases the strain has not been mentioned. HIV-2 has been included in two studies only. Two of the reported plants have been found active against feline immunodeficiency virus (FIV), a close congener of HIV. Most of the publications in this case also are from foreign laboratories and there are only seven Indian publications. There have been claims of usefulness of Ayurvedic and Siddha formulations in treatment of AIDS but no reliable clinical data is available either with these formulations or with the plants listed in Table 3. Data with *Curcuma longa* has not been included in this table because curcumin isolated from this plant and its several semi-synthetic and synthetic analogues have been tested. The data has been included in concluding remarks.

Hepatitis Viruses

Large number of medicinal plants has been used for treatment of hepatic disorders in most traditional system of medicine. The parameters generally followed were clearance of jaundice and return of liver function tests to normalcy. Clearance of viraemia in infective hepatitis, the commonest hepatic disorder, became an important parameter after the demonstration of carrier stage and possible induction of malignancy in such persons. One of the earliest demonstrations of viral clearance was provided by the pioneering studies of Thyagarajan et al. [106] with *Phyllanthus amarus*. This led to screening of large number of plants for activity against the virus. The availability of the duck model for in vivo studies materially facilitated these studies. Protective effect has been reported with 17 Indian plants belonging to 14 families. These have been listed in Table 4. Most of the plants have been tested against hepatitis B virus by several in vitro procedures. The active compound has been isolated and characterised in nine of these plants.

Several hepatoprotective plants have been tested for anti-hepatitis B virus surface antigen (HB_sAg) activity in vitro using serum from patients or asymptomatic carriers harbouring the infection. Neutralizing activity has been reported with extract of *Phyllanthus amarus* [21]. A purified standardized extract (Picroliv) and a pure compound catalpol isolated from *Picrorhiza kurroa* were also found active while andrographolide (active constituent of *Andrographis paniculata*) and silymarin were inactive [22].

Clinical studies have been undertaken with some of the active plants in patients of infective hepatitis. As already reported above [23] efficacy of Picroliv has been demonstrated in Phase III multicentric trials. Beneficial effects have been reported with *Phyllanthus amarus* and glycyrrhizin also. These and other studies have been reviewed by Handa in a comprehensive publication [114] on hepatoprotective activity of Indian medicinal plants.

Respiratory Viruses

Interest in respiratory virus has increased following the recent epidemics of SARS and H_1N_1 infection. Activity has

