Red rice control in rice [On-line]

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Summary: Several experiments were carried out in Italy to test red rice control methods in rice pre- and post-planting.
In rice pre-planting and in pre-emergence of the weed the mixture of dimethenamid + pretilachlor (1.25+ 0.64 kg a.i./ha) in flooded soil gave the best results and prevented red rice germination by about 90%. The results of the experiments carried out to control red rice in rice pre-planting and in post-emergence of the weed showed that minimum tillage and good soil moisture conditions favoured red rice emergence, creating the best conditions for post-emergence control, while ploughing and flooding remarkably affected weed germination. Harrowing or shallow ploughing were significantly less effective than chemical treatment with dalapon to control red rice seedlings. Some experiments also showed that cycloxydim (0.95 kg a.i./ha) and clethodim (0.28 kg a.i./ha) were as effective as dalapon, and indicated the possibility of replacing this herbicide at much lower dosages.
Red rice control in crop post-planting was studied by testing the efficacy of the cutting equipment and the wiping bar. The interventions at 9 days from the flowering of red rice panicles with the double pass of the cutting equipment or the application of glyphosate (7.2 % a.i. concentration) and cycloxydim (4% a.i. concentration) affected the viability of red rice seeds by more than 90%.

Introduction

Known since the last century, red rice (*Oryza sativa* L. var. *sylvatica*) started to spread significantly after the shift from rice transplanting to direct seeding. Weed infestations became very severe in European countries about 15 years ago, mainly because of the cultivation of weak, semidwarf indica-type varieties, the planting of commercial rice seeds containing red rice grains and the difficulties involved in controlling the weed in rice fields (Tarditi and Vercesi, 1993; Ferrero and Finassi, 1995; Ferrero *et al.*, 1996; Ferrero and Vidotto, 1997).

Red rice is a weedy biotype of cultivated rice (*Oryza sativa* L.) which can be distinguished from the crop only after tillering mainly because of the taller and slender plants, higher tillering and greener leaves. Weed grains show a red pigmented pericarp that requires an extra milling, which results in broken grains and grade reduction (Baker *et al.*, 1986; Coppo and Sarasso, 1990; Kwon *et al.*, 1992). At maturity, most seeds break off shattering onto the soil before crop harvesting thus allowing the weed to disseminate and feed the soil seed bank (Smith, 1981; Diarra *et al.*, 1985a; Diarra *et al.*, 1985b). Shattered grains can also persist in the soil in a dormant condition, remaining viable for more than 2 years (Ferrero and Vidotto, 1997).

The main weed control strategies that are applied by rice growers are those of the planting of clean seeds, chemical or mechanical control of weed seedlings before rice planting (e.g. with the false seeding technique) or after (e.g. by cutting the panicle) and rotation (Parker and Dean, 1976; Tarditi and Vercesi, 1993; Català, 1995; Ferrero and Vidotto, 1998; Vidotto *et al.*, 1998). The successful application of these measures greatly depends on the cultural conditions and the eco-physiological characteristics of the weed. The knowledge of red rice dormancy and seed bank evolution is, for example, essential in order to choose the type and the length of the rotation as well is the depth of germination in order to establish the kind of tillage to be adopted. It has been seen, for example, that minimum tillage operations favour the germination of red rice seeds which are buried in the upper soil layers, while mouldboard ploughing remarkably reduces weed emergence.

Red rice control in crop pre-planting has been studied with several experiments carried out in the framework of the 3-year