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Host Plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas

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Review article

Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas

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The fall armyworm, *Spodoptera frugiperda* (J.E. Smith, 1797) (Lepidoptera: Noctuidae), is the most important noctuid pest in the Americas and has recently become an invasive pest in Africa. A detailed record of *S. frugiperda*'s host plants is essential to better understand the biology and ecology of this pest, conduct future studies, and develop Integrated Pest Management programmes. In this study, we collected and systematically arranged the fragmented bibliographic information on *S. frugiperda* feeding records. Furthermore, we registered new records of host plants for *S. frugiperda* based on eight years of surveys in Brazil. The literature review and surveys resulted in a total of 353 *S. frugiperda* larval host plant records belonging to 76 plant families, principally Poaceae (106), Asteraceae (31) and Fabaceae (31). The literature search revealed 274 (77 % of total) bibliographic records, while 82 (23 %) are new records from surveys in Brazil. The new comprehensive and updated host plant list will improve our understanding of pest biology and management, as well as facilitate future studies on this pest.

Key words: fall armyworm, invasive species, polyphagia, host plant range.

INTRODUCTION

The fall armyworm, *Spodoptera frugiperda* (Smith, 1797) (Lepidoptera: Noctuidae), is recognised as one of the most important noctuid moth pests of North and South America (Chittenden 1901; Luginbill 1928; Vickery 1929; Ashley *et al.* 1989; Pogue 2002; Casmuz *et al.* 2010; Murúa *et al.* 2015). In addition, this pest has recently spread to Africa (Goergen *et al.* 2016) and has been intercepted in Europe, with specimens collected in Germany and the Netherlands (CABI 2017).

In the Americas, the polyphagous nature, voracity of feeding, periodic outbreaks, and economic importance of *S. frugiperda* has been widely repor-

ted in the literature for many years (Smith 1797; Chittenden 1900, 1901; Dew 1913; Luginbill 1928; Vickery 1929; Bourquin 1939; Hynes 1942; Etcheverry 1957; Crumb 1956; Labrador 1967; Costilla & Mercado 1968; Silva *et al.* 1968; Peairs & Saunders 1979; Sparks 1979; Andrews 1980, 1988; Saunders *et al.* 1983; Ashley *et al.* 1989; Ferguson *et al.* 1991; Passoa 1991; Coto *et al.* 1995; Heppner 1998; Pogue 2002; Pastrana 2004; Bentancourt & Scatoni 2006; Angulo *et al.* 2008; Casmuz *et al.* 2010). *Spodoptera frugiperda* larvae attack a large number of cultivated plant species (Casmuz *et al.* 2010) but the greatest damage is observed in



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grasses such as maize and sorghum (its main hosts), along with other monoculture crops such as cotton and soybean (Pitre & Hogg 1983; Bueno *et al.* 2011; Hardke *et al.* 2015). In Brazil, several tonnes of insecticidal active ingredients are applied for *S. frugiperda* control each year, and it is estimated that in maize the annual losses can be between 19 and 100 % (Cruz & Turpin 1982; Cruz *et al.* 1999), although variable seasonal and environmental conditions can make these types of estimates difficult. Based on estimates published by the Centre for Agriculture and Bioscience International (Day *et al.* 2017), in the absence of proper control methods, *S. frugiperda* has the potential to cause maize yield losses of 8.3 to 20.6 t per year, in just 12 of Africa's maize-producing countries. This represents a range of 21–53 % of the annual production of maize in these countries. The monetary value of these losses is estimated to be between US\$2.48 billion and US\$6.19 billion.

The objective of this study was to report new host plants of *S. frugiperda* in Brazil and catalogue the host plant information available in the literature. This paper presents the most complete list of host records for *S. frugiperda* to date, including many records originally published only in Spanish or Portuguese. Presenting a thorough summary of the existing host plant literature, as well as new host plant records detected by extensive survey sampling in Brazil, in a format accessible to the English language scientific community will be an essential tool for further understanding of this critical pest, particularly in its newly invaded geographic range in Africa.

MATERIAL AND METHODS

Literature review

An extensive review of published works reporting plants being consumed by *S. frugiperda* was conducted. A variety of bibliographic sources were consulted, particularly previous reviews (Casmuz *et al.* 2010), country or state surveys (Luginbill 1928; Labrador 1967; Silva *et al.* 1968; Tietz 1972; Biezanko *et al.* 1974; Pastrana 2004; Heppner 2007; Angulo *et al.* 2008), specific works (Baxter 1960; Bachini 1966; Palmer 1987; Sánchez & Ortiz 1998; Meagher *et al.* 2004, 2007; Maes 2004; Jiménez 2005; Austin 2007; Dias *et al.* 2009; Fazolin *et al.* 2009; Vázquez-Moreno 2009; Quimbayo *et al.* 2010; Silvie *et al.* 2010; Morales-Payan 2011; León-García *et al.* 2012; Boregas *et al.* 2013) and

Institutional Web Sites (*e.g.* Janzen & Hallwachs 2009; CABI 2017).

