SS-AGR-10

UF UNIVERSITY of FLORIDA
IFAS Extension

Weed Management in Rice[1]

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Successful weed control is essential for economical rice production in the Everglades Agricultural Area (EAA). Weeds can reduce rice yields by competing for moisture, nutrients, and light during the growing season. Weed infestations can also interfere with combine operation at harvest and significantly increase harvesting and drying costs. Weed seed contamination of rice grain lowers grain quality and may lower the cash value of the crop. As with any biological system, an effective weed management program must consider many factors that vary from crop to crop and year to year. The most important of these factors include planting date, climatic conditions, seedbed preparation, seed quality, stand establishment, and water management.

The first step in effective weed control is to ensure a solid, uniform stand of rice. Only high quality, uncontaminated, certified rice seed should be planted. The Florida state regulations for rice seed certification specifies that a maximum of 0.05% weed seed is allowed in certified rice seed. There is zero tolerance for "objectionable" or "noxious" weed seeds, as listed in the General Seed Certification Standards, which includes red rice (*Oryza sativa*), purple nutsedge (*Cyperus rotundus*), and Texas panicum (*Panicum texanum*).

Rice should be planted in a well-prepared seedbed that should receive a final disking as close to planting as possible. Disking immediately prior to planting destroys existing weeds and allows the rice to be competitive with later emerging weeds. On lighter muck soils, rolling the field prior to drill seeding allows for more precise planting depth and greater uniformity of emergence. Planting in a dry seedbed may require that the field be "flushed" immediately after planting to help ensure uniform rice germination and emergence. The duration of a flush will vary depending on field size and soil type and on how level the field is. The goal is to get the water on and off the planted field in approximately 48 hours. A poor stand of rice encourages infestation by weeds such as dayflower (*Commelina* sp.), primrose willow (*Ludwigia* sp.), and redstem (*Ammania* sp.). These weeds can become established in areas of open water where the rice population is sparse. In a solid stand of rice, these weeds usually cannot compete for essential sunlight and do not become a problem.

1. This document is SS-AGR-10, one of a series of the Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Revised November 2005 and March 2011. Please visit the EDIS website at http://edis.ifas.ufl.edu.

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The permanent flood should be applied as soon as possible in order to suppress weed seed germination. The timing of the flood will depend on the growth rate of the rice crop, which is largely controlled by the planting date. The degree to which the field is level also plays an important role in flood timing since care must be taken not to flood over and drown the rice in the lower area of the field. Typically, the permanent flood is applied 3-6 weeks after planting.

The most concentrated weed control effort should be targeted for the time span between rice emergence and the application of the permanent flood. Two sets of tools can be used in an effective weed control program in rice, including water management and chemical control. Chemical control will be effective only if the herbicides are used in conjunction with a carefully controlled water management plan (Table 1).

Water management for weed control is effective in Florida because most of the weed species in our rice crops are only semi-aquatic weeds and their growth can be retarded and ultimately controlled by standing water. In order to control rice weeds solely by water management, the grower is walking a fine line between killing the weeds and killing the rice. A high level of management skill and intensity is required. The theory behind water management for weed control is that rice can tolerate submergence better than many weed species. Therefore, the grower must know what weed species are potential problems and whether or not these weeds are easily controlled by submergence. Rice, particularly drill-seeded rice, can also be killed by submergence.

Anoxic or drowned rice will appear pale and flaccid and will not stand up after the flood has been taken off. The water depth should be kept as shallow as possible while still keeping all of the weeds totally submerged. The maximum allowable submergence time for rice depends on the water temperature because of the direct effect of temperature on plant respiration rate. The higher the water temperature, the shorter the maximum survivable duration of submergence. Typically, on most light- to medium-textured muck soils, rice can tolerate submergence for approximately 48 hours. On heavier mucks and high mineral muck soils, rice will only tolerate shorter periods of flooding. After draining, the rice is allowed to recover for a week to 10 days, and then the flood cycle is repeated once or twice before the permanent flood is applied.

In the EAA, only a few commercial herbicides are widely used for chemical weed control in rice. These and other products and their uses are summarized in Table 1. Other herbicides are labeled for use in Florida rice production, but their use patterns are generally not appropriate to our production system except under special conditions. As with any agricultural chemical, the product label should be consulted and understood prior to use.

The underlying strategy behind using herbicides for weed control in rice is to kill or stunt the growth of weedy plants while allowing the rice plants to grow and achieve a competitive height advantage. Maintaining an effective height differential between the rice and weeds will allow the flood water to control weed growth by keeping them submerged while the rice plants grow above the water surface after the permanent flood is applied. If a good height differential exists between the weeds and the rice near the time of permanent flood, herbicide application may not be necessary.

Of the herbicides available for weed control in Florida rice, "Stam 4E" (the 4 lb active ingredient per gallon formulation of propanil) is the most commonly used. Early applications of 2-3 pt per acre to small weeds and rice in the 1-2 leaf stage are most effective. At this timing, the herbicide is less phytotoxic to the rice seedlings and the smaller weeds are more sensitive. Ten gallons of water carrier per acre should be used when applying propanil.

Because propanil is a contact herbicide and supplies no residual control, a second application of 1 to 1.5 pt per acre prior to permanent flood may be necessary. Second applications should be made to rice in the 5-6 leaf growth stage and followed by the permanent flood within 24 to 48 hours. Applications at the 3-4 leaf stage should be avoided because during this growth stage rice plants are extremely sensitive to the herbicide and are less able to recover from phytotoxic stress.

