UF IFAS Extension UNIVERSITY of FLORIDA

ENH1085

Prevention, Early Detection, and Eradication of Benghal Dayflower in Field Nurseries[1]

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Benghal dayflower (*Commelina benghalensis* L.), an increasingly problematic weed, is also known as jio, tropical spiderwort, hairy wandering jew, and Indian dayflower, among other names. It is an herbaceous monocot (flowering plant that produces one seed leaf and has fibrous roots, leaves with parallel veins, and flower parts occurring in multiples of three) that is native to Asia and tropical Africa. It was first collected in the continental United States in 1928, and in 1983, it was designated a "noxious weed" by the U.S. Department of Agriculture (Faden 1993). Benghal dayflower is also listed as a noxious weed by at least nine states, including Florida. This listing means that "**it is unlawful to introduce, multiply, possess, move, or release any… noxious weed, or invasive plant** regulated by the department [in Florida, the Department of Agriculture and Consumer Services] or the USDA …" (Florida Administrative Code Rule 5B-57.004).

Benghal dayflower has many characteristics that make it a successful weed in field nurseries. First, Benghal dayflower is tolerant of many herbicides, including glyphosate (Glyfos® Pro, Roundup Pro®, Touchdown®, etc.) (Lacerda and Victoria Filho 2004). Many nurseries have depended on glyphosate as their sole herbicide to control weeds, and this widespread use of glyphosate has greatly reduced competition from other non-glyphosate-resistant plants. These other weeds may have, in the past, suppressed Benghal dayflower growth. Benghal dayflower may survive treatment with glyphosate, and this can result in selection for Benghal dayflowers with greater glyphosate tolerance. Glyphosate, besides having limited effectiveness against Benghal dayflower, has no preemergence activity to prevent Benghal dayflower seed germination. Benghal dayflower plants will reestablish from seed even if glyphosate or other postemergence herbicides are used. Therefore, preemergence herbicides with residual activity should be used to help ensure Benghal dayflower eradication from nurseries. Unfortunately, many residual herbicides labeled for use in nursery crops are also ineffective on this weed.

Second, not only is Benghal dayflower a vigorous plant with succulent stems that can root at each node (Figure 1), but it also produces underground stems. These attributes allow the plants to spread vegetatively. Stem pieces on or buried slightly below the soil surface have been shown to become established and produce new plants (Budd et al. 1979). This characteristic also makes Benghal dayflower stems hard to remove by cultivation or by hand. Further, preemergence herbicides, in general, work poorly on plants emerging from vegetative structures. Third, this plant produces flowers both above- and belowground. A single plant can produce over 1,600 seeds (Pancho 1964); once Benghal dayflower stands are established, seed production can exceed 1,100 per square foot (Walker and Evenson 1985a).

Fourth, besides producing a lot of seed, Benghal dayflowers produce four different types of seeds (Figure 2) that have various germination characteristics (dormancies and

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optimum germination temperatures) that allow new Benghal dayflower plants to become established from seed over an extended period of time (Walker and Evenson 1985b). Therefore, germination may occur after herbicide barriers have dissipated below effective levels. Also, some seeds can germinate several inches deep in the soil, and the seedlings can successfully reach the soil surface (Budd et al. 1979; Walker and Evenson 1985b). By the time they emerge from the soil, these seedlings have formed deep root systems that make them difficult to control by many preemergence herbicides since seeds have germinated below the zone of herbicide treatment. Larger seeds have the potential to grow to the soil surface from greater depths than smaller seeds (Walker and Evenson 1985b).

Figure 1. Benghal dayflower readily roots from nodes along its stems.

Figure 2. Benghal dayflower seeds from above-ground (left) and subterranean (right) flowers.

To make matters worse, in addition to being a well-adapted invasive plant, Benghal dayflower is also a host to the root-knot nematode, *Meloidogyne incognita* (Davis et al. 2006), a widespread and economically important nematode pest of ornamental and other crops.

What It Means to Your Nursery

As mentioned previously, Benghal dayflower is a federally and state-regulated species. All necessary steps should be taken to prevent this weed from becoming established at your nursery. Prevention, early detection, and eradication are critical since the presence of this noxious weed at your nursery can lead to quarantine, thereby preventing the shipment of plants to your customers. Employees should be trained to scout for this weed. Because the presence of this weed can have such an impact on your nursery business, correct identification is critical.

