

BROADLEAF WEEDS AND NARROWLEAF WEEDS, MONOCOTYLEDONS AND DICOTYLEDONS

Herbicide labels often have statements like 'to control broad leaved weeds in narrow leaved crops' or 'for grass weed control in broadleaf crops'. Such statements are usually adequate in the (temperate climate) context in which they are usually made and are roughly understood in general terms by the more sophisticated users. However, they sometimes provoke questions of the type 'How broad do the leaves have to be for the plant to be a broadleaf?' Furthermore, some languages do not differentiate between broadleaf weeds, narrowleaf weeds and grass weeds; often there is a single word translatable as 'all weeds', but often translated from French (*mauvaise herbe*) and some Slavic languages (*korov*) into English as 'grass'. This highlights the inadequacy of these terms and the need to unequivocally describe the types of plants referred to.

The terms monocotyledon and dicotyledon are the precise and unequivocal botanical terms for which the imperfect terms 'broad leaf plants' and 'narrow leaf plants' have been used as proxies. In contrast, the term 'grass weed', a subset of 'narrow leaved plants', needs no refining; it is absolutely synonymous with Poaceae, a clearly defined botanical family of monocotyledons. Nevertheless, conveying the concept of grasses being a clearly defined sub-set of 'narrow leaves' to farmers across linguistic and cultural barriers is sometimes surprisingly difficult!

Botanists divide all plants into classes, the more familiar of which are: mosses, ferns, conifers and flowering plants. The flowering plants are divided on strict and absolutely clear botanical criteria into two sub-classes: dicotyledons and monocotyledons. These terms are self-evident, the seeds of monocotyledons typically have a single cotyledon, dicotyledons typically have two cotyledons. A number of other morphological characters are closely associated with either monocotyledons or dicotyledons.

Early development of chemical herbicides occurred in the northern temperate regions. In this geographically limited area, the overwhelming majority of monocotyledon species have narrow leaves which are not subdivided, and have parallel leaf veins. The majority of dicotyledon plants have relatively broad leaves (even if they are sub-divided into narrow segments) with branching leaf-veins. The few exceptions to these rules (woodland, wetland and tropical monocots) which were not significant weeds or crops in temperate agriculture) showed clear resemblances to related species that conform to these rules, and so did not threaten their general acceptance

The early 'hormone' herbicides first used in temperate regions proved highly effective at killing dicotyledon weeds in (monocotyledon) cereals and pasture grasses. The botanical terms 'monocotyledon' and 'dicotyledon' were not familiar to farmers, so the terms 'broadleaved weeds' and 'narrow leaved crops' were born.

As herbicides came to be used in a greater variety of crops over wider geographical areas, and as newer herbicides became increasingly selective to individual plant families and not necessarily confined to either monocots or dicots, the flaws in the usage of the broadleaf/narrowleaf terminology became apparent. Many tropical and wetland monocotyledons such as bananas and yams have broad leaves. Some tropical

grasses also have leaves which are broad relative to those of temperate grasses and of course the leaf segments of some common dicotyledons with divided leaves are narrow. The original hormone herbicides kill some tropical species of grasses and aquatic monocots. Thus a consideration of what botanical family a plant belongs to became more important.

The plant family became critically important with the invention of acc-ase inhibitor herbicides (the 'fops' and 'dims') which are active mainly on a single family of monocotyledons (Poaceae, grasses). This further exposed the disadvantage of the broadleaf/narrowleaf terminology and highlighted the need for more precise botanical description of a herbicide's activity.

THE TERMS MONOCOTYLEDON AND DICOTYLEDON ARE PRECISE TERMS WHICH RELATE TO AN UNAMBIGUOUS CLASSIFICATION OF PLANTS. USE OF THE TERMS BROADLEAF AND NARROWLEAF ARE IMPRECISE AND SHOULD BE DISCONTINUED. A CONSIDERATION OF THE PLANT FAMILY TO WHICH A SPECIES BELONGS IS MUCH MORE VALUABLE TO THE EFFECTIVE USE OF MODERN HERBICIDES.

At least for weed scientists who reside in the temperate regions of the world, it is easy to understand the class and sub-class to which a plant belongs:

- If a plant has spores but no seeds it's a **lower plant** (alga, moss, fern etc.)
- If it has simple, narrow, resinous leaves, a woody stem with pollen and seeds born in separate cones it's a **conifer**.
- If it has seeds enclosed in ovaries it's a **flowering plant**.
- If a flowering plant has a taproot, leaves with dendritic branched veins, has petals in fours, fives or greater numbers, and the seeds contain two cotyledons it's a **dicotyledon** (even the few species with narrow or divided leaves).
- If a flowering plant has veins which follow the shape of the leaf without obvious branching, leaf margin not lobed except when lobed below the point of petiole insertion (sagitate or cordate), petals and other flower parts in whorls of three and a single cotyledon (or much endosperm and apparently no cotyledon) it's a **monocotyledon** (even if it does have broad leaves).