Table 2 Indian plants active against herpes simplex viruses in vitro

Plant	Family	Product	Strain	References
1. *Adansonia digitata*	Bombaceae	Ext	HSV	[27]
2. *Aglai odorata*	Meliaceae	Ext	1[a]	[28]
3. *Aloe vera*	Liliaceae	Ext	2	[29]
4. *Andrographis paniculata*	Acanthaceae	Diterpenes	1	[30]
5. *Atlantia* sp.	Rutaceae	Pyrophorbide	2	[31]
6. *Azadirachta indica*	Meliaceae	Ext	1	[32]
7. *Barleria lupulina*	Acanthaceae	Iridoid glycoside	1	[33]
8. *Bauhinia racemosa*	Caesalpiniaceae	Ext	HSV	[34]
9. *Bauhinia variegate*		Ext	1,2	[35]
10. *Bidens pilosa*	Asteraceae	Ext	1,2	[36]
11. *Cedrus libani*	Pinaceae	Ext, oil	1	[37]
12. *Cissus quadrangularis*	Vitaceae	Ext	1,2	[38]
13. *Conyza aegyptica*	Asteraceae	Ext	HSV	[27]
14. *Cyperus rotundus*	Cyperaceae	Ext	1	[39]
15. *Euphorbia peplus*	Euphorbiaceae	Diterpene esters	2	[40]
16. *Glycyrrhiza glabra*	Fabaceae	Glycyrrhizin	HSV	[41]
17. *Heliotropium marifolium*	Boraginaceae	Alkaloid	HSV	[42]
18. *Holoptelea integrifolia*	Ulmaceae	Ext	HSV	[43]
19. *Houttuynia cordata*	Sarauiaceae	Ext	1,2	[36]
		Pure compounds	1	[44]
20. *Hypericum hookerianum*	Hyperaceae	Ext	1	[45]
21. *Hypericum mysorense*		Ext	1	[45]
22. *Lippia alba*	Verbenaceae	Ext	1	[46]
23. *Melia azaderach*	Meliaceae	Ext	2[a]	[47]
		Meliacine	1	[48]
24. *Mentha piperata*	Lamiaceae	Essential oil	1,2	[49]
25. *Momordia charantia*	Cucurbitaceae	Ext	1	[50]
26. *Moringa oleifera*	Moringaceae	Ext	1[a]	[28]
27. *Myrica rubra*	Myricaceae	Pure compounds	2	[51]
28. *Neerium indicum*	Apocynaceae	Ext	HSV	[43]
29. *Pandanus amaryllifolius*	Pandanaceae	Pandanin	1	[52]
30. *Peganum harmala*	Rutaceae	Ext	1	[53]
31. *Phyllanthus emblica*	Euphorbiaceae	Pure compounds	HSV	[54]
32. *Phyllanthus urinaria*		Pure compounds	1,2	[55]
33. *Pinus massoniana*	Pinaceae	Ext	HSV	[56]
34. *Plantago major*	Plantaginaceae	Ext	HSV	[56]
35. *Portulaca oleracea*	Portulacaceae	Polysaccharides	2	[57]
36. *Salvia officinalis*	Lamiaceae	Ext	1,2	[58]
37. *Santalum album*	Santalaceae	Oil	1,2	[59]
38. *Scinaia hatei*	Liagonaceae	Polysaccharides	HSV	[60]
39. *Scoparia dulcis*	Scrophulariaceae	Scopadulcic acid	1	[61]
40. *Solanum torvum*	Solanaceae	Torvanol A	1	[62]
		Torvoside H	1	
41. *Sorghum bicolor*	Poaceae	Peptide	1	[63]
42. *Strobilanthus cusia*	Acanthaceae	Lupeol	1	[64]
43. *Swertia chirata*	Gentinaceae	Ext	1	[65]
44. *Syzygium aromaticum*	Myrtaceae	Eugenin	1	[66]
45. *Syzygium jambos*		Ext	1	[67]

Table 2 continued

Plant	Family	Product	Strain	References
46. *Taracetium vulgare*	Asteraceae	Ext, Parthenolide	1,2	[68]
47. *Usnea complanta*	Usneaceae	Ext	1	[45]
48. *Ventilago denticulate*	Rhamnaceae	Ext	1[a]	[28]
49. *Withania somnifera*	Solanaceae	Ext	1	[69]

Ext crude extracts in different solvents; *HSV* unspecified strain, 1 or 2 HSV-1 or HSV-2

[a] Tested in vivo

been reported in 18 Indian plants belonging to 16 families. Pure compounds isolated from plants have been tested in nine cases. Activity has been reported against five respiratory viruses. Activity against influenza has been observed in seven samples and against H_1N_1 in four cases. One sample was active against SARS. The data about active plants has been summarized in Table 5.

Pox Viruses

Interest in this group of viruses has continued because of continued occurrence of chicken-pox and measles infection. Only 14 plants have been reported active against a variety of pox viruses. These plants belong to 13 families. Glycyrrhizin from *Glycyrrhiza glabra* is the only pure compound reported active. Extract from *Hibiscus sabdariffa* is the only product showing activity against measles. Most of the extracts have been found active against fowl pox. Details of activity have been shown in Table 6.

Other Viruses

Activity in several Indian plants has also been reported against a variety of other viruses causing human infection or their close congeners. Table 7 shows such plants belonging to 24 families. In 10 cases pure compounds isolated from plants have been found active. The list includes 12 viruses. The preparations showing activity against chikungunya, Japanese encephalitis and rotavirus are of particular interest due to wide occurrence of these infections in the country and need to be investigated on a priority basis.

Concluding Remarks

The broad based biological screening program of CDRI had included tests for several other activities also with the same standardized protocol. An analysis of the results has shown that each particular activity was preferentially observed in certain families. The top 11 families for anti-viral activity and three other major activities have been arranged in rank order in Table 8. It will be observed that rank order is different for different activities even though some families exhibit more than one type of activity. The top 11 families in each case contain 35–45% of the plants for the concerned activity. The 11 families identified for anti-viral activity contain about 41% of the 242 active plants from 96 families. About 27% plants reported active against other viruses and included in Tables 2, 3, 4, 5, 6 and 7 also belong to these 11 families. It should be useful to screen other plants of these families to obtain more active plants. It will be evident from data in Tables 1 and 8 that many plants and families have both anti-viral and anticancer properties. It may be mentioned also that several smaller countries like Egypt [39], Nepal [43], Sudan [54] and Togo [27] have undertaken systematic evaluation of their flora for anti-viral activity following the lead given by CDRI.