Identification

Benghal dayflower can generally be differentiated from the other dayflowers that grow in most of Florida

- by their violet rather than blue flowers (Figure 3);
- by their broader (leaf length to width ratio of less than 3:1), less lance-shaped, ¾–3½-inch-long leaves (Figure 4);
- by the presence of hairs (pubescence) on the upper surface and edges (margins) of the leaves; and
- by the production of whitish, underground (subterranean) stems and flowers (Figure 5). (*Commelina forskaolii* also produces subterranean flowers, but it has been reported as occurring at only one site in Miami-Dade County.)

Figure 3. Benghal dayflower (right) has violet/lavender flowers rather than blue ones that are common for many other dayflowers.

Figure 4. The leaves of Benghal dayflower (right) are generally broader than those of other dayflowers currently in Florida (whitemouth dayflower, *C. erecta*, on left).

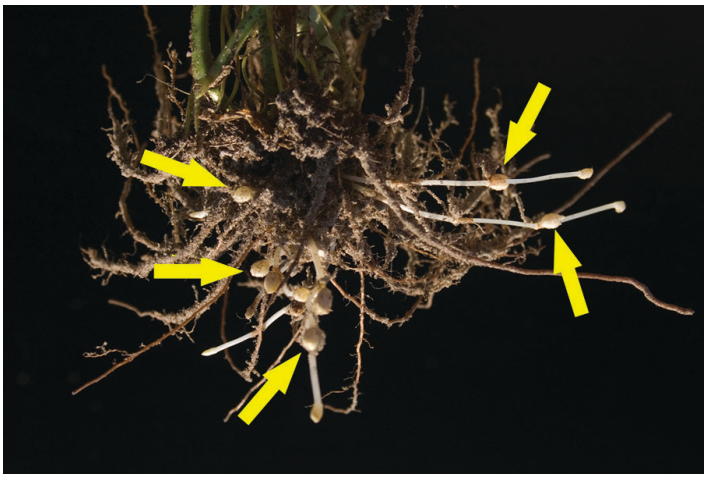

Figure 5. Benghal dayflower is one of the few plants in the world that produces underground (subterranean) flowers (whitish in color).

Prevention - Exclusion Is the Best Control

The most effective method for controlling Benghal dayflower is to institute procedures to prevent it from being brought into the nursery in the first place. Remember, the cost of preventing weed introductions is usually much lower than the cost of managing weeds once you have an infestation. Efforts should be made to prevent the introduction of this weed on uncleaned equipment, in growing medium, or with incoming plant material. Employees accepting plant material from outside sources should scrutinize the new plants, looking for Benghal dayflower (and other weeds and pests). In addition, if possible, visit your media and plant suppliers to make sure they do not have Benghal dayflower at their operations. Unfortunately, there is another potential source of Benghal dayflower introductions to the nursery that is not as easy to control: seed introduction by animals, especially birds. For example, mourning doves have been shown to feed on Benghal dayflower capsules, and the seeds remain viable after traveling through the birds' intestinal tracts (Goddard et al. 2009).

Of course, all your employees should be trained to identify and control Benghal dayflower and any other weeds they might encounter. It is particularly important to make sure that they know the key characteristics that help differentiate Benghal dayflower from the other dayflowers they are likely to encounter. It bears repeating that Benghal dayflower is on both the U.S. Department of Agriculture's and many states' noxious weed lists; therefore, the presence of Benghal dayflower in a nursery can lead to quarantine restrictions and the prohibition of plant shipments. Some states now require a phytosanitary certificate indicating that the nursery area is free of Benghal dayflower before they will accept shipments.