Larval host plant survey

New records of plants associated with *S. frugiperda* larvae in Brazil were determined by informal host plant surveys conducted by the authors (D.G.M., A.S.). The host plant surveys were conducted from June 2003 to February 2011, in Caxias do Sul municipality, Rio Grande do Sul State, Brazil. Suspect *S. frugiperda* larvae found feeding on plants in the field were collected by the authors (D.G.M., A.S.) or brought to the authors by members of the local community, including farmers and agricultural professionals, and reared in the laboratory until the emergence of the moths and subsequent identification (Pogue 2002). The larvae as well as plants on which larvae were collected were brought to the laboratory, where plants were identified by the botanist R.A. Wasum of the Herbarium at the University of Caxias do Sul. The plants were compared with herbarium specimens and specific bibliographical references. The botanical family and specific names were based on the following resources: Tropicos[®] database (Missouri Botanical Garden 2017), Centre for Agriculture and Biosciences International (CABI 2017), Catalogue and database of Peter H. Raven Library (Peter H. Raven Library 2017) and United States Department of Agriculture Plants database (USDA 2017). Host plants were organised according to the botanical family, specific (or generic), name, common name (when used) and references or new record indication. Host plants, of which only generic names were cited, in cases where specific names have been cited already, were disregarded. Due to the large number of host plant synonyms cited in bibliographic sources, these synonyms were omitted from the list.

RESULTS

Based on reports in the literature, larvae of *S. frugiperda* can feed on at least 274 taxa of host plants. Additional surveys conducted by the authors in Brazil identified an additional 82 new host plant species, which resulted in a list of 353 plants belonging to 76 plant families (Table 1). The families with the greatest number of host taxa reported as hosts of *S. frugiperda* include Poaceae (106 taxa), Asteraceae and Fabaceae (31 taxa each). The plant *Schlumbergera*

truncata (Haw.) Moran (Cactaceae), cited by Cazmuz *et al.* (2010), was not included in the final table. In the original observation made by Silva *et al.* (1968), this host plant record is referred to only by its common name 'flor-de-maio' which may also refer to 'quaresmeira' (*Tibouchina* spp., Melastomataceae). Due to this potential ambiguity, neither *S. truncata* nor *Tibouchina* spp. were included in Table 1.

DISCUSSION

The record of 353 plants from 76 families reported here (Table 1) represents the most comprehensive host plant list for *S. frugiperda* published to date, surpassing Cazmuz *et al.* (2010), who listed 180 species. In addition, many of the host plant records from Central or South America have been published in Spanish or Portuguese and may provide only botanical common names or outdated scientific name synonyms. The results presented here provide a synthesis of the scattered literature using updated scientific names accessible to English language audiences. The present study increases the host plant knowledge about *S. frugiperda*, the most important *Spodoptera* species in the Americas, which has recently also been reported on the African and European continents (Goergen *et al.* 2016; CABI 2017). Having updated and standardised information on host plants of this species can contribute significantly to development of more effective insect pest management strategies and the understanding of polyphagous behaviour.

The current list of plants includes both crop and non-crop species, with a high number of species commonly considered weeds, such as beggarticks, burn weed, daisies, morning-glories, romerillo, spiny amaranth and wild grasses (Table 1). A single larva of *S. frugiperda* is able to feed on several different hosts during its development (Chittenden 1901; Luginbill 1928; Hynes 1942; Leiderman & Sauer 1953; Baxter 1960; Labrador 1967; Guagliumi 1973; Hallman 1979). Thereby, according to Bernarys & Singer (2002), it can therefore also be considered polyphagous at the individual level. The number of host plants reported for *S. frugiperda* is higher when compared to other congeneric species of agricultural importance such as *Spodoptera albula* (Walker) (65), *Spodoptera cosmioides* (Stoll) (126), *Spodoptera dolichos* (Fabricius) (94) and *Spodoptera eridania* (Stoll) (202)

(Montezano *et al.* 2013, 2014, 2015; Specht & Roque-Specht 2016).

The extensive and broad host plant list for *S. frugiperda* can be influenced by several biological factors, including female moth oviposition behaviour and larval movement. Female *S. frugiperda* moths will lay eggs on several species of plants, including the most abundant and also the scarcest, particularly in the absence of preferred hosts (Luginbill 1928; Leiderman & Sauer 1953; Labrador 1967). In addition, this species oviposits in large egg masses that could contain hundreds of eggs. Larvae need to quickly disperse (Pannuti *et al.* 2016) in order to find food and avoid intra-specific competition and high levels of cannibalism (Bentivenha *et al.* 2017a, b), increasing their chances of survival. Hence, the behaviour of ovipositing in large masses is related to polyphagy at the species and individual level, which is common within the *Spodoptera* genus (Pogue 2002; Montezano *et al.* 2013, 2014, 2015; Specht & Roque Specht 2016).

Knowing which plant species *S. frugiperda* is capable of feeding on, including non-crop plants such as weeds, is particularly important in the context of pest management. If oviposition and early instar development occurs on non-crop plants adjacent to or within crop fields, later instars are capable of moving *en masse* to cultivated crops after consuming their original host, thereby maximising crop damage potential (Chittenden 1901; Luginbill 1928; Hynes 1942; Leiderman & Sauer 1953; Baxter 1960; Labrador 1967; Guagliumi 1973; Hallman 1979). In addition, polyphagous feeding behaviour can allow *S. frugiperda* to build or maintain populations outside of the primary cropping season or outside of cropping areas, contributing to increased pest pressure. For example, it was detected that *S. frugiperda* feeds on millet (*Pennisetum glaucum* (L.) R.Br.) during the dry season in Brazil, leading to high populations during the off-season and subsequent primary cropping season (Favetti *et al.* 2017). Therefore, effective *S. frugiperda* pest management practices must take into account the presence of host plants within and surrounding crop fields throughout the year. Knowing which plants are potential hosts for *S. frugiperda* is an essential component of this approach. This study emphasises the importance of basic biological information, such as host plant lists, in the development of pest management strategies.

Table 1. Host plants of *Spodoptera frugiperda* larvae. For each record, botanical family, scientific name, common name and source in brackets (bibliographic sources are numbered; asterisks indicate new records from Brazil).

