ANNALI DI BOTANICA
Ann. Bot. (Roma), 2010

EXOTIC SPECIES OF SOCOTRA ISLAND, YEMEN: A FIRST CONTRIBUTION

SENAN A. S.[1], SOMASHEKAR R. K [1], ATTORRE F. [2*], TALEB N.[3],BRUNO F.[2]

[1] *Department of Environmental Science, Bangalore University, Bangalore, 056*
e-mail: senan1970@yahoo.co.uk
[2] *Department of Plant Biology, Sapienza University of Rome, Italy*
** corresponding author: fabio.attorre@uniroma1.it*
[3] *Socotra Archipelago Conservation and Development Programme*
e-mail: talebnadim@yahoo.com

ABSTRACT - A first inventory of the exotic species of Socotra has been compiled on the basis of the published literature and original distribution data collected by field surveys from 2006 to 2008. A strictly geographical and conservative approach was adopted including only cultivated species and those with a native range separated from Socotra territory. The extracted aliens (87 taxa, 68 genera, 40 family) represent approximately 9% of the total flora of the region (850 taxa). Most were introduced in the past 10 to 20 years. Agricultural cultivated or crop species dominated with 38 species (43.7%), fruit followed by basing 14 species (16.1%) and ruder or ornamental species (35 species, 40.2%).

KEY WORDS: SOCOTRA ISLAND, EXOTIC SPECIES, INVASIVE SPECIES

INTRODUCTION

Invasive alien species are one of the most significant drivers of environmental change worldwide (Mooney and Hobbs, 2000). Invasions are in many cases irreversible and the problem is worsening due to global trade, transport, tourism and climate change. Globally, the United Nations Environment Program has estimated that invasive species represent a major factor in the potential extinction of 30% of threatened bird species, and 15% of threatened plant species (CBD, 2003). Overall, approximately two-thirds of species extinctions may involve competition with invasive species. Many international efforts are aimed at the management and control of the spread of invasive alien species which are considered as the most significant cause of population declines and species extinctions in island ecosystems (Reaser *et al.*, 2007). The Global Invasive Species Program (GISP) meeting in September 2000 identified islands as a special case warranting cooperative initiatives and the Convention on Biological Diversity (CBD) also recognized the urgent need to deal with invasive alien species issues in isolated and vulnerable ecosystems. Islands are more prone to invasion by alien species because of the lack of natural competitors and predators that control populations in their native ecosystems. In addition, islands often have ecological niches that have not been filled because of the distance from colonizing populations, also increasing the probability

Received September 10, 2009
Accepted November 11, 2009

of successful invasions (Mooney and Hobbs, 2000).

Invasive alien species pose a particular risk to small island developing states (SIDS) by threatening the ecosystems, livelihoods, economies and public health of inhabitants. Increased trade, tourism and transportation are significant vectors, and the most common pathways are ship ballast water, hull fouling, cargo containers and packaging materials, unprocessed commodities such as timber/agricultural goods, imported food species such as fish, horticultural/plant imports, waste material, military activities, and biological agents to combat pests. Moreover, it is nevertheless likely that the global warming may change the conditions in a way that the introduced species might gain advantage at the expense of the naturally occurring species.

Well known examples of the magnitude of the plant biological invasion are reported as follow:

in Hawaii Islands now live about 4,600 plant species that have been introduced over the last 200 years (John, 1973).

In the Maldives 277 indigenous and 450 introduced vascular plants have been recorded (Timmermann, 2005),

in the Cape Verde archipelago more than 50% of plant species (on a total of 621) have been introduced by man (Bannerman and Bannerman, 1968).

In Saint Helena Island, of the 320 introduced plant species, 260 are now naturalized and many of them are invasive (Kendle and Rose, 2001).

Galapagos archipelago hosts over more than 120 islands of various sizes more than 500 alien species causing several different impacts on the native flora, fauna and habitats (Mauchamp, 1997).