It is evident from the data reviewed above that little effort has been made to study the marine flora around the vast Indian coast line for antiviral compounds. Several Indian mangrove plants (*Ceriops decandra*, *Excocaria agallocha* and three species of *Rhizophora* i.e. *lamarckii*, *mucoranata* and *spiculata*) have been reported to exhibit potent anti-HIV activity [142] highlighting the need of further exploration of this valuable resource.

Most of the data reported in this review is from in vitro studies and the leads do not appear to have been followed up. This is partly because of lack of suitable animal models for several infections and partly due to lack of the requirement containment facility in majority of Indian institutions. It is suggested that multi-pronged strategy should be adopted to utilise these leads. There are certain viral infections like Japanese encephalitis, chikungunya or rotavirus which are major national concern. Only few leads are available against them and these need to be followed.

Table 3 Indian plants with in vitro anti-HIV activity

Plant	Family	Product	Strain	References
1. *Acacia nilotica*	Mimosaceae	Ext	HIV	[70]
2. *Acacia tortilis*		Ext	1	[71]
3. *Ailanthus allisima*	Simaroubaceae	Ocotillone	1	[72]
4. *Alpinia galanga*	Zingiberaceae	Ext	1	[73]
5. *Anisomeles indica*	Lamiaceae	Ovatodiolide	HIV	[74]
6. *Artemesia caruifolia*	Asteraceae	Coumaryl spermines	1	[75]
7. *Camellia japonica*	Theaceae	Camelliatannin H	1	[76]
8. *Cardiospermum helicabum*	Sapindaceae	Ext	1,2	[77]
9. *Chrysanthemum morifolium*	Asteraceae	Flavonoids	1	[78]
10. *Cinnamomum cassia*	Lauraceae	Ext	1,2	[77]
11. *Desmos* sp.	Annonaceae	Flavonoids	HIV	[79]
12. *Ficus glomerata*	Moraceae	Ext	1	[80]
13. *Glycyrrhiza glabra*	Fabaceae	Glycyrrhizin	1	[41]
14. *Harrisonia perforate*	Simaroubaceae	Ext	1	[80]
15. *Hyssopus officinalis*	Lamiaceae	Ext	1	[81]
16. *Illicium verum*	Illiaceae	Illicinone-A	HIV	[82]
17. *Justicia replans*	Acanthaceae	Ext	HIV	[83]
18. *Lippia javanica*	Verbenaceae	Piperitenone	1	[84]
19. *Mimusops elengli*	Sapotaceae	Mimusopic acid	HIV	[85]
20. *Momordia charantia*	Cucurbitaceae	Lectin	1	[86]
		Protein MRK 29	1	[87]
21. *Morinda citrifolia*	Rubiaceae	Ext	1	[88]
22. *Nelumbo nucifera*	Nymphaceae	Cocalaurine	HIV	[89]
		Nuciferine	HIV	
23. *Pedilanthus* sp.	Euphorbiaceae	Pedilotanin	1	[90]
24. *Pericampylus glaucus*	Menispermaceae	Periglaucines	1	[91]
25. *Phaseolus vulgaris*	Fabaceae	Lectin	1	[86]
26. *Polyalthea suberosa*	Annonaceae	Furans	HIV	[92]
27. *Polygonum viscosum*	Polygonaceae	Quercitin	1	[93]
28. *Ricinus communis*	Euphorbiaceae	Lectins	1	[86]
29. *Rhus sinensis*	Anacardiaceae	Benzofuranones	1	[94]
		Rhuscholide A	HIV	[95]
30. *Sambucus nigra*	Caprifoliaceae	Ext	HIV(f)	[96]
31. *Schisandra rubriflora*	Schisandraceae	Rubrifloxine	1	[97]
32. *Scoparia dulcis*	Scrophulariaceae	Ext	1	[98]
33. *Sida* sp.	Malvaceae	Ext	HIV	[99]
34. *Sophora flavescens*	Fabaceae	Ext	1	[76]
35. *Terminalia chebula*	Combretaceae	Galloyl glucose	1	[100]
36. *Urtica dioica*	Urticaceae	Ext	FIV	[96]
37. *Ximenia americana*	Oleaceae	Ext	1	[101]
38. *Zingiber officinale*	Zingiberaceae	Ext	1	[73]