Family	Scientific name and authority	Common name	References
Aizoaceae	<i>Trianthema portulacastrum</i> L.	desert horse purslane	*
Amaranthaceae	<i>Alternanthera ficoidea</i> L. P. Beauv.	sanguinaria	*
	<i>Amaranthus dubius</i> Mart. ex Thell.	spleen amaranth	14
	<i>Amaranthus hybridus</i> L.	slim amaranth	4
	<i>Amaranthus quitensis</i> Kunth	ataco	21, 33
	<i>Amaranthus spinosus</i> L.	spiny amaranth	5, 33
	<i>Amaranthus viridis</i> L.	slender amaranth	5, 38
	<i>Beta vulgaris</i> var. <i>cicla</i> L.	chard	6, 26, 10, 21, 33
	<i>Beta vulgaris</i> var. <i>vulgaris</i> L.	beet	1, 9, 10, 21, 24, 26, 33, 42
	<i>Beta vulgaris</i> var. <i>saccharifera</i> Alef.	sugar beet	21, 33, 42
	<i>Celosia cristata</i> L.	cockscomb	*
	<i>Chenopodium album</i> L.	bacon-weed	1, 9, 24, 33, 42
	<i>Chenopodium quinoa</i> Willd.	quinoa	42
	<i>Spinacia oleracea</i> L.	spinach	1, 9, 10, 21, 24, 26, 33, 42
Amaryllidaceae	<i>Allium cepa</i> L.	onion	1, 6, 5, 9, 10, 21, 24, 33, 42, 26
	<i>Allium fistulosum</i> L.	bunching onion	*
	<i>Allium sativum</i> L.	garlic	10, 21, 33
Anacardiaceae	<i>Mangifera indica</i> L.	mango	5, 24, 33
Apiaceae	<i>Coriandrum sativum</i> L.	coriander	36
	<i>Daucus carota</i> L.	carrot	*
	<i>Daucus pusillus</i> Michx.	wild carrot	*
	<i>Eryngium foetidum</i> L.	fit-weed	42
	<i>Eryngium horridum</i> Malme	gravatá	*
	<i>Eryngium megapotamicum</i> Malme	Murray's red gum	*
Apocynaceae	<i>Asclepias</i> sp.	milkweed	9, 24, 33
	<i>Carissa</i> sp.	carissa	24
	<i>Plumeria rubra</i> L.	temple tree	15, 33
Aquifoliaceae	<i>Ilex paraguariensis</i> A. St.-Hil.	maté	*
Araceae	<i>Philodendron cordatum</i> Vell. Kunth	philodendron	24
Arecaceae	<i>Chamaerops humilis</i> L.	European fan palm	24
	<i>Cocos nucifera</i> L.	coconut	24
	<i>Elaeis guineensis</i> Jacq.	African oil palm	18
	<i>Phoenix roebelinii</i> O'Brien	pygmy date palm	24
Asparagaceae	<i>Yucca guatemalensis</i> Baker	bluestem yucca	24
	<i>Asparagus officinalis</i> L.	asparagus	1, 9, 24, 26, 33, 42
Aspleniaceae	<i>Asplenium nidus</i> L.	bird's-nest fern	21, 33
Asteraceae	<i>Acanthospermum hispidum</i> DC.	bristly star-bur	14
	<i>Ageratum conyzoides</i> L.	tropic ageratum	6
	<i>Aster</i> sp. L.	aster	34
	<i>Baccharis dracunculifolia</i> DC.	alecrim-do-campo	*
	<i>Baccharis neglecta</i> Britton	Roosevelt weed	16
	<i>Bidens alba</i> L. DC	romerillo	*
	<i>Bidens pilosa</i> L.	beggar-ticks	24
	<i>Calendula officinalis</i> L.	pot marigold	32
	<i>Carduus</i> sp.	plumeless thistle	33
	<i>Carthamus tinctorius</i> L.	safflower	30

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Table 1 (continued)