There are many families of monocotyledons, but few of them have species that are serious weeds of dryland agriculture. The majority of weedy families are dicotyledons, however the few monocotyledon weeds are extremely successful. Thus it is easiest to learn the characteristics of the few agriculturally important monocotyledons (and the even fewer ferns) and any other non-aquatic weed is likely to be a dicotyledon. If the (non-rice) agronomist learns the characteristics of just two monocotyledon families (the grasses, [*Poaceae*] and the sedges, [*Cyperaceae*]), he should be able to identify most major arable monocotyledon weeds to the family. If he also becomes familiar with the *Liliaceae* and *Juncaceae*, he will have the knowledge to cope with practically all temperate arable and most grassland monocotyledon weeds.

Those involved with rice, aquatic weed control and tropical agriculture need to add knowledge of another 6-8 families, since a number of monocotyledon families seem to have specialised in tropical, aquatic and water-margin habitats. These families include the *Typhales* and the final five in the list below.

Above all other monocotyledons, the grasses deserve the most intensive study by weed scientists. The family *Poaceae* includes many of the most important crops, and is the most important weed family, based upon grasses holding six of the top ten places in 'The World's Worst Weeds' (see table below). Furthermore, effective use of acc-ase inhibitor herbicides, which kill only grasses (with very few exceptions), relies upon the efficient identification of the target weeds on which they are effective.

WEEDY MONOCOTYLEDON FAMILIES

Poaceae [Gramineae] (grasses). The largest, most important and widespread family of flowering plants. Contains many of the most important crops ('cereals') and many important weeds. All (except the bamboos) are herbs with usually **hollow cylindrical (and never 3-angled) stems**. Leaves are mostly basal and on flowering and non-flowering stems. **Leaves alternate** with a pronounced sheath around the stem and with ligules in many species. **Flowers in spikelets with two sterile bracts (glumes) at the base, plus abaxial and adaxial bracts (lemmas and paleas) on each fertile floret.** There are no petals and pollination is mainly by wind. The seed is a caryopsis enclosed in a series of bracts.

Cyperaceae (sedges). Contains *Cyperus rotundus* and *C. esculentus*, two of the 'world's worst weeds'. Other species of *Cyperus*, *Fimbristylis*, *Eliocharis* and *Scirpus*, are important particularly in rice. Herbs, often perennial, usually with **three-angled, solid stems that are devoid of leaves** (but have bracts). **Leaves all basal, three ranked**, linear with sheaths, flat near tips but v-shaped near the base. **Flowers in spikelets with glumes not petals**, wind pollinated, fruit a nut, which is often triangular.

Juncaceae (rushes). Seldom weeds of temperate arable crops, but occur on wet grassland, waterways and can be important in rice. **Stems are round or oval, solid**, filled with pith that may have large air cavities. Leaves usually in threes, usually **without an obvious ligule**, flat, channelled or cylindrical, with sheaths. Flowers often in congested clusters, **perianth present, but reduced to small brown bracts**, so no showy petals. **Fruit a capsule** with three to (usually) many seeds.

Typhaceae (reedmace, cattail). Only one genus, *Typha*, with 9 species. Rhizomatous herbs growing in shallow water. Minor weeds of waterways and amenity/conservation habitats. Stems solid, leaves mainly radical, flat, sheathing at base. Distinguished by the **unmistakable cylindrical inflorescence** with densely packed brown female flowers below and lighter coloured male flowers above. **Perianth severely reduced to minute scales or bristles**, the female flowers with one-seeded ovary and single style, the male with 1-5 stamens. The fruit is a small achene with a **pappus which is dispersed by wind and water**.

Liliaceae (lilies) A very large family including onion, asparagus, many garden flowers, but no major weed. However, many genera such as *Allium*, *Colchicum*, *Muscari*, *Ornithogalum*, *Asphodelus* have species which occur particularly in perennial crops in Mediterranean climates (to which their geophytic habit is well adapted). Most are **herbs with underground storage organs** (bulbs, corms, rhizomes or roots) but some are evergreen shrubs. Leaf shape is very variable. **Flowers have two rows of three, normally showy and brightly coloured, 'petals'** sometimes fused. Stamens usually 6, styles usually either 1 or 3. Fruit usually a 3-celled capsule, sometimes a berry.