Recently IUCN (2008) recognized that IAS will pose a future challenge to the biodiversity conservation of Socotra particularly with increasing access and transport to the island. For this reason the main aim of this study was to survey and identify the invasive and introduced plant species of Socotra island in order to support the elaboration of effective strategies for the prevention and control of IAS.

MATERIALS AND METHODS

Study site

Socotra island (Yemen) is the largest and most easterly island of Indian Ocean archipelago, located approximately 240 km east of the Horn of Africa (and 380 km south of the Arabian Coast (Ras Fartak in Yemen), between latitudes 12°19' and 12°42' N and longitudes 53°18' and 54°32 E (Fig. 1). The other main islands in the archipelago are Abd al Kuri, and Semhah and Darsa called the Brothers. Socotra, the largest island, approximately 130 km long by 35

km wide and the covers an area of about 3600 km² (Wranik, 1996) and it is one of the most isolated landforms on Earth of continental origin. The archipelago was once part of the supercontinent of Gondwana and detached during the Middle Pliocene about 6 million years ago (Beydoun and Bichan, 1970). The main island has three geographical terrains: the narrow coastal plains, a limestone plateau with karstic caves, and the Haghier Mountains up to 1,525 m a. s. l. The climate of the Socotra Archipelago located in a arid tropical zone is influenced by the monsoonal winds, with SW dry summer monsoon and NE wet winter monsoon. The human population is 50,000 and consist of shepherds (sheep, goats, and dwarf cattle) and fisherman. Socotra is characterized by a high level of plant species endemism: of its 850 plant species belonging to 430 genera, 307 species (37%) and 15 genera are endemic. Botanists rank the flora of Socotra among the ten most endangered sets of island flora in the world (Miller and Morris, 2004).

Data collection and analysis

Socotra was divided in a grid map of 10 km x 10 km (Fig. 2) so as to obtain 42 quadrates covering an area of 3625 km^2 . Thirty-six quadrates (about 75%) of total study area were surveyed and a first inventory of introduced plant species was prepared. Field surveys were carried out with the support of Socotra