Family	Scientific name and authority	Common name	References
	<i>Chrysanthemum cinerariifolium</i> Trevir. Vis.	pyrethrum	10, 21, 33
	<i>Chrysanthemum morifolium</i> Ramat	florist's daisy	42
	<i>Cichorium endivia</i> L.	endive	2
	<i>Cichorium intybus</i> L.	chicory	6, 26, 33
	<i>Conyza canadensis</i> L. Cronquist	bitter-weed	*
	<i>Cynara cardunculus</i> L.	artichoke	6, 33
	<i>Cynara scolymus</i> L.	globe artichoke	10, 21
	<i>Dahlia pinnata</i> Cav.	margarita	42
	<i>Dahlia variabilis</i> Willd. Desf.	dahlia	9, 24
	<i>Dendranthema grandiflorum</i> Ramat. Kitam.	mum cremon	34
	<i>Erechtites hieraciifolius</i> L. Raf. ex DC.	American burn weed	3
	<i>Erechtites valerianifolius</i> Link ex Spreng. DC	tropical burn weed	*
	<i>Gerbera jamesonii</i> Bolus ex Hook. F.	barberton daisy	*
	<i>Helianthus annuus</i> L.	sunflower	10, 21, 33, 41
	<i>Lactuca sativa</i> L.	lettuce	6, 33, 42
	<i>Pascalia glauca</i> Ortega	beach creeping oxeye	21, 33
	<i>Senecio brasiliensis</i> Spreng. Less.	Brazilian ragwort	*
	<i>Sonchus oleraceus</i> L.	common sow thistle	6
	<i>Taraxacum officinale</i> F.H. Wigg.	dandelion	21, 33
	<i>Tragopogon porrifolius</i> L.	common salsify	6
	<i>Xanthium strumarium</i> L. var. <i>canadense</i> Mill. Torr. & A. Gray	Canada cocklebur	9, 24, 33, 42
Babaceae	<i>Lupinus albus</i> L.	white lupinus	41
Balsaminaceae	<i>Impatiens walleriana</i> Hook. f.	busy lizzy	*
Begoniaceae	<i>Begonia rex</i> Putz.	begônia	*
Boraginaceae	<i>Onosmodium virginianum</i> L. A. DC.	wild Job's tears	9, 24
Brassicaceae	<i>Brassica napus</i> L. var. <i>napus</i> L.	rape	5, 10, 21, 33
	<i>Brassica oleracea</i> var. <i>acephala</i> DC.	bore cole	1, 6, 9, 10, 21, 24, 26, 33, 42
	<i>Brassica oleracea</i> var. <i>botrytis</i> L.	broccoli	10, 21, 33, 42
	<i>Brassica oleracea</i> var. <i>capitata</i> L.	cabbage	1, 6, 5, 9, 10, 21, 26, 33, 42
	<i>Brassica rapa</i> L. var. <i>rapa</i> L.	field mustard	1, 9, 24, 33, 42
	<i>Coronopus didymus</i> L. Sm.	swine-cress	*
	<i>Raphanus raphanistrum</i> L.	wild radish	*
	<i>Raphanus sativus</i> L.	cultivated radish	10, 21, 33, 41
Cactaceae	<i>Cereus hildmannianus</i> K. Schum.	hedge cactus	*
Campanulaceae	<i>Campanula</i> sp.	campanula	34
Caricaceae	<i>Carica papaya</i> L.	papaya	5, 32, 33
Caryophyllaceae	<i>Dianthus caryophyllus</i> L.	carnation	42
Celtidaceae	<i>Celtis ehrenbergiana</i> Klotzsch Liebm.	tala	21, 33
Combretaceae	<i>Terminalia catappa</i> L.	Indian almond	5, 33
Commelinaceae	<i>Commelina benghalensis</i> L.	jio	*
	<i>Commelina diffusa</i> Burm. F.	climbing dayflower	*
	<i>Commelina erecta</i> L.	white mouth dayflower	*
	<i>Tradescantia pallida</i> Rose D.R. Hunt	purple queen	*
	<i>Tradescantia zebrina</i> hort. ex Bosse	inchplant	*
Convolvulaceae	<i>Convolvulus arvensis</i> L.	field bindweed	33

Table 1 (continued)

Family	Scientific name and authority	Common name	References
	<i>Ipomoea aquatica</i> Forssk.	swamp morning-glory	23
	<i>Ipomoea batatas</i> L. Lam.	sweet potato	1, 6, 9, 10, 21, 24, 33, 42
	<i>Ipomoea grandiflora</i> L. f. Lam.	morning glory	*
	<i>Ipomoea purpurea</i> L. Roth	tall morning-glory	9, 24, 42
	<i>Ipomoea triloba</i> L.	little bell	14
Cucurbitaceae	<i>Citrullus lanatus</i> Thunb. Matsum. & Nakai var. <i>lanatus</i>	watermelon	1, 5, 9, 10, 21, 24, 33, 42
	<i>Cucumis melo</i> L.	melon	6, 21, 26, 33,
	<i>Cucumis sativus</i> L.	cucumber	1, 5, 9, 21, 24, 32, 33, 42
	<i>Cucurbita argyrosperma</i> K. Koch	cushaw pumpkin	33
	<i>Cucurbita maxima</i> Duchesne	pumpkin	33
	<i>Cucurbita pepo</i> L.	marrow	7
	<i>Fevillea cordifolia</i> L.	antidote vine	*
	<i>Luffa cylindrica</i> L. M. Roem.	sponge	*
	<i>Sechium edule</i> Jacq. Sw.	chayote	*
Cyperaceae	<i>Carex</i> sp.	sedge	9, 24, 42
	<i>Cyperus compressus</i> L.	poorland flat sedge	33
	<i>Cyperus esculentus</i> L.	yellow nut sedge	33
	<i>Cyperus papyrus</i> L.	papyrus	5, 33
	<i>Cyperus retrorsus</i> Chapm. var. <i>robustus</i> Boeckeler Kük	globe sedge	33
	<i>Cyperus rotundus</i> L.	nut grass	1, 5, 9, 14, 21, 24, 33, 42
	<i>Fimbristylis littoralis</i> Gaudich.	fimbry	3
	<i>Kyllinga odorata</i> Vahl	fragrant spikes edge	33
Ebenaceae	<i>Diospyros kaki</i> Thunb.	Japanese persimmon	*
Ericaceae	<i>Vaccinium corymbosum</i> L.	highbush blueberry	42
	<i>Vaccinium macrocarpum</i> Aiton	cranberry	5, 9, 24
	<i>Vaccinium oxycoccos</i> L.	small cranberry	5
Euphorbiaceae	<i>Acalypha</i> sp.	copperleaf	24, 33
	<i>Codiaeum variegatum</i> L. A. Juss.	garden croton	42
	<i>Croton capitatus</i> Michx.	hog-wort	9, 24, 33
	<i>Hevea brasiliensis</i> Willd. ex A. Juss. Müll. Arg.	rubber-tree	6, 33, 42
	<i>Jatropha curcas</i> L.	Barbados nut	39
	<i>Manihot esculenta</i> Crantz	cassava	27
	<i>Ricinus communis</i> L.	castor bean	5, 33
	<i>Vernicia fordii</i> Hemsl. Airy-Shaw	tung oil tree	*
Fabaceae	<i>Acacia mearnsii</i> De Willd.	black wattle	*
	<i>Arachis hypogaea</i> L.	peanut	1, 6, 5, 9, 10, 21, 24, 33, 42
	<i>Arachis pintoi</i> Krapov. & Gregory	pinto peanut	*
	<i>Cajanus cajan</i> L. Millsp.	pigeon pea	32, 33
	<i>Canavalia ensiformis</i> L. DC.	jack bean	19
	<i>Cicer arietinum</i> L.	chickpea	1, 9, 21, 24, 32, 33, 42
	<i>Crotalaria breviflora</i> DC.	short flower rattlebox	*
	<i>Crotalaria juncea</i> L.	sunhemp	20, 41
	<i>Crotalaria spectabilis</i> Roth	showy rattlebox	*
	<i>Desmodium adscendens</i> Sw. DC.	zarzabacoa galana	*
	<i>Glycine max</i> L. Merr.	soybean	1, 6, 5, 9, 10, 21, 24, 33, 42
	<i>Kummerowia striata</i> Thunb. Schindl.	Japanese clover	10, 21, 33