Besides implementing procedures to prevent the introduction of Benghal dayflower, using preemergence herbicides with residual activity can serve as an additional line of defense. These chemicals can create a protective barrier that can kill germinating weed seeds, such as those brought in on equipment or by animals. In addition, some of them can inhibit the weeds from rooting into the soil, thereby reducing weed growth and making plant removal easier (Stamps 1993). As with other pesticides, growers should rotate among preemergence herbicides with different sites of action in order to reduce the chances of selection for resistance by Benghal dayflower. Not all of the preemergence herbicides labeled for use on ornamental crops have been evaluated for controlling Benghal dayflower; however, those that have already been tested and shown to provide fair to good control are indicated in Table 1. Undoubtedly, more testing will identify more herbicides that can help control Benghal dayflower from seed. Additional information on preemergence herbicides labeled for use on ornamentals is available at http://edis.ifas.ufl.edu/wg058. Note that preemergence herbicides need to be activated by a water event (irrigation or rainfall) to form the protective barrier on the growing medium and soil surfaces.

What to Do if You Find Benghal Dayflower in Your Nursery

Quarantine the infested area. Do not allow plants to be moved from the infested area. Do not allow equipment to be moved from the infested area until it has been inspected and thoroughly cleaned. Take immediate action to eradicate all the Benghal dayflower plants and to protect against reestablishment from seed.

Eradication of Existing Infestations

First, make sure the weeds in question are actually Benghal dayflower (*Commelina benghalensis*) rather than Asiatic dayflower (C. *communis*), Carolina dayflower (C. *caroliniana*), common dayflower (C. *diffusa*), or Florida natives Virginia dayflower (C. *virginica*) or whitemouth dayflower (C. *erecta*), or some other dayflower. See http://www.plantatlas.usf.edu/ for a list of species found in Florida and pictures of some of them. The information provided earlier in this publication provides some characteristics useful for identifying Benghal dayflower. Department of Plant Industry inspectors and county Extension agents can also help identify dayflowers.

There are multiple methods that, when used together (integrated pest management [IPM]), can help you rid your nursery of Benghal dayflower. These methods include physical (cultural, mechanical), biological, and chemical techniques. This is a continuous, long-term process due to the possibility of reintroduction from outside the nursery and reinfestation from germination of seeds on-site. Be aware that the underground flowers may develop before the aerial flowers, so seed may be being produced on plants that have no aboveground flowers (Walker and Evenson 1985a).

PHYSICAL CONTROL METHODS

Mowing. Mowing may spread the Benghal dayflower problem beyond the initial site of infestation, so it may be best to treat turfgrass row middles with selective turf herbicides to control established plants before doing any further mowing. Mowing can spread Benghal dayflower by chopping up and spreading stem pieces to where they can then root into the ground and establish new plants. Mowing can also disperse Benghal dayflower seeds that can then germinate where they land, again establishing new plants. In addition, both plant parts and seed may be moved from one area to another on the mowing equipment itself. However, mowing may be beneficial in row middles that are free of Benghal dayflower when combined with techniques to keep the cover crop vigorous and weed free. Care should be taken to mow at a high enough height that the cover crop still shades the ground even after mowing.

Mulches. The use of mulches, both organic and especially inorganic (e.g., geotextile fabrics), can help prevent the establishment and facilitate hand weeding of Benghal dayflower. Organic mulches should be applied about 2–3 inches deep and should be kept 3 inches away from the trunks of crop plants. Their use around the perimeter and in areas of the nursery that are devoid of competitive cover crops can inhibit the introduction and spread of Benghal dayflower.

Hoeing and hand weeding. Although onerous, use hoeing and hand weeding to eradicate small infestations. Whole plants, including roots and underground flowers, should be hoed or pulled and immediately bagged and disposed of. It is easier to pull the plants if the soil is moist and the plants are small. Do not leave Benghal dayflower stem pieces on or in the soil; they can root and establish new plants. Also, measures should be taken to prevent Benghal dayflower from reestablishing from seed in the hoed or weeded areas.

BIOLOGICAL CONTROL METHODS

Plant competition can be an effective weed control technique. Maintaining weed-free cover crops in the middles between the rows and around the perimeter of the nursery can help prevent Benghal dayflower plants from getting close enough to infest the crops. However, cover crops (just like weeds) can compete with nursery crops, so they must be managed so that there are vegetation-free zones around the nursery plants. Bahiagrass is a common cover crop grown in row middles. It should be mowed to a height of about 3½–4 inches and, ideally, frequently enough that only about a third of the leaf blade is removed at each mowing. This will help ensure that it grows vigorously, maintains a canopy over the soil, and remains competitive with broadleaf weeds. The herbicide 2,4-D amine has been shown to control Benghal dayflower and should be considered for Benghal dayflower control in turfgrass row middles.

