controlled it very well each year in every water treatment.

Smallflower umbrellaplant (table 1) responded well to water depth, with the poorest control achieved in the shallow and late drain treatments without herbicides. Bentazon also provided poor control in shallow and drained plots, so these treatments may stimulate the development of smallflower umbrellaplant and reduce the efficacy of herbicides.

Redstem ratings were only slightly lower (table 1) in deeper water than in shallow and drained treatments. Bentazon gave nearly complete control in all water treatments. Water depth is not critical in managing this weed, although it may be some help.

Ducksalad is a common rice weed that may have dense growth in open water areas, but because of its short stature it competes poorly in normal-density rice stands. Though ducksalad responded slightly to increasing water depths the first year, domination by more competitive weeds in later years rendered multiyear ratings less meaningful (table 1). Overall, ducksalad did not show any strong response either to water depth or to drainage. Bentazon provided only partial control of ducksalad in all water treatments, and there was no interaction of water and herbicide.

An increased water depth suppresses some rice weeds more than others. As measured by visual ratings, barnyardgrass, watergrass, and smallflower umbrellaplant are strongly affected, redstem species are slightly to moderately affected, and ducksalad and roughseed bulrush are slightly or not at all affected by an 8-inch continuous water depth treatment. Other common rice weeds noted in the study were sprangletop (strongly affected) and California arrowhead (slightly or not at all affected).

Increasing water depths also increased the herbicide's efficacy on watergrass and smallflower umbrellaplant. Conversely, shallow water and drainage increased the severity of weed infestations and reduced herbicidal efficacy. Bentazon activity against roughseed bulrush, redstem, and ducksalad was not influenced by water treatments.

Rice growth and performance

The combined potential for stand loss, slow emergence, and weak rice plants make rice growers dislike deep-water culture. In standing water, growth is always stressful during seedling establishment, and deep water can jeopardize the crop. It is important, then, to determine a safe limit for water

Water management effects on rice weed growth

Weed growth measurements taken in 1986 from the no-herbicide side of the study described in the companion article support one of the project's main findings — that water management can be an important tool for weed control. Early in the season, we collected 20 weeds every week from each water treatment and measured them for height and top biomass. Late-season measurements were less frequent. Biomass is reported in order to show the effects of different water regimes on weed growth.

In the early season, biomass of all weed species except roughseed bulrush decreased significantly as the depth of the water increased (fig. 1). The trend of decreasing biomass with increasing water depth was generally consistent for all weed species and sampling dates. Even though we measured some large differences in biomass, the high degree of variability made it hard to show significance in some cases.

Deep water effectively suppressed weed growth early in the season, while shallow water enhanced it. In deep water, weeds were generally smaller, and in some cases they appeared weak. Those in shallow water were larger and appeared to be vigorous and competitive.

Deep water suppressed the growth of some weeds more than others. Smallflower umbrellaplant and watergrass were affected the most by deep water, while roughseed bulrush was affected the least. In deep water, smallflower umbrellaplant biomass was 72 and 90% less than in shallow water (P = .05) at 34 and 41 DAP, respectively, and watergrass biomass was reduced by more than 80% (P = .05) at 27 DAP. Even though roughseed bulrush tended to have less biomass in deeper water, the differences were not significant.

Redstem and ducksalad were intermediate in their reaction to water depth. Redstem biomass was 46 and 50% less in deep water than in shallow (P = .05) at 27 and 55 DAP, respectively, while ducksalad biomass was 34% less (P = .05; 34 DAP).

The presence of a mixture of two watergrass species, *Echinochloa oryzoides* and *E. crus-galli*, each with a different growth habit and a different response to water depth, confounded the watergrass growth measurements.

Late-season weed biomass decreased for most weed species as water depth decreased. This trend is the opposite of the early season pattern, and probably results from the greater density and height of watergrass that grew in shallow water.

Late drainage (20 to 30 DAP) enhanced the growth of smallflower umbrellaplant, watergrass, and redstem, as compared to the comparable continuously flooded treatment. These species had significantly more biomass at 27 DAP. The differences in growth help explain the reduced control of smallflower umbrellaplant and watergrass in the late drain treatment.

The effects of water depth and drainage on the growth of smallflower umbrellaplant, watergrass, and to a lesser extent redstem, explain the differences in weed control that we observed. The impact of these water management practices on other weed species is apparently transitory or insufficient to materially effect weed control.

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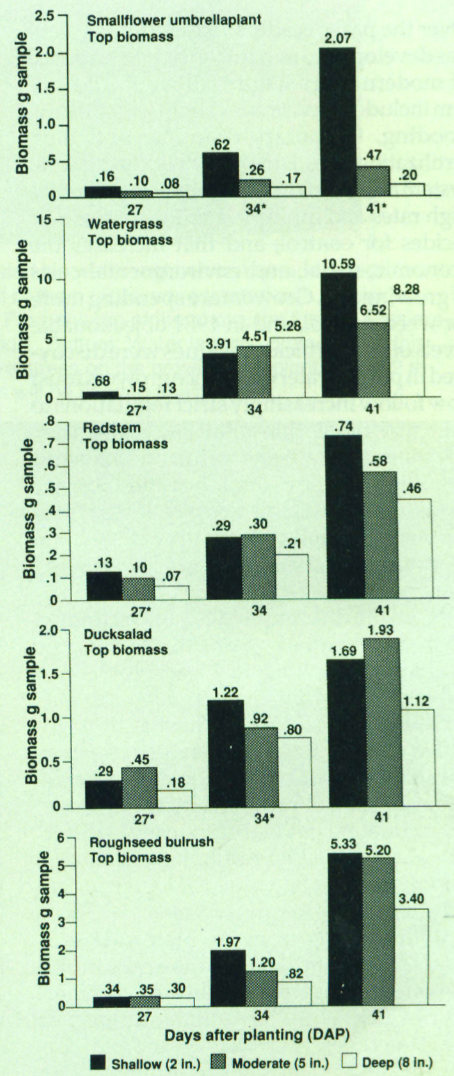

Fig. 1. Early season water depths have varying effects on different weeds (* denotes significant difference [P = .05] among depths).