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Table 1 (continued)

Family	Scientific name and authority	Common name	References
	<i>Lespedeza bicolor</i> Turcz.	shrub lespedeza	33
	<i>Lespedeza thunbergii</i> DC. Nakai	Thunberg's lespedeza	10, 33
	<i>Medicago sativa</i> L.	alfalfa	1, 6, 5, 9, 10, 21, 24, 26, 33, 42
	<i>Melilotus officinalis</i> L. Lam.	sweet clover	21, 33
	<i>Mucuna pruriens</i> var. <i>utilis</i> Wall. ex Wight Baker ex Burck	velvet bean	9, 24, 33, 42
	<i>Phaseolus lunatus</i> L.	sieva bean	24, 32, 33
	<i>Phaseolus vulgaris</i> L.	kidney bean	6, 5, 9, 10, 21, 24, 26, 33, 42
	<i>Pisum sativum</i> L.	garden pea	1, 5, 9, 10, 21, 24, 26, 33, 42
	<i>Pueraria montana</i> Lour. Merr. var. <i>lobata</i> Willd. Maesen & S.M. Almeida ex Sanjappa & Predeep	kudzu	32, 33
	<i>Senna obtusifolia</i> L. Irwin & Barneby	Java-bean	4
	<i>Stylosanthes guianensis</i> Aubl. Sw.	stylozanthos	*
	<i>Trifolium incarnatum</i> L.	crimson clover	21, 33
	<i>Trifolium polymorphum</i> Poir.	peanut clover	6, 21, 33
	<i>Trifolium pratense</i> L.	red clover	1, 5, 9, 24, 42
	<i>Trifolium repens</i> L.	white clover	1, 5, 9, 24, 42
	<i>Vicia faba</i> L.	fava bean	10, 21, 33
	<i>Vigna unguiculata</i> L. Walp. ssp. <i>unguiculata</i>	cowpea	1, 5, 9, 24, 33, 42
	<i>Vigna unguiculata</i> L. Walp. subsp. <i>cylindrica</i> L. Verdc.	catjang	6
	<i>Wisteria sinensis</i> Sims DC.	Chinese wisteria	1, 9, 10, 21, 24, 33
Geraniaceae	<i>Geranium</i> sp.	geranium	9, 24
	<i>Pelargonium hortorum</i> L.H. Bailey	bedding geranium	24
Iridaceae	<i>Cipura campanulata</i> Ravenna	cipura	29
	<i>Gladiolus gandavensis</i> Van Houtte	gladiolus	5, 33
Juglandaceae	<i>Carya illinoensis</i> Wangenh. K. Koch	pecan	9, 24, 33, 42
	<i>Juglans regia</i> L.	English walnut	*
Lamiaceae	<i>Leonurus japonicus</i> Houtt.	honey weed	*
	<i>Melissa officinalis</i> L.	common balm	*
	<i>Ocimum basilicum</i> L.	sweet basil	32
Lauraceae	<i>Persea americana</i> Mill	avocado	5
Leeaceae	<i>Leea coccinea</i> Bojer	West Indian holly	24
Liliaceae	<i>Aloe vera</i> L. Burm. f.	Barbados aloe	24
Linaceae	<i>Linum usitatissimum</i> L.	linen	10, 21, 33, 26
Lytracaeae	<i>Lagerstroemia</i> L.	lagerstroemia	24
Malpighiaceae	<i>Malpighia glabra</i> L.	wild crape myrtle	5, 33
Malvaceae	<i>Abelmoschus esculentus</i> L. Moench	okra	6, 10, 21, 24, 33
	<i>Alcea rosea</i> L.	hollyhock	1, 9, 24, 42
	<i>Corchorus capsularis</i> L.	jute	3, 6
	<i>Corchorus olitorius</i> L.	nalta jute	3
	<i>Gossypium hirsutum</i> L.	cotton	1, 5, 6, 9, 10, 21, 24, 26, 33, 42
	<i>Hibiscus cannabinus</i> L.	brown Indian hemp	32, 42
	<i>Pavonia cancellata</i> L. Cav.	swamp mallow	*
	<i>Sida cordifolia</i> L.	'ilima	*
	<i>Sida rhombifolia</i> L.	Cuban jute	*

Table 1 (continued)