Ext crude extract in different solvents; *HIV* strain not specified; *1*, *2* HIV I or II strain; *FIV* feline immunodeficiency virus (has many common features with HIV) [96]

A number of pure compounds have demonstrated activity against several viral infections. These are compounds of varying chemical complexity ranging from simple compounds like curcumin to complicated structures like iridoids glycosides. Adequate attention has not been paid to use them as basic templates to optimise the activity

Table 4 Indian plants active against hepatitis virus in vitro

Plant	Family	Product	Strain	References
1. *Agrimonia eupatoria*	Rosaceae	Ext	B	[102]
2. *Alpinea galanga*	Zingiberaceae	Ext	C	[73]
3. *Bupleurum* sp.	Apiaceae	Saikosaponins	B	[103]
4. *Glycyrrhiza glabra*	Fabaceae	Glycyrrhizin	B, C[a]	[41]
5. *Hypericum perforatum*	Hypericaceae	Hypericin	C[a]	[104]
6. *Oenanthe javanica*	Apiaceae	Phenolics	B	[105]
7. *Pericampylus glaucus*	Menispermaceae	Periglaucines	B	[91]
8. *Phyllanthus amarus*	Euphorbiaceae	Ext	B[a]	[21, 106]
9. *Phyllanthus urinaria*		Ext	B[a]	[107]
10. *Picrorhiza kurroa*	Scrophulariaceae	Picroliv	B	[22]
11. *Potentila anserine*	Rosaceae	Triterpine saponins	B, E	[108]
12. *Ranunculus scleratus*	Ranunculaceae	Apigenins	B	[109]
13. *Rubia cardifolia*	Rubiaceae	Naphthoquinones	B	[110]
14. *Saussurea lappa*	Asteraceae	Ext	B	[111]
15. *Terminalia chebula*	Combretaceae	Ext	B	[112]
16. *Wrightia tinctoria*	Apocynaceae	Ext	C	[113]
17. *Zingiber officinale*	Zingiberaceae	Ext	C	[73]

Ext crude extract in different solvents; *B*, *C*, *E* the strain of virus used

[a] Clinical study

Table 5 Indian plants active in vitro against respiratory viruses

Plant	Family	Product	Virus	References
1. *Alpinia officinarium*	Zingiberaceae	Diaryl heptanoids	H_1N_1	[115]
2. *Andrographis paniculata*	Acanthaceae	Andrographolide	Influenza H_1N_1	[116][a]
3. *Avicennia marina*	Avecenniaceae	Ext	Newcastle	[117]
4. *Barleria prionitis*	Acanthaceae	Iridoids	Resp. Syn.[b]	[118]
5. *Berginia ligulata*	Saxifragaceae	Ext	Influenza	[43]
6. *Caesalpinea sappan*	Cesalpineaceae	Sappan chalcones	Influenza	[119]
7. *Curcuma longa*	Zingiberaceae	Curcumin	Newcastle	[120]
8. *Ephedra sinica*	Ephedraceae	Catechin[c]	H_1N_1	[121]
9. *Gardenia* sp.	Rubiaceae	Ext	Influenza	[122][d]
10. *Glycyrrhiza glabra*	Fabaceae	Glycyrrhizin	Influenza Resp. Syn. SARS	[41]
11. *Hottuynia cordata*	Piperaceae	Ext	SARS	[123]
12. *Neerium indicum*	Apocynaceae	Ext	Influenza	[43]
13. *Nigelia sativa*	Ranunculaceae	Ext	Newcastle	[117]
14. *Pandanus amaryllifoius*	Pandanaceae	Pandanin	H_1N_1	[52]
15. *Phyllanthus amarus*	Euphorbiaceae	Ext	Newcastle	[120]
16. *Punica granatum*	Puniaceae	Ext	Influenza	[124]
17. *Wickstroemia indica*	Thymelaceae	Daphnoretin	Resp. Syn.	[125]
18. *Zizyphus spira-christi*	Rhamnaceae	Ext	Newcastle	[117]

Ext crude extract in different solvents

[a] Tested in vivo

[b] Respiratory synticial virus

[c] Main source of catechin is *Acacia catechu* [126]