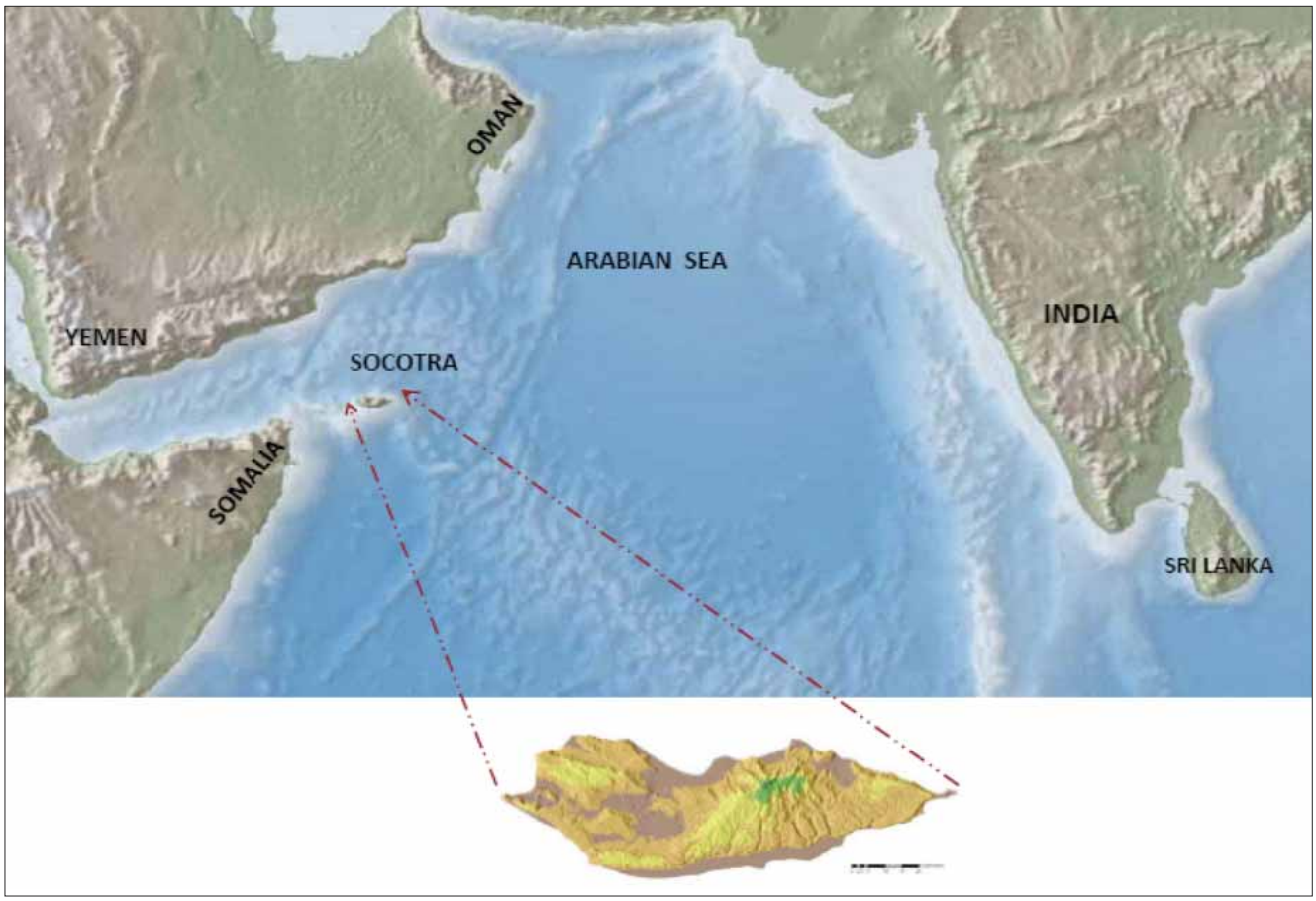

Fig. 1 - Location of study area

Conservation Development Program (SCDP) work team and also according to information provided by local people.

The field campaign strategy was designed according to following criteria: selected areas had to be good representatives of roadsides, geomorphological features, land use areas and nearby settlements where the most dense populations of introduced species can be found. Surveys were conducted by car and foot. Roadside surveys were conducted by keeping the vehicle between 8 and 16 kilometers speed per hour and scanning both sides of the roadside for exotic species. When an exotic plant was encountered, a standardized data collection protocol was used (Carlton and Ruiz, 2003). In this way a preliminary database of the alien flora of Socotra island was compiled by integrating field surveys conducted between 2006 to 2008 with published literature **(**AL Khulaid, 2000; Miller, Morris, 2004; Král and Pavlis, 2006).

Identification of the exotics plant specimens was conducted with reference to the Etnoflora of Socotra (Miller and Morris, 2004), Flora of Somalia (Thulin, 1995), Flora of Ethiopia (Edward *et al.*, 2000*)* and Flora of Yemen (*AL* Khulaid*,* 2000*)*. For critical identifications taxonomic specialists of the Agriculture Research and Extension Authority of Taiz (Yemen) were consulted.

RESULTS AND DISCUSSION

The first preliminary inventory of the introduced plant species of Socotra listed 87 species (Table 1) that potentially can have a devastating effect on the survival of the 850 native species, as their number

would increase continuously if restrictions are not imposed. It is imperative that the import of alien plants be stopped and the continued disturbance of native ecosystems prevented.

Alien species now account for the 9 % of the total flora of the island (Fig. 3). Most of the exotics in the list (i.e., 61%) have been intentionally introduced for cultivation as crops and for forage production in 2003 by the Triangle Project aimed at supporting the use of house gardens among the inhabitants. Agricultural weeds, ornamental, ruderal and multipurpose species account for the residual 39% (Table. 1).