Family	Scientific name and authority	Common name	References
	<i>Sidastrum paniculatum</i> L. Fryxell	panicled sand mallow	4
Marantaceae	<i>Thalia geniculata</i> L.	bent alligator-flag	33
	<i>Maranta arundinacea</i> L.	arrowroot	6
	<i>Marantha leuconeura</i> E. Morren	prayer plant	24
Moraceae	<i>Ficus carica</i> L.	fig	5
Musaceae	<i>Musa paradisiaca</i> L.	banana	33
Myrtaceae	<i>Eucalyptus camaldulensis</i> Dehnh.	river redgum	32, 33
	<i>Eucalyptus robusta</i> Sm.	swamp mahogany	12
	<i>Eucalyptus urophylla</i> S.T. Blake	Timor white gum	11, 33
	<i>Psidium guajava</i> L.	guava	5, 24, 33
Nictaginaceae	<i>Mirabilis jalapa</i> L.	marvel of Peru	*
Nyctaginaceae	<i>Boerhavia erecta</i> L.	erect spiderling	14
Orchidaceae	<i>Spathoglottis plicata</i> Blume	Philippine ground orchid	32
Oxalidaceae	<i>Oxalis divaricata</i> Mart. ex Zucc	azedinha	*
	<i>Oxalis eriocarpa</i> DC	trevo	*
Pandanaceae	<i>Pandanus</i> sp.	screw pine	32
Passifloraceae	<i>Passiflora alata</i> Dryand.	passionflower	*
	<i>Passiflora edulis</i> Sims	purple granadilla	*
	<i>Passiflora laurifolia</i> L.	golden bell apple	6, 33
Pedaliaceae	<i>Sesamum orientale</i> L.	sesame	4, 26, 33
Phytolaccaceae	<i>Phytolacca</i> sp.	pokeweed	24
Pinaceae	<i>Pinus caribaea</i> Morelet	Caribbean pine	13, 33
Piperaceae	<i>Piper</i> sp.	pepper	33
Pittosporaceae	<i>Pittosporum tobira</i> Thunb. W.T. Aiton	Japanese cheesewood	24
Plantaginaceae	<i>Plantago tomentosa</i> Lam.	plantain	*
Platanaceae	<i>Platanus occidentalis</i> L.	American sycamore	9, 24, 42
Poaceae	<i>Agrostis gigantea</i> Roth.	redtop	42
	<i>Agrostis hyemalis</i> Walter Britton, Sterns & Poggenb.	hair grass	1, 9, 24, 33
	<i>Agrostis stolonifera</i> L.	creeping bent grass	1, 5, 9, 24, 33
	<i>Andropogon leucostachyus</i> Kunth	matojillo bluestem	*
	<i>Andropogon virginicus</i> L.	beard grass	9, 24, 33, 42
	<i>Avena byzantina</i> K. Koch	red oat	10
	<i>Avena sativa</i> L.	cultivated oat	1, 6, 5, 9, 10, 21, 24, 26, 33, 42
	<i>Avena strigosa</i> Schreb.	black oat	10, 33, 41
	<i>Axonopus compressus</i> Sw. P. Beauv.	broadleaf carpet grass	*
	<i>Axonopus fissifolius</i> Raddi Kuhlms.	common carpet grass	1
	<i>Bothriochloa pertusa</i> L. A. Camus	pitted beard grass	22
	<i>Briza lamarckiana</i> Nees	Lamarck quaking grass	*
	<i>Briza minor</i> L.	little quaking grass	*
	<i>Bromus catharticus</i> Vahl	prairie grass	*
	<i>Cenchrus echinatus</i> L.	southern sandbur	38
	<i>Cenchrus spinifex</i> Cav.	coastal sandbur	42
	<i>Cenchrus tribuloides</i> L.	sand dune sandbur	1, 33

Table 1 (continued)