[d] Tested in vitro and in vivo

Table 6 Indian plants active in vitro against pox viruses

Plant	Family	Product	Virus	References
1. *Acacia nilotica*	Fabaceae	Ext	Fowl pox	[117]
2. *Aristolochia bracteolate*	Aristolocheaceae	Ext	Fowl pox	[117]
3. *Avicenna marina*	Avecennaceae	Ext	Fowl pox	[117]
4. *Azadirachta indica*	Meliaceae	Ext	Buffalo pox	[127]
			Fowl pox	[128]
			Measles	
			Vaccinia	
5. *Bauhinia variegata*	Ceasalpineaceae	Ext	Vaccinia	[35]
6. *Cissus quadrangularis*	Vitaceae	Ext	Fowl pox	[117]
7. *Eugenia jambolana*	Myrtaceae	Ext	Buffalo pox	[129]
8. *Glycyrrhiza glabra*	Fabaceae	Glycyrrhizin	Vaccinia	[41]
			Varicella	[130]
9. *Hibiscus sabdariffa*	Malvaceae	Ext	Measles	[131]
10. *Ipomea carnea*	Convolvulaceae	Ext	Fowl pox	[117]
11. *Maerua oblongifolia*	Capparidaceae	Ext	Fowl pox	[117]
12. *Ocimum sanctum*	Lamiaceae	Ext	Vaccinia	[3]
13. *Prosposis chilensis*	Mimosaceae	Ext	Fowl pox	[117]
14. *Trebulus terrestris*	Zygophyllaceae	Ext	Fowl pox	[117]
15. *Trigonella foenum graecum*	Fabaceae	Ext	Fowl pox	[117]

Ext crude extract in different solvents

in synthetic or semi-synthetic derivatives. Successful use of this strategy has been made in the case of andrographolide [143] and curcumin [136], for example.

Activity has also been reported in certain compounds which have undergone extensive clinical evaluation in non-viral diseases. Their available safety and dosage regimen data would help in initiating clinical evaluation in viral infection where in vitro or in vivo activity *data* is available. Andrographolide is a potent hepatoprotective agent [114] besides being active against herpes [30], influenza and H_1N_1 infections [116]. Dehydroandrographolide succinic acid monoester is active against HIV [143]. Another clinically authenticated hepatoprotective agent Picroliv [23] is also active against several viral infections including hepatitis B [24–26]. Curcumin has received the maximum attention after its activity against HIV was demonstrated. Large number of semi-synthetic or synthetic derivatives have been prepared and tested for anti-HIV activity. Its boron complexes; semi-synthetic reduced curcumin, allyl curcumin and tocopheryl-curcumin and synthetic analogues dicafferoyl methane and rosemarinic acid are highly active against HIV in a variety of in vitro protocols. Curcumin is active against herpes simplex 2 in a mouse model and Human papilloma and Epstein Barr viruses in vitro. These activities have been reviewed recently by Krishnaswamy [136]. Its in vitro activity against Friends leukaemia [25], Newcastle and Poliomyelitis viruses [120] has also been reported. Fiore et al. [41] in a recent review have provided reference for activity of glycyrrhizin and its analogues against herpes, hepatitis (including clinical trial), influenza, respiratory syncytial, SARS and vesicular stomatitis viruses. Other investigators have found it active against Japanese encephalitis [137], poliomyelitis [138], vaccinia and varicella [130]. It perhaps has the widest spectrum of antiviral activity among the natural products so far investigated. Adequate clinical evaluation is necessary to assess its role in treatment of viral disorders. *Azadirachta indica* also is a promising plant, even though most of the studies have used its extract. It has a variety of compounds and also has a long history of use in traditional medicine in many countries of the world. The viruses against which the extracts or some of the isolated compounds have shown activity include chikungunya, fowl pox, measles, vaccinia [128], buffalo pox [127], Coxsackie [134] and herpes [32]. Detailed studies against some of these viruses, specially herpes and chikungunya are strongly warranted. In conclusion it may be stated that the rich and valuable resource of Indian plants needs to be more extensively exploited to provide new drugs for the treatment of viral disorders.