Life form (Fig. 5) include herbs (37%), trees (28%), vines (17%), shrubs (11%), sub shrubs (5%) and succulents (2%). Most of the exotics (33%) have an Asian origin, while the second major contingent comes from America mainly from tropical and Central America (31%), followed by India (15%), Africa (11%) and Arabia (5%). *Fabaceae* is the most represented family (10%), followed by *Cucurbitaceae* (9%), *Solanaceae* (9%), *Mimosaceae* (6%), *Poaceae* (5%), *Amaryllidaceae* (5%) and *Asteraceae* (5%). Up to now only three exotic species have become widely spread, namely *Argemone mexicana*, *Calotropis procera* and *Nicotiana glauca*. Based on the information collected from local people during the field surveys, it was determined that most of the introduction occurred in the last 20 years due to the increasing accessibility and transport to the island.

About 35 alien plants, having the potential to become serious weeds in Socotra, were already recorded as serious weeds in many other oceanic islands, i. e. *Leucaena leucocephala, Prosopis juliflora, Acacia sp., Nicotiana glauca, Tagetes minuta, Opuntia sp. and Parkinsonia aculeata*. Introduction of new species should be carefully evaluated for its potential to cause problems since there is often a time lag between initial introduction and evidence of invasiveness and it is difficult to predict which introduced plant species will become a successful invader and