With a plant already so widely distributed as Benghal dayflower, the only long-term control solution may be the use of biological control agents (pathogens and pests) brought in from the country of origin. However, this is a very lengthy process and complicated, especially in a state like Florida since there are several other non-native species and two native species of *Commelina*. Finding biological controls that are specific only to Benghal dayflower may be impossible.

CHEMICAL CONTROL METHODS

Herbicides are the primary tool used to eradicate Benghal dayflower from nurseries. To be most effective, postemergence herbicides should be applied in the early stages of the weed growth cycle. This is why it is so important to have a regular scouting program so that early detection is possible, thereby facilitating and reducing the costs of eradication. Also, the label is the law, so the entire label should be read and the directions and restrictions followed.

Postemergence herbicides (Table 2) combined with preemergence herbicides (Table 1) can aid greatly in the eradication of Benghal dayflower. Postemergence herbicides can be classified as contact (damage is limited to only the Benghal dayflower stem and leaf areas that are in direct contact with the herbicide) or systemic (the herbicide moves [i.e., is translocated] from the sites of contact to other parts of the plant). Systemic herbicides, in general, are more effective in killing perennial weeds like Benghal dayflower. Keep in mind, however, that Benghal dayflower is tolerant to glyphosate, which is a systemic herbicide, and higher-than-normal glyphosate rates are required for

control. Avoid postemergence herbicide contact with the nursery crop or damage may occur.

Some Factors Affecting the Efficacy of Postemergence Herbicides:

Soil moisture – Research has shown that damage to Benghal dayflower from some herbicides (e.g., flumioxazin, glufosinate, and metolachor) increases with rising soil moisture (Steptoe et al. 2006). The effects of several other herbicides (2,4-D, diclosulam, glyphosate) are not impacted by soil moisture.

Benghal dayflower growth – The smaller the plant and the more vigorously it is growing, the better the chances of killing it.

Application rate – Read the product label completely and follow all guidelines. Have a knowledgeable person check your calculations to make sure the correct amount of herbicide is used for each tank size.

Water quality – There are adjuvants that can help reduce the detrimental effects of hard water on herbicide effectiveness. For example, hard water ions (Ca^{2+}, Fe^{3+}, Mg^{2+}) can bind with salts of certain herbicides and surfactants to form insoluble salts, thereby reducing their efficacy. Glufosinate and glyphosate are salt-formulated herbicides commonly used in nurseries. Ammonium sulfate (NH_4SO_4), which can be used to bind some of the hard water minerals, may also help the herbicide enter the plant and result in increased weed control (Carvalho et al. 2008). Urea-ammonium nitrate, organic acids, and commercial products containing combinations of these and other ingredients can also help counteract the effects of hard water. Spray solution pH can also affect herbicide breakdown and subsequent activity. Read the label of any herbicide you intend to use for information on potential water quality effects and measures to optimize efficacy.

Adjuvants – Again, read the label. If an adjuvant is called for, use the type listed at the recommended concentration. Some adjuvants can increase spray coverage, retention, and/or penetration. Not using a required adjuvant, using the wrong adjuvant, or using an adjuvant at an incorrect rate can all reduce herbicide efficacy. More adjuvant is not necessarily better; use recommended rates.

Time of application – Apply postemergence herbicides early in the day but after the dew has dried. Herbicide effectiveness is reduced if plants are water stressed, as often occurs late in the afternoon.

Coverage – Thorough coverage is important even with systemic herbicides. Consider using a colorant or dye to aid in visualizing spray coverage during directed applications. However, use dyes that are known to have little or no adverse effects on herbicide efficacy.

Addition of preemergence herbicides in spray mix – In one study, the combination of glyphosate + metolachlor improved the uptake of both constituents over that of applying either one alone (Steptoe et al. 2006). Other preemergence herbicides or formulations may not have this effect; however, their inclusion may still be beneficial if they provide residual control of Benghal dayflower coming from seed.