Family	Scientific name and authority	Common name	References
	<i>Chloris barbata</i> Sw.	swollen finger grass	*
	<i>Chloris gayana</i> Kunth	Rhodes grass	1, 9, 24, 42
	<i>Chusquea lorentziana</i> Griseb.	Lorentz chusquea	33
	<i>Cortaderia selloana</i> Schult. & Schult. f. Asch. & Graebn.	Pampas grass	*
	<i>Cynodon dactylon</i> L. Pers.	Bermuda grass	1, 6, 5, 21, 24, 33
	<i>Cynodon nlemfuensis</i> Vanderyst	African Bermuda grass	28
	<i>Cynodon plectostachyus</i> K. Schum. Pilg.	stargrass	32
	<i>Dactyloctenium aegyptium</i> L. Willd.	Egyptian grass	1, 5, 9, 24, 33
	<i>Dichanthium aristatum</i> Poir. C.E. Hubbard	Angleton bluestem	22
	<i>Digitaria aequiglumis</i> Hack. & Arechav. Parodi	Argentinian crabgrass	6, 33
	<i>Digitaria ciliaris</i> Retz. Koeler	southern crabgrass	*
	<i>Digitaria connivens</i> Trin. Henrard	connivens crabgrass	*
	<i>Digitaria eriantha</i> Steud.	digitgrass	5, 32, 33
	<i>Digitaria horizontalis</i> Willd.	Jamaican crabgrass	*
	<i>Digitaria ischaemum</i> Schreb. Schreb. ex Muhl.	finger grass	9, 24
	<i>Digitaria pseudodiagonalis</i> Chiov.	African digitaria	33
	<i>Digitaria sanguinalis</i> L. Scop.	hairy crabgrass	1, 6, 5, 9, 10, 21, 24, 33
	<i>Digitaria swazilandensis</i> Stent		33
	<i>Echinochloa colona</i> L. Link	jungle rice grass	14, 33, 42
	<i>Echinochloa crus-galli</i> L. P. Beauv.	barnyard grass	33
	<i>Eleusine coracana</i> L. Gaertn.	finger millet	35
	<i>Eleusine indica</i> L. Gaertn.	Indian goose grass	6, 4, 33
	<i>Eleusine tristachya</i> Lam. Lam.	threespike goose grass	*
	<i>Elymus repens</i> L. Gould	quackgrass	33
	<i>Eragrostis airoides</i> Nees	darnel love grass	*
	<i>Eremochloa ophiuroides</i> Munro Hack.	centipede grass	33
	<i>Eriochloa punctata</i> L. Desv. ex Ham.	Louisiana cup grass	10, 33
	<i>Eustachys disticophylla</i> Lag. Nees	weeping finger grass	*
	<i>Festuca arvensis</i> Auquier, Kerguelén & Markgr.-Dannenb.	field fescue	*
	<i>Hemarthria altissima</i> Poir. Stapf & C.E. Hubbard	limpograss	25
	<i>Hordeum vulgare</i> L.	barley	1, 9, 10, 26, 24, 33, 42
	<i>Leptochloa panicea</i> Retz. Ohwi ssp. <i>mucronata</i> Michx. Nowack	mucronate sprangletop	*
	<i>Lolium perenne</i> L. ssp. <i>multiflorum</i> Lam. Husnot	annual ryegrass	21
	<i>Melinis minutiflora</i> P. Beauv.	molasses grass	*
	<i>Melinis repens</i> Willd. Zizka	rose Natal grass	*
	<i>Miscanthus</i> × <i>giganteus</i> J.M. Greef & Deuter ex Hodk. & Renvoize	giant miscanthus	31, 33
	<i>Oryza latifolia</i> Desv.	broadleaf rice	5, 33
	<i>Oryza sativa</i> L.	rice	1, 6, 5, 9, 10, 21, 24, 26, 33, 42
	<i>Panicum dichotomiflorum</i> Michx.	fall panic grass	*
	<i>Panicum laxum</i> Sw.	lax panic grass	*
	<i>Panicum miliaceum</i> L.	proso millet	1, 9
	<i>Panicum virgatum</i> L.	switchgrass	31, 33
	<i>Paspalum conjugatum</i> P.J. Bergius	hilo grass	*
	<i>Paspalum cromyrorhizon</i> Trin. ex Döll	crown grass	10, 33
	<i>Paspalum dilatatum</i> Poir.	dallisgrass	10, 21, 33
	<i>Paspalum distichum</i> L.	knotgrass	10, 33
	<i>Paspalum exaltatum</i> J.Presl	paia mansa	10, 33

Table 1 (continued)

Family	Scientific name and authority	Common name	References
	<i>Paspalum fimbriatum</i> Kunth	Panama crown grass	5, 33
	<i>Paspalum notatum</i> Flueggé	bahiagrass	10, 24, 33
	<i>Paspalum pumilum</i> Nees	mijo	10, 33
	<i>Paspalum stelatum</i> Humb. & Bonpl. ex Flügge	stargrass	*
	<i>Paspalum urvillei</i> Steud.	vasey grass	33
	<i>Paspalum vaginatum</i> Sw.	seashore paspalum	37
	<i>Pennisetum clandestinum</i> Hochst. ex Chiov.	kikuyu grass	21, 33, 42
	<i>Pennisetum glaucum</i> L. R. Br.	pearl millet	1, 9, 24, 33, 35, 41, 42
	<i>Pennisetum purpureum</i> Schumach.	elephant grass	5, 6, 33
	<i>Phalaris angusta</i> Nees ex Trin.	timothy canary grass	*
	<i>Phalaris canariensis</i> L.	bird-seed grass	21, 33
	<i>Phleum pratense</i> L.	Timothy	1, 5, 9, 24, 33, 42
	<i>Poa annua</i> L.	annual bluegrass	6, 9, 10, 24, 33, 42
	<i>Poa pratensis</i> L.	Kentucky bluegrass	1, 5, 9, 24, 33, 42
	<i>Saccharum angustifolium</i> Nees Trin.	macega	*
	<i>Saccharum officinarum</i> L.	sugarcane	1, 6, 5, 9, 10, 21, 24, 26, 33, 42,
	<i>Schedonorus arundinaceus</i> Schreb. Dumort.	tall fescue	33
	<i>Schizachyrium tenerum</i> Nees	slender little bluestem	*
	<i>Secale cereale</i> L.	rye	5, 9, 10, 24, 33, 42
	<i>Setaria italica</i> L. P. Beauv.	foxtail millet	9, 24, 42
	<i>Setaria viridis</i> L. P. Beauv.	green bristle grass	42
	<i>Setaria parviflora</i> Poir. Kerguelén	marsh bristle grass	6, 33
	<i>Sorghum bicolor</i> L. Moench ssp. <i>arundinaceum</i> Desv. de Wet & Harlan	common wild sorghum	38
	<i>Sorghum bicolor</i> L. Moench ssp. <i>bicolor</i>	grain sorghum	1, 4, 5, 6, 9, 10, 21, 24, 32, 33, 35, 42
	<i>Sorghum bicolor</i> L. Moench ssp. <i>drummondii</i> Nees ex Steud. de Wet & Harlan	Sudangrass	33
	<i>Sorghum halepense</i> L. Pers.	Johnson grass	1, 5, 9, 10, 21, 24, 33, 42
	<i>Sporobolus indicus</i> L. R. Br.	smut grass	33
	<i>Stenotaphrum secundatum</i> Walter Kuntze	St. Augustine grass	*
	<i>Triticum aestivum</i> L.	wheat	6, 5, 9, 24, 26, 42
	<i>Urochloa arrecta</i> Hack. ex T. Dur. & Schinz O. Morrone & F. Zuloaga	African signal grass	22, 28
	<i>Urochloa brizantha</i> Hochst. ex A. Rich. R. Webster	palisade grass	35, 38, 41
	<i>Urochloa decumbens</i> Stapf R. Webster	spreading liverseed grass	33, 41
	<i>Urochloa fusca</i> Sw. B.F. Hansen & Wunderlin	browntop signal grass	17
	<i>Urochloa maxima</i> Jacq. R. Webster	Guinea grass	5, 29, 32, 33, 38
	<i>Urochloa mutica</i> Forssk. T.Q. Nguyen	para grass	1, 5, 6, 9, 21, 22, 24, 32, 33
	<i>Urochloa plantaginea</i> Link R. Webster	plantain signal grass	6
	<i>Urochloa platyphylla</i> Munro ex C. Wright r R.D. Webste	broadleaf signal grass	33
	<i>Urochloa ramosa</i> L. Nguyen	browntop millet	33
	<i>Urochloa texana</i> Buckley R. Webster	Texas signal grass	1, 9, 24, 33
	<i>Zea mays</i> L.	corn	1, 5, 6, 9, 10, 21, 24, 33, 41, 42
	<i>Zea mexicana</i> Schrad. Kuntze	Mexican teosinte	1, 5, 9, 24, 33, 42
	<i>Zoysia</i> sp.	lawn grass	24, 33
Polygoniaceae	<i>Fagopyrum esculentum</i> Moench	buckwheat	1, 9, 24, 33, 42
	<i>Muehlenbeckia sagittifolia</i> Ortega Meisn.	wire vine	33
	<i>Rumex crispus</i> L.	curled dock	*