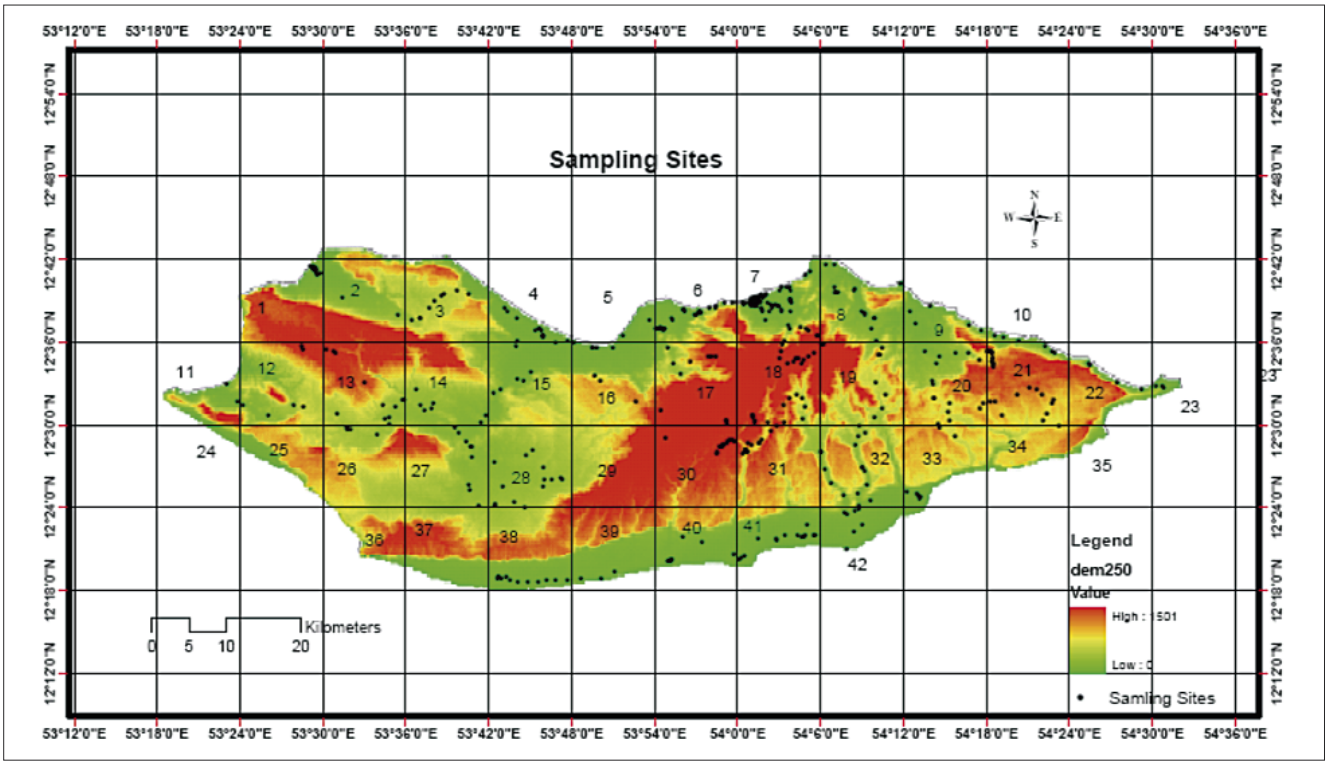

Fig. 2 - Sampling sites

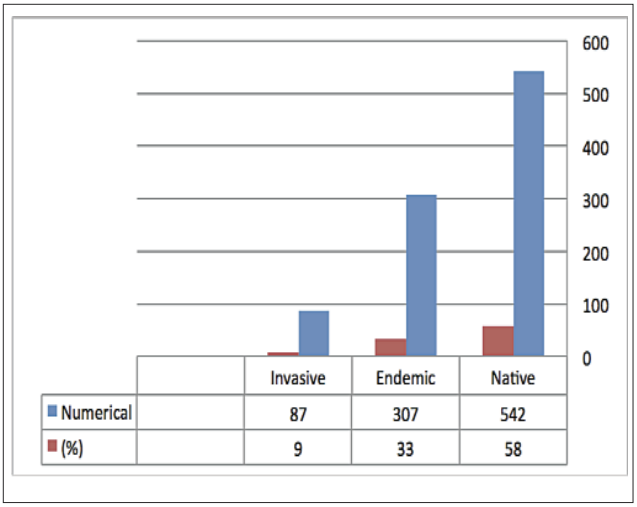

Fig. 3 - Flora of Socotra island

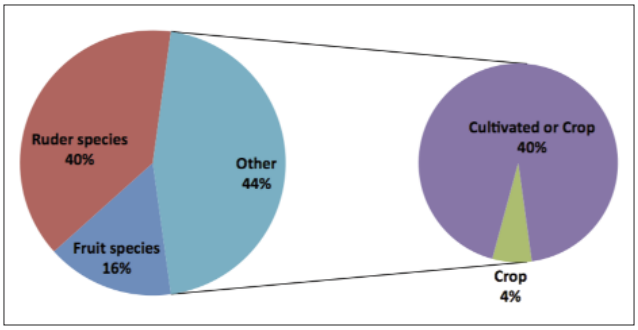

Fig. 4 - The utility of pattern exotic species

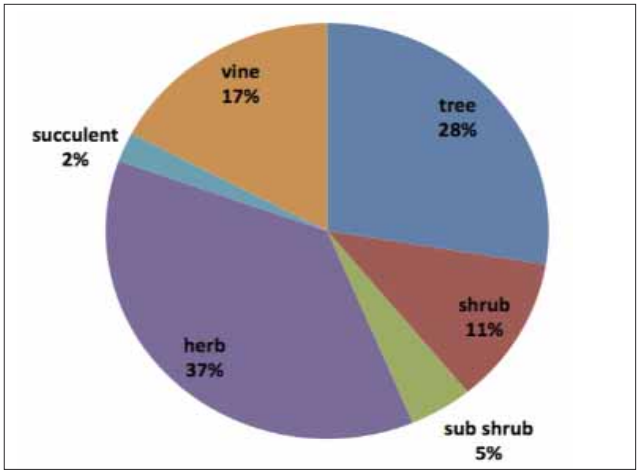

Fig. 5 - Life form spectrum of exotic flora of Socotra island

when invasions will occur leading to unwanted change (Richardson *et al.*, 2000).