The proper selection and application of **preemergence herbicides** is essential to controlling established Benghal dayflower populations since this weed is a prolific seeder and will reestablish from seed. Preemergence herbicides must be applied and activated before the weed seeds germinate. Activation is usually by irrigation or rainfall. Usually ½–¾ inch of rain or irrigation is required, and this may be somewhat difficult during the dry season in nurseries that do not have overhead irrigation systems. However, rainfall records in Florida indicate there would be adequate daily rainfall events occurring most weeks of the year, even during the dry season. Repeated very light daily rainfall amounts after herbicide application may not be adequate to activate the herbicide to an effective depth in the soil or growing medium and could cause a reduction in weed control. Conversely, very heavy rainfall after herbicide application and before the herbicide is adsorbed to the soil or growing medium may move the herbicide below the germination zone of some of the Benghal dayflower seeds or erode treated soil to off-target areas.

Some Factors Affecting the Efficacy of Preemergence Herbicides:

Benghal dayflower growth – If the seeds have already germinated, it is too late to use a preemergence herbicide alone.

Application rate – Read the product label completely and be sure to follow all guidelines. Have a knowledgeable person check your calculations to make sure the correct amount of herbicide is used for each tank size. Using

lower-than-recommended rates (sublethal rates) can result in poor control and increased selection for herbicide resistance.

Application uniformity – Preemergence herbicides form a chemical barrier on the soil or growing medium surface. If the herbicide is not applied uniformly, there will be areas where control will be poor or lacking (and areas where too much herbicide will be applied, which could cause crop damage).

Herbicide activation – As mentioned above, preemergence herbicides need to be activated in order to be effective. A ½–¾ inch irrigation or rain event is needed to activate a preemergence herbicide. Although activation can in some cases be done by shallow cultivation, in nurseries it is usually done using water. Mechanical cultivation may disturb crop roots and bring more weed seeds to the soil surface. If cultivation reduces crop vigor, the crop can become less competitive with Benghal dayflower.

Herbicide selection – As information on the efficacy of herbicides for controlling Benghal dayflower becomes available, products that are most efficacious should be used. However, products with the same site of action (see Table 2) should not be used repeatedly or resistance may develop. Also, using the same herbicide over and over can cause steady shifts in the weed spectrum (since no product controls all weeds) and other, perhaps even worse, weeds may replace Benghal dayflower in the nursery.

Watering – Overwatering may increase leaching of herbicides from the soil or medium surface, enhance conditions promoting microbial breakdown of herbicides, and enhance weed seedling survival by reducing water stress. Overwatering should also be avoided because of potential detrimental effects on the crops, nutrient leaching, additional production costs, and the wasting of a limited resource.

Application intervals – The period of time during which preemergence herbicides remain effective depends on numerous factors, including application rate, soil or medium type, soil temperatures, irrigation or rainfall, herbicide breakdown characteristics, and microfauna in the soil or medium. Therefore, scouting for weed control failure should be an integral component of a Benghal dayflower control or eradication program. Scouting can save money by signaling if and when follow-up herbicide applications are necessary.

The most effective herbicide control strategies for Benghal dayflower include using a combination of both postemergence and preemergence herbicides.

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Table 1. Site-of-action groups[1] for some preemergence herbicides that have shown some efficacy in controlling Benghal dayflower and are labeled for ornamental crops

Common name(s)/ active ingredient(s)[3]	Trade name(s)	Manufacturer(s) or distributor(s)
GROUP 3 HERBICIDE		
prodiamine	Barricade® 4FL, 65WG; Cavalcade™ 65WDG; ProClipse™; ProdiaGuard 65WDG; Prodiamine 65 WDG; RegalKade® 0.5G, 65WDG; Stonewall® 65WDG; etc.	Syngenta, Sipcam Agro USA, Nufarm Turf & Specialty, Control Solutions, FarmSaver.com, Regal Chemical, Lesco, etc.
GROUP 5 HERBICIDE		
simazine	Princep® 4L; Simazine 4L; Simazine 90DF, 90WDG; Sim-Trol® 4L, 90DF	Syngenta, Drexel, Riverside, UAP, Sipcam Agro USA
GROUP 12 HERBICIDE		
norflurazon	Predict® 78.6WDG	Nufarm Turf & Specialty
GROUP 14[2] HERBICIDES		
flumioxazin	BroadStar™ 0.25G, SureGuard™ 51WDG	Valent USA
oxadiazon	Ronstar® 2G, Ronstar® 50WSP	Bayer CropScience, Regal
oxyfluorfen	Galigan® 2EC; Goal® 1.6E, 2EC; OxiFlo 2EC	Makhteshim Agan, Dow AgroSciences, FarmSaver.com
GROUP 15 HERBICIDES		
dimethenamid-P	Tower® 6EC	BASF
S-metolachlor	Pennant Magnum® 7.6EC	Syngenta
Combination products with more than one site of action **[site-of-action group number in brackets]**		
oxyfluorfen [14] + oryzalin [3]	Double O E-Pro 3G, Rout® 3G	Etigra, Scotts
oxyfluorfen [14] + prodiamine [3]	Biathon™ 2.75 G	OHP
pendimethalin [3] + dimethenamid-P [15]	FreeHand™ 1.75G	BASF

