

Directions for Management of Annual Grasses in Lowland Rice

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Some of the most frequently encountered annual grasses of rice in rain-fed and irrigated lowlands include: *Acroceras amplexans*, *Cenchrus echinatus*, *Dactyloctenium aegyptium*, *Digitaria horizontalis*, *D. longiflora*, *Echinochloa colona*, *E. crus-galli*, *E. crus-pavonis*, *E. obtusiflora*, *Eleusine indica*, *Eragrostis japonica*, *E. tenella*, *E. tremula*, *Ischaemum rugosum*, *Leptochloa caerulea*, *Oryza barthii* (wild rice), *O. glaberrima* (weedy rice), *O. sativa* (weedy rice), *O. rufipogon* (annual/perennial), *Panicum laetum*, *P. laxum*, *P. antidotale* (syn. *P. proliferum*; annual/perennial), *P. subalbidum* (annual/perennial), *Rottboellia cochinchinensis*, *Setaria pumila* and *Sorghum arundinaceum* (annual/perennial).

Annual weed species depend on seed production and seed dissemination for their distribution and persistence (Zimdahl, 2007). Hence control strategies, in particular strategies aiming at reducing future infestations, should aim at avoiding seed production and dispersal (Johnson, 1997). The most effective way to avoid seed production is to target the weeds before flowering. They should be physically removed, by hand or hoe, or killed by effective, lethal doses of the right choice of herbicide at the right time (e.g. Wopereis et al., 2007, Rodenburg and Johnson, 2009, Ampong-Nyarko, 1996). Suitable herbicides for annual grasses in lowland rice are listed in Table 1.

On the short term, within a cropping season, recruitment from the existing seed bank should be avoided. This can be achieved by applying pre-emergence herbicides (see Table below), or by ploughing the soil such that seeds are buried to depths from where they cannot germinate anymore. The latter principle was experimentally shown for species like *Echinochloa colona*, *Eleusine indica*, *Digitaria longiflora* and *Rottboellia cochinchinensis* (e.g. Chauhan and Johnson, 2009, Chauhan and Johnson, 2008a, Chauhan and Johnson, 2008b). Seed burial to depths of 8-10 cm or preventing light to reach the soil surface by using a natural or artificial mulch will help decreasing many annual grass species. The seed bank can also be actively reduced by preparing a so-called 'false' or 'stale' seed bed (Mortimer et al., 1997). The weed seed bank is reduced prior to sowing by preparing a seed bed but delaying the actual sowing/planting. Land is properly prepared, flooded and drained, then weeds are allowed to emerge for 2 weeks or so and then removed or killed (for instance using herbicides like glyphosate). After this the crop can be sown or transplanted followed by flooding. The false seed bed can be repeated a second time before the crop is sown/planted to recruit and kill more weeds. Many annual grasses are sensitive to shade (e.g. *R. cochinchinensis*, *Echinochloa* spp.), hence a dense crop stand, achieved through optimum N fertilizer applications and the use of optimum plant densities and competitive vigorous varieties (e.g. Saito et al., 2010, Rodenburg et al., 2009, Haefele et al., 2004) can contribute to their control (Ampong-Nyarko and De Datta, 1991). Early flooding can also be used to suppress annual grasses such as

Echinochloa crus-galli (Chauhan and Johnson, 2010). *Echinochloa crus-pavonis* favours flooded conditions but *E. crus-calli* and *E. colona*, as well as many other annual grasses, can be controlled by early and prolonged flooding (Johnson, 1997). A 10-20 cm flood layer can effectively control many annual grasses. This requires however good land preparation, including bunding and levelling (Rodenburg and Johnson, 2009). Annual wild rice species such as *Oryza barthii* do not germinate when their seeds are buried in flooded or water-saturated soils (Ampong-Nyarko and De Datta, 1991). As many annual grasses resemble the rice crop (e.g. *Echinochloa* spp., *Oryza barthii*) their control also requires the use of clean rice seeds and careful selection at transplanting, while seed multiplication during the off-season should be prevented by off-season cuttings, rogueing or tillage (e.g. Delouche et al., 2007). Hand rogueing of any initial infestations can prevent them from becoming more serious later in the season (Johnson, 1997). In general, hand-weeding at 2-3 well-timed weeding passes prior to crop canopy closure is an effective, albeit time and energy consuming, control method that reduces competition in the season as well as the build-up of future weed populations across seasons. The crop's competitiveness can also be increased by transplanting given the rice plants a time advantage over the weeds (see references in: Rodenburg and Johnson, 2009). Transplanting in rows will also facilitate distinguishing the rice from the look-a-like grass weeds such as wild rice (Ampong-Nyarko and De Datta, 1991), and mechanical weeding operations for instance with push-weeders (a.k.a. rotary hoes). The most effective weed-control can be achieved when the rice is transplanted in a 5-cm water layer, drained for 2-3 days directly thereafter and flooded again to at least 5 cm until about 2 weeks before maturity with a gradual increase of the water level to 10 cm (e.g. Wopereis et al., 2007). Crop rotations, in particular with a dicot (crop species other than cereals) can reduce many typical rice weeds in particular the annual grasses, such as *Echinochloa* spp. and *Rottboellia cochinchinensis* (Ampong-Nyarko and De Datta, 1991), as it enables the use of selective herbicides against grasses, easier detection of the weeds (due to clear morphological differences with the broad-leaved rotation crop) and the rotation crop can out-shade some of the weeds that have a specific competitive advantage over rice.

Table 1 Suitable herbicides for grasses in rain-fed and irrigated lowland rice

Common name	Example of product	Rates (kg a.i. ha ⁻¹)	Timing
• bifenox	As a mixture= Foxpro D	1.5-2.4	Pre
• butachlor	Machete	1.0-2.5	Pre/early post
• dymrone (K-223)	Dymrone	3.0-5.0	Pre
• glyphosate	Round-up	1.5-3.0	Pre/post
• molinate*	Ordram	1.5-4.0	Pre/early post
• oxadiazon**	<ul style="list-style-type: none"> • Ronstar 25EC • Ronstar 12L 	0.6-1.5	Pre/early post
• pendimethalin***	<ul style="list-style-type: none"> • Stomp 500 • Prowl 	0.5-1.5	Pre
• piperophos****	Rilof 500	0.5-2.0	Pre/early post

• pretilhachlor + ○ dimethametryne	Rifit extra 500 EC	1.5/0.5	Pre
• propanil*****	• Stam F34 • Propanil • Surcopur • Rogue	2.5-4.0	Early post
• quinclorac	Facet	0.25-0.5	Pre/post
• thiobencarb*****	Saturn	1.5-3.0	Pre/early post

* Known exception is *Ischaemum rugosum*

** Exception is *Oryza barthii*

*** Exceptions are *Oryza barthii*, *Rottboellia cochinchinensis*

**** Exception is *Eleusine indica*

***** Exceptions are *Oryza barthii* and *Rottboellia cochinchinensis*

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