Commelinaceae (spiderworts). *Commelina benghalensis* is a sub-tropical arable weed, *C. diffusa* and other spp. are weeds of perennial crops in the humid tropics. The leaves are alternate, relatively broad, often at least $\frac{1}{4}$ as wide as long. Leaf sheaths clasp the succulent stem. Flowers are few, they have three sepals, three white or blue petals, six stamens and a single style. Fruits usually, not always, a capsule. **Achenes 'seeds' of weedy species always have a heavily sculptured, wrinkled surface.**

Pontaderiaceae (pickerelweeds) *Monochoria* and *Heteranthera* are important weeds of rice. *Eichhornia* is an important floating aquatic weed. A small family of mainly tropical and subtropical, mainly aquatic species. Leaves broad, simple. Flowers with six showy 'petals', three or six stamens and three stigmas.

Alismataceae (water plantains). *Alisma* and *Sagittaria* are weeds of rice and waterways. Leaves are all basal (or in clusters on aquatic stolons). Usually rooted in mud with either or both ribbon-like submerged leaves and broad emergent leaves. Flowers have 3 sepals, 3 petals, 6 or more stamens and one or more whorls of carpels with short stigmas. Fruit a cluster of achenes.

Araceae (Arums). A diverse, mainly tropical and subtropical family. Various yams and starch crops belong to the family. The important water weed *Pistia stratiotes* (water lettuce) is the main weedy member, but its floating habit is atypical of the family. Typical Araceae are terrestrial, with root tubers, broad, arrow shaped leaves, all basal. The insect pollinated flowers may be bisexual or monoecious. Male flowers are born above the female flowers and the whole inflorescence is enclosed in a spathe that promotes insect pollination. Fruit a berry, nut or capsule.

Lemnaceae (duckweeds) Various species of *Lemna* are of minor economic importance as water weeds. The plant is reduced to a 'frond' or 'thallus' which may or may not have roots. Flowers are minute, embedded in the frond.

Hydrocharitaceae (frogbits). A family of aquatic perennials including *Hydrochaeris*, *Lagarosiphon*, *Hydrilla* and *Elodea*. Of significance only in waterways. May have submersed or floating leaves. Inflorescence subtended by a spathe (a big bract), flowers dioecious (separate male and female flowers) 3 sepals, 3 petals, 2-6 stamens, 3 or 6 stigmas. Fruit a capsule.

MONOCOTYLEDON WEEDS: A SMALL NUMBER OF FAMILIES, BUT A HIGH ECONOMIC IMPORTANCE.

'The World's Worst Weeds' published by Holm, Plucket, Pancho and Herberger, 1977 lists the species that their collaborators around the world considered to be of the greatest economic importance. There is an impressive proportion of monocotyledons, especially grasses, in the 18 species considered the most important, as the following table shows:

THE WORLD'S WORST WEEDS

RANK	SPECIES	MONOCOTYLEDON. or DICOTYLEDON	FAMILY
1	<i>Cyperus rotundus</i>	Monocot	Cyperaceae
2	<i>Cynodon dactylon</i>	Monocot	Poaceae

3	Echinochloa crus-galli	Monocot	Poaceae
4	Echinochloa colonum	Monocot	Poaceae
5	Eleusine indica	Monocot	Poaceae
6	Sorghum halepense	Monocot	Poaceae
7	Imperata cylindrica	Monocot	Poaceae
8	Eichhornia crassipes	Monocot	Pontaderiaceae
9	Portulaca oleracea	Dicot	Portulacaceae
10	Chenopodium album	Dicot	Chenopodiaceae
11	Digitaria sanguinalis	Monocot	Poaceae
12	Convolvulus arvensis	Dicot	Convolvulaceae
13	Avena fatua	Monocot	Poaceae
14	Amaranthus hybridus	Dicot	Amaranthaceae
15	Amaranthus spinosus	Dicot	Amaranthaceae
16	Cyperus esculentus	Monocot	Cyperaceae
17	Paspalum conjugatum	Monocot	Poaceae
18	Rottboellia exaltata	Monocot	Poaceae

SUMMARY

The terms monocotyledon and dicotyledon are botanically precise divisions of flowering plants that should be used in preference to the imprecise and confusing terms 'broad leaved/broadleaf' and 'narrow leaved/narrowleaf'.

The division of weeds into monocotyledons and dicotyledons was valuable to describing herbicide selectivity in the early days of herbicide technology, but more recently discovered herbicides are more specific, either to a few plant families, or to a small number of species. Thus modern field agronomists need a greater degree of botanical knowledge, particularly in recognition of plant families, than their predecessors. Nevertheless, the number of agronomically important weedy families of monocotyledons is very limited, so their identifying characters can easily be learned. There is a much greater number of agronomically important dicotyledon families, but their diversity of vegetative and floral characteristics makes their identification more intuitive to the non-botanist than the 'sameness' of monocotyledons.

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