Table 1 (continued)

Family	Scientific name and authority	Common name	References
Pontederiaceae	<i>Eichhornia crassipes</i> Mart. Solms	water hyacinth	24
Portulacaceae	<i>Portulaca oleracea</i> L.	purslane	4, 5, 9, 14, 21, 24, 33, 42
Rosaceae	<i>Cydonia oblonga</i> Mill.	quince	21, 33
	<i>Fragaria ananassa</i> Duchesne	cultivated strawberry	40, 42
	<i>Fragaria chiloensis</i> L. Mill.	beach strawberry	9, 24, 33, 42
	<i>Fragaria vesca</i> L.	tree strawberry	21, 26, 32, 33
	<i>Malus pumila</i> Mill.	paradise apple	1, 5, 9, 24, 26, 33, 42
	<i>Prunus persica</i> L. Batsch	peach	1, 5, 6, 9, 24, 33, 42
	<i>Pyrus comunis</i> L.	pear	33
	<i>Rosa</i> sp.	rose	21, 24, 33
Rubiaceae	<i>Borreria latifolia</i> Aubl. K.Schum.	buttonweed	3
	<i>Coffea arabica</i> L.	coffee	6, 33
	<i>Mitracarpus hirtus</i> L. DC.	tropical girdlepod	*
	<i>Richardia grandiflora</i> Cham. & Schlttdl. Schult. & Schult. f.	large flower Mexican clover	*
Rutaceae	<i>Citrus aurantium</i> L.	sour orange	1, 5, 26, 42
	<i>Citrus limon</i> L. Burm. F.	lemon	9, 24, 26, 42
	<i>Citrus reticulata</i> Blanco ssp. <i>unshiu</i> Marcow. D.Rivera Núñez et al.	Unshu orange	9, 24
	<i>Citrus paradisi</i> Macfad.	grapefruit	24
	<i>Citrus reticulata</i> Blanco	tangerine	42
	<i>Citrus sinensis</i> L. Osbeck	sweet orange	9, 21, 24, 33, 42
Sapindaceae	<i>Melicoccus bijugatus</i> Jacq.	Spanish lime	5, 33
Scrophulariaceae	<i>Verbascum virgatum</i> Stokes	wand mullein	*
Solanaceae	<i>Atropa bela-donna</i> L.	belladonna	9, 24, 42
	<i>Brugmansia candida</i> Pers.	angel's-trumpet	32
	<i>Capsicum annum</i> L.	bell pepper	5, 9, 10, 21, 24, 26, 33, 42
	<i>Nicotiana tabacum</i> L.	tobacco	1, 5, 9, 10, 21, 24, 26, 33, 42
	<i>Solanum dulcamara</i> L.	climbing nightshade	9, 24
	<i>Solanum lycopersicum</i> Mill.	tomato	1, 5, 9, 10, 21, 24, 26, 33, 42
	<i>Solanum melongena</i> L.	eggplant	6, 5, 10, 21, 26, 33, 42
	<i>Solanum sisymbriifolium</i> Lam.	sticky nightshade	*
	<i>Solanum tuberosum</i> L.	potato	1, 5, 6, 9, 10, 21, 24, 26, 33, 42
Sterculaceae	<i>Teobroma cacao</i> L.	cacao	8
Talinaceae	<i>Talinum paniculatum</i> Jacq. Gaertn.	jewels of Opar	*
Urticaceae	<i>Urera aurantiaca</i> Weedd.	urera	*
Verbenaceae	<i>Stachytarpheta cayennensis</i> Rach. Vahl	cayenne porte rweed	*
Violaceae	<i>Viola</i> sp.	violet	1, 5, 9, 24, 33, 42
Vitaceae	<i>Vitis vinifera</i> L.	vine grape	5, 24, 26, 33, 42
Zingiberaceae	<i>Zingiber officinale</i> Roscoe	ginger	42

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