Table 7 Indian plants active in vitro against other human viruses

Plant	Family	Product	Virus	References
1. *Adansonia digitata*	Bombacaceae	Ext	Polio	[27]
			Sindbis	
2. *Aegle marmelos*	Rutacaeae	Ext	Coxsackie	[132]
3. *Alpinea galanga*	Zingiberaceae	Ext	Cytomegalus	[73]
4. *Artocarpus integrifolia*	Moraceae	Ext	Rotavirus	[133]
5. *Azadirachta indica*	Meliaceae	Ext	Chikungunya	[128]
			Coxsackie	[134]
6. *Baccaurea ramiflora*	Euphorbiaceae	Ext	Semiliki[a]	[14]
7. *Bauhinia variegate*	Caesalpineaceae	Ext	Ves Stomatitis[b]	[35]
8. *Berberis aristata*	Berberidaceae	Berberine	Friends Leu[c]	[25]
9. *Camelia sinensis*	Theaceae	Triterpinoids	Epstein Barr	[135]
10. *Conyza aegyptica*	Asteraceae	Ext	Polio	[27]
			Sindbis	
11. *Curcuma longa*	Zingiberaceae	Curcumin	Epstein Barr	[136]
			Friends Leu	[25]
			HPV[d]	[136]
			Polio	[120]
12. *Glycyrrhiza glabra*	Fabaceae	Glycyrrhizin	JE[e]	[137]
			Polio	[138]
			Ves Stomatitis	[41]
13. *Heliotropium marifolium*	Boraginaceae	Alkaloids	Coxsackie	[42]
			Polio	
14. *Hernandia ovigera*	Hernandiaceae	Lignans	Epstein Barr	[139]
15. *Kalanchoe pinnata*	Crassulaceae	Bryophyllin A	Epstein Barr	[140]
16. *Lippa alba*	Verbenaceae	Ext	Polio	[64]
17. *Mallotus philippensis*	Euphorbiaceae	Triterpinoids	Epstein Barr	[141]
18. *Momordia charantia*	Cucurbitaceae	Ext	Sindbis	[50]
19. *Myristica fragrans*	Myristicaceae	Ext	Rotavirus	[134]
20. *Nyctanthes arbor-tristis*	Oleaceae	Ext	EMCV[f]	[14]
21. *Paedaria scandens*	Rubiaceae	Paederoside	Epstein Barr	[26]
22. *Phyllanthus amarus*	Euphorbiaceae	Ext	Polio	[120]
23. *Picrorhiza kurroa*	Scrophulariaceae	Ext	Epstein Barr	[26]
		Picroliv	EMCV	[24]
			Friends Leuk	[25]
24. *Plumbago zeylanica*	Plumbaginaceae	Ext	Coxsackie	[46]
25. *Scilla hyacinthine*	Liliaceae	Ext	Semiliki	[14]
26. *Spondias lutea*	Anacardiaceae	Ext	Rotavirus	[132]
27. *Syzigium jambos*	Myrtaceae	Ext	Ves Stomatitis	[67]
28. *Turpinea pomifera*	Staphleaceae	Ext	JE	[14]
29. *Zingiber officinale*	Zingiberaceae	Ext	Cytomegalus	[73]

Ext crude extract in different solvents

[a] Semiliki Forest virus

[b] Vesicular stomatitis

[c] Friends leukemia

[d] Human papilloma virus

[e] Japanese encephalitis

[f] Encephalomyocarditis virus

Table 8 Top 11 families for selected pharmacological activities in CDRI plants

Anti-viral	Anti-cancer	CNS active	Hypoglycemic
No. of active plants			
239	131	639	156
No. in top 11 families			
98	58	228	61
% in top 11 families			
41.0	44.2	35.7	39.1
Rank order of top 11 families			
Euphorbiaceae	Asteraceae	Ericaceae	Cucurbitaceae
Fabaceae	Euphorbiaceae	Minosaceae	Fagaceae
Asteraceae	Fabaceae	Fabaceae	Zingiberaceae
Fagaceae	Combretaceae	Euphorbiaceae	Rutaceae
Myrtaceae	Lamiaceae	Rosaceae	Verbenaceae
Rubiaceae	Meliaceae	Lauraceae	Euphorbiaceae
Rosaceae	Anacardiaceae	Malvaceae	Fagaceae
Caesalpineaceae	Celastraceae	Rubiaceae	Acanthaceae
Lamiaceae	Convolvulaceae	Lamiaceae	Lamiaceae
Lauraceae	Acanthaceae	Asteraceae	Rubiaceae
Anacardiaceae	Rosaceae	Poaceae	Asteraceae

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