The first inventory of introduced plant species of Socotra had the main aim to guide subsequent taxonomic studies, further field researches and to highlight the need of additional assessments on IAS impacts. The introduction of 87 plants can hinder the survival of native species and habitat if specific control actions including hand removal and monitoring are not put in practice. Moreover prevention mechanisms such screening support tools and quarantine policies have to be implemented for further

ACKNOWLEDGEMENTS

We thank the United Nation Development Program, the Italian Cooperation and the Socotra Conservation Development Program SCDP for providing the facilities and the technical and scientific support for the investigation. Heartful thanks to Dr. Al Khulaid and to Dr. Lisa Banfield for their help.

REFERENCES

Al Khulaid, A.W. 2000. Flora of Yemen. Sustainable Environmental Project; Agriculture Research and Extension, Taiz, Yemen.

Bannerman, D A, Bannerman, W. M. 1968. Birds of the Atlantic Islands, IV. A History of the Birds of the Cape Verde Islands, Oliver & Boyd, Edinburgh & London.

Beydoun, Z.R., Bichan, H.R. 1970. The geology of Socotra Island, Gulf of Aden. Quarterly Journal of the Geological Society of London 125, 413–446.

Carlton, J., Ruiz, G. 2003. Invasive Species. Vectors And Management Strategies. Island Press, Washington, DC.

CBD. 2003. The ecological and socio-economic impact of invasive alien species on island ecosystems. 9th SBSTTA meeting, Montreal Canada.

Edwards, S., Tadesse, M., Demissew, S., Hedberg, I. 2000. Flora of Ethiopia and Eritrea. Addis Ababa, Ethiopia & Uppsala, Sweden.

John, H. 1973. List and summary of the flowering plants in the Hawaiian Islands. Pac. Trop. Bot. Gard. Mem. 1: 1-519.

Kendle, A.D., Rose, J.E. 2001. Invasive plants on land recovering from desertification on Saint Helena Island. In G. Brundu, J. Brock, I. Camarda, L. Child & M. Wade, eds. Plant invasions: species ecology and ecosystem management, pp. 311-318. Leiden, the Netherlands, Backhyus Publishers.

Kral, K., Pavlis, J. 2006. The first detailed land-cover map of Socotra island by Land sat/ETM + data. International Journal of Remote Sensing 27, 3239–3250.

MAUCHAMP, A. 1997. Threats from alien plant species in the Galapagos Islan. Conservation Biology 11: 260-263.

MILLER, A., MORRIS, M. 2004. Ethnoflora of the Sqotra archipelago. The Royal Botanic Garden Edinburgh, UK.

Mooney, H. A., Hobbs, R. J. 2000. Invasive Species in a Changing World. Island Press.

REASER J.K., MEYERSON L.A., CRONK Q., DE POORTER M., ELDREGE L.G., GREEN E., KAIRO M., LATASI P., MACK R.N., MUREMOTOOTOO J., O'DOWD D., ORAPA W., SASTROUMOTO S., SAUNDERS A., SHINE C., THRAINSSON S., VAIUTU L. 2007. Results of an experts consultation on the ecological and socio-economic impacts of invasive alien species on island ecosystems. Environmental Conservation, 34:2:98-111.

RICHARDSON, D.M., PYSEK, P., REJMANEK, M., BARBOUR, M.G., PANETTA, D., WEST, C.J. 2000. Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distribution, 6, 93–107.

THULIN, M. 1995. Flora of Somalia. Royal Botanic Garden Kew.

TIMMERMANN, A. 2005. The Maldives. In: Ehlers B. K., Ingversen T., Larsen M. W., Dupont Y.L., Olesen J.M. (eds.) Island Biology. Essays in Evolutionary Biology, Aarhus university, Sweden, pp. 54-56.

WRANIK, W. 1996. Faunistic notes on Soqotra Island. In: Dumont, H.J., (ed.) 1998: Proceedings of the First International Symposium on Soqotra Island: Present and Future, Aden 1996, New York, United Nations Publications, pp. 135-198.