[1]Herbicide groups are based according to primary sites of action (Mallory-Smith and Retzinger 2003) and can be used to select herbicides that have differing sites of action. This information can be used to help select herbicides in order to minimize the potential for the development of herbicide-resistant weeds. Group 3 = microtubule assembly inhibitors, Group 5 = photosystem II inhibitors, Group 12 = carotenoid biosynthesis inhibitors, Group 14 = PPO inhibitors, and Group 15 = acetamides (unknown site of action).

[2]Group 14 herbicides also have some postemergence activity, especially when weeds are small.

[3]Additional trade-named products and various fertilizer formulations containing some of these herbicides are available but not listed in this table. Be aware that not all these products are labeled for use on containerized ornamentals. Read the section "Some Factors Affecting the Efficacy of Preemergence Herbicides" for additional information.

Table 2. Site-of-action groups[1] for some postemergence nonselective herbicides that have shown some efficacy in controlling Benghal dayflower. Some of these can be used as directed sprays around but not applied to ornamental crops; others can only be used on turfgrass row middles farther away from the ornamental crops.

Common name(s)/ active ingredient(s)	Trade name(s)	Manufacturer(s) or distributor(s)	Contact	Systemic
GROUP 4 HERBICIDES				
2,4-D amine[2]	2,4-D Amine 3.8L, Weedar® 64 3.8L, etc.	Helena, Nufarm, etc.		X
bentazon	Basagran® T/O 1EC	BASF	X	
GROUP 9 HERBICIDE				
glyphosate[3]	FireBall 1.55L; Glyphosate 4L; Glyphosate T&O 4L; Prosecutor 4EC; Rattler® 4L; Razor® 4L; Roundup Pro® 4L, 5L; Touchdown® Pro 3L; etc.	Helena, FarmSaver.com, Quali-Pro, Lesco, Nufarm, Monsanto, Syngenta, etc.		X
GROUP 10 HERBICIDE				
glufosinate	Finale® 1EC	Bayer Environmental Science		X
GROUP 22 HERBICIDES				
diquat dibromide	Reward® 2EC; WeedPlex Pro 2EC	Syngenta, Sanco Industries	X	
paraquat dibromide[4]	Boa® 2.5L; Gramoxone Inteon™ 2.5L	Griffin, Syngenta	X	
GROUP 27 HERBICIDE				
pelargonic & related fatty acids	Scythe® 4.2L	Mycogen	X	
Combination product with more than one site of action **[site-of-action group number in brackets]**				
glyphosate [9] + prodiamine [3]	ProDeuce™	Nufarm Americas		X

[1]Herbicide groups are based according to primary sites of action (Mallory-Smith and Retzinger 2003) and can be used to select herbicides that have differing sites of action. This information can be used to help select herbicides in order to minimize the potential for the development of herbicide-resistant weeds. Group 4 = synthetic auxins, Group 9 = inhibition of EPSP synthase, Group 10 = inhibition of glutamine synthetase, Group 22 = photosystem I - electron diversion, and Group 27 = unknown.
[2]For use in turfgrass row middles only, but only for some turfgrasses and not around ornamentals. Ester formulations should not be used due to their greater volatility and potential to damage crops.
[3]Many populations of Benghal dayflower are known to be tolerant of glyphosate at lower rates of activity. Read the section "Some Factors Affecting the Efficacy of Postemergence Herbicides" for more information.
[4]Restricted-use pesticide