If weed pressure is light, a single early-season application of propanil may be all that is necessary in order to ensure an adequate height differential between the rice and the weeds so that the permanent flood will effectively control weed growth. If the opportunity to spray early was missed, a single late-season "salvage" application can be helpful. Since late-season propanil applications must be at the lower rate, it is essential that the permanent flood be established within 24 to 48 hours after herbicide application in order to achieve satisfactory control of large weeds.

Halosulfuron (Sandea) can provide good control of yellow and purple nutsedge. The nutsedge species are among the most common weeds found in Florida rice. Halosulfuron can be applied from planting until field flooding, and it can be tank-mixed with propanil to control grassy weeds. Some propanil formulation labels indicate any propanil tank-mixture is done at the user's risk due to the possibility of reduced control or increased injury; consult the propanil label for specific information.

Table 1. Weed management in rice.

Trade Name and Broadcast Rate/Acre of Commercial Product	Common Name and Broadcast Rate/Acre of Active Ingredient	Remarks
Aim EC (1.6 - 3.2 fl. oz)	carfentrazone-ethyl (0.025 - 0.05 lb)	Preflood/Postemergence: Best control is obtained when applied to weeds less than 4" in height. Apply when rice is at the 2-leaf stage or larger, but prior to flooding. Use a nonionic surfactant at 0.25% v/v or crop oil at 0.5-1% v/v for greater activity. Some temporary leaf spotting (speckling) may occur after treatment. Excellent control of pigweeds and suppression of redstem, alligatorweed, and Texasweed.
Aim EC (1.6 - 6.3 fl. oz)	carfentrazone-ethyl (0.025 - 0.1 lb)	Postflood/Postemergence to exposed weeds: Apply to rice and weeds after permanent flood and when 80% of the foliage of the weeds is exposed. Use 0.25% v/v nonionic surfactant or 0.5-1% v/v crop oil concentrate. Apply when rice is at 2-leaf stage or later before internode elongation.
Bolero 8 EC (4.0 pt)	thiobencarb (4.0 lb)	Preemergence control of grasses and broadleaf weeds. Soil must be moist at application. Apply as soon as possible after planting and following a post-planting flushing if soil is dry.
Stam 4E (2.0 - 3.0 pt) (early application) or Stam 80 EDF (1.25 - 1.88 lb)	propanil (1.0 - 1.5 lb)	Early application is 1-2 leaf stage of rice. Contact herbicide activity on grasses and broadleaf weeds.
Stam 4E (1.0 - 1.5 pt) (late application) or Stam 80 EDF (0.63 - 0.94 lb)	propanil (0.5 - 0.75 lb)	Application at the 3-4 leaf stage is not recommended because of phytotoxicity. Late application is 5-6 leaf stage of rice in combination with the application of permanent flood.
Stam 4E (2.0 - 3.0 pt) or Stam 80 EDF (1.25 - 1.88 lb) **+** Bolero 8 EC (3.0 - 4.0 pt)	propanil (1.0 - 1.5 lb) **+** thiobencarb (3.0 - 4.0 lb)	See previous remarks for compounds used individually. Apply at the 1-2 leaf stage of rice. Soil must be moist at application.
Basagran (1.5 - 2.0 pt)	bentazon (0.75 - 1.0 lb)	Best control with early application. Yellow nutsedge (4-6 leaf) may be controlled with the lower rate. Also can provide some control of dayflower and redstem. Higher rates needed for larger yellow nutsedge. May be tank-mixed with Stam 4E for mixed weed populations. Continuous agitation is necessary.
Londax (1 - 1.66 oz)	bensulfuron-methyl (0.0375 - 0.0626 lb)	Best control is obtained when applied early postemergence to small, actively growing weeds. Can be applied to flooded rice; see label for specific requirements. Controls Mexicanweed, Texasweed, and yellow nutsedge. Can suppress growth of alligatorweed. Does not offer control of most grassy weeds, but can be tank-mixed with propanil to enhance weed control spectrum.

Table 1. Weed management in rice.

Regiment (0.4 - 0.57 oz)	bispyribac-sodium (0.02 - 0.0285 lb)	Most effective when applied early postemergence to small, actively growing weeds, but after rice is at the 3-leaf stage. Can be applied before or after establishment of a flood. Provides excellent control of barnyardgrass. Can suppress growth of Texasweed, Mexicanweed, and alligatorweed.
Prowl 3.3EC (1.8 - 2.4 pt)	pendimethalin (0.75 - 1.0 lb)	May be used as a tank-mix with propanil as very early postemergence application in drill-seeded rice. **DO NOT USE ON MUCK SOILS. DO NOT USE ON SANDS FOR DELAYED PREEMERGENCE**. Controls barnyardgrass, junglerice, and sprangletop.
Ultra Blazer (0.5 pt)	acifluorfen (0.125 lb)	For use as a postemergence application for hemp sesbania control. Apply from late tillering up to early boot stage of rice. Do not apply after boot stage. Use an 80% nonionic surfactant at 0.125-0.25% v/v in spray mix. Can be tank-mixed with propanil.
Sandea (0.75 - 1.33 oz)	halosulfuron-methyl (0.035 - 0.0623 lb)	Provides control of purple and yellow nutsedges. Also provides some control of redroot pigweed, common ragweed, and several other broadleaf species; see product label for details. When applied alone, Sempra may be used for postemergence weed control from prior to the emergence of rice until field flooding occurs. Do not apply within 28 days of harvest. Add an 80% active nonionic surfactant at 0.25-0.5% v/v or a crop oil concentrate containing at least 14% emulsifiers at a rate of 1% v/v.