Tab. 1 (front page) - Socotra exotic species

*: new records on Socotra

edi = edible, orn = ornamental, med = medicine, f = forage, mp = multipurpose ;sh = shrub, ssh = sub shrub, h = herb ,v = vine , s = succulent, t = tree

No	Scientific name	Family	Common name	Use	Habit	Introduced year
1	Acacia ehrenbergiana *	Mimosaceae	Prickly Acacia	orn	sh	2002
2	Acacia nilotica subsp. Indica*	Mimosaceae	Thorn mimosa	orn	t	2003
3	Acacia tortilis *	Mimosaceae	Umbrella acacia	orn	t	2001
4	Albizia lebbek L *	Mimosaceae	Siris Tree,	mp	t	1993
5	Allium cepa	Amaryllidaceae	Onion	edi	h	2003 Triangle
6	Allium chinensis	Amaryllidaceae	Chive	edi	h	2003 Triangle
7	Allium fistulosum	Amaryllidaceae	Spring onion	edi	h	2003 Triangle
8	Amaranthus cruentus	Amaranthceae	Amaranth	edi	h	2003 Triangle
9	Annona squamosa	Annonaceae	Sugar apple	edi	t	2003 Triangle
10	Apium gavelens	Apiaceae	Celery	edi	h	2003 Triangle
11	Argemone Mexicana	Papaveraceae	Mexican poppy	med	h	Old introduction
12	Azadirachta indica *	Meliaceae	Neem tree	mp	t	1993
13	Bougainvillea spectabilis *	Nyctaginceae	Bogainvilleas	orn	sh	2004
14	Brassica juncea	Brassicaceae	Cabbage	edi	h	2003 Triangle
15	Calotropis procera	Acslepiadaceae	Mudar Yercum	med	sh	Old introduction
16	Capsicum annuum	Solanaceae	Hot pepper	edi	h	2003 Triangle
17	Capsicum frutescent	Solanaceae	Hot pepper	edi	h	2003 Triangle
18	Carica papaya *	Caricaceae	Papaya	edi	t	1992
19	Catha edulis L *	Celastraceae	Khat	edi	sh	2007
20	Catharanthus roseus *	Apocynaceae	Finka	orn	h	2005
21	Chloris jubaensis *	Poaceae	Finger grass	f	h	1984
22	Citrullus lanatus	Cucurbitaceae	Water melon	edi	v	2003 Triangle
23	Citrus aurantifolia	Rutaceae	lemon	edi	t	2004

24	Citrus sinensis	Rutaceae	Sweet Orange	edi	t	2004
25	Cocos nucifera *	Arecaceae	Coconut	orn	t	2004
26	Corchorus olitorius	Tiliaceae	Jew's mallow	edi	h	2003 Triangle
27	Cucumis anguria	Cucurbitaceae	Cucumber	edi	v	2003 Triangle
28	Cucumis maxima	Cucurbitaceae	Squash	edi	v	2003 Triangle
29	Cucumis metuliferus	Cucurbitaceae	Pumpkin	edi	v	2003 Triangle
30	Cucumis moschata	Cucurbitaceae	Squash	edi	v	2003 Triangle
31	Cucumis sativa	Cucurbitaceae	Cucumber	edi	v	2003 Triangle
32	Cucurbita pepo	Cucurbitaceae	Pumpkin	edi	v	2003 Triangle
33	Daucus carota	Apiaceae	Carrots	edi	h	2003 Triangle
34	Eleusine floccifolia	Poaceae	Kanab	edi	h	Old introduction
35	Ficus carica *	Moraceae	Fig tree	edi	sh	2004

No	Scientific name	Family	Common name	Use	Habit	Introduced year
36	Glysine hispida *	Fabaceae	Soja	edi	ssh	2003
27	Helianthus annus *	Asteraceae	Sunflower	orn	ssh	2003 Triangle
38	Hibiscus esculentus	Malvaceae	Okra	edi	v	2003 Triangle
39	Hibiscus sabdariffa	Malvaceae	Sorrel	med	h	2003 Triangle
40	Hyphaene thebaica	Arecaceae	Doum	mp	t	2005
41	Ipomoea aquatic *	Convolvulaceae	Aseri	orn	v	2004
42	Ipomoea batatas L	Convolvalaceae	Sweet potato	edi	v	2003 Triangle
43	Jatropha curcas *	Euphorbiaceae	Pig Nut	mp	sh	2005
44	Lablab purpureus	Fabaceae	Lablab	edi	v	2004
45	Lactua sativa	Asteraceae	Lettuce	edi	h	2003 Triangle
46	Lawsonia inermis L *	Lythraceae	Mehndi	mp	sh	2003 Triangle
47	Leucaena leucocephala *	Fabaceae	Leucaena	mp	t	2003 Triangle
48	Lycopersicum esculentum	Solanaceae	Tomato	edi	ssh	2003 Triangle
49	Malus sylvestris *	Rosaceae	Apple	edi	t	2004
50	Mangifera indica *	Meliaceae	Mango	edi	t	1998
51	Medicago sativa L	Fabaceae	Alfalfa	f	h	2003 Triangle
52	Mentha piperita L *	Lamiaceae	Pepper mint	med	h	2005
53	Momordica charantia	Cucurbitaceae	Bitter squash	edi	v	2003 Triangle
54	Moringa oleifera *	Moringaceae	Horseradish	mp	t	2003 Triangle
55	Murus niger *	Moraceae	Mulberry	edi	t	2006
56	Musa pardisiaca *	Musaceae	Banana	edi	h	1998
57	Nerium oleander *	Apocyanaceae	Oleander	orn	sh	2003
58	Nicotiana glauca *	Solanaceae	tree tobacco	orn	sh	2007
59	Occinum basilicum	Iridaceae	Basil	edi	h	2003 Triangle

60	Opuntia delenii *	Cactaceae	Indian Fig	orn	s	2004
61	Opuntia ficus – indica *	Cactaceae	Indian Fig	orn	s	2004
62	Pancratium maximum *	Amarylidaceae	White flower	orn	h	2004
63	Parkinsonia aculeate *	Fabaceae	Jerusalem-thorn	orn	t	2004
64	Phaseolus vulgaris	Fabaceae	Bean	edi	v	2003
65	Pithecellobium dulce	Fabaceae	Madras thorn	orn	t	1978
66	Prosopis juliflora	Mimosaceae	Mesquite	orn	t	1998
67	Psidium guajava *	Myrtaceae	Guava	edi	t	2001
68	Punica granatum *	Punicaceae	Pomegranate	edi	sh	2004
69	Raphanus cativus	Brassicaseae	Radish	edi	h	2003 Triangle
70	Ruta chalepensis L *	Rutaceae	Ruta	med	h	2005
71	Solanum aethiopicum	Solanaceae	Eggplant	edi	h	2003 Triangle

No	Scientific name	Family	Common name	Use	Habit	Introduced year
72	Solanum macrocarpum	Solanaceae	Eggplant	edi	h	2003 Triangle
73	Solanum melongena	Solanaceae	Eggplant	edi	h	2003 Triangle
74	Solanum nigrum	Solanaceae	Black nightshade	edi	h	2003 Triangle
75	Sorghum bicolor *	Poaceae	Corn	edi	ssh	1998
76	Sapindus mukorossi	Sapindaseae	Soap nut	orn	t	2001
77	Species 1	F2		orn	t	
78	Species 2	F3		orn	t	
79	Spilanthes acmela	Fabaceae	Para cress	edi	h	2003 Triangle
80	Tagetes minuta *	Asteraceae	Wild Marigold	med	h	2005
81	Tagetes patula *	Asteraceae	Tagetes red	orn	h	2006
82	Terminalia catappa *	Combretaceae	Bidan	orn	t	1998
83	Thespesia populnea *	Malvaceae	Portia tree	orn	t	1998
84	Typha domingensis *	Typhaceae	Cat tails	f	h	1993
85	Vigna unguiculata *	Fabaceae	Bean	edi	v	2003
86	Vitis vinifera .L *	Vitaceae	Grape	edi	v	2004
87	Zea mays L *	Poaceae	Maize	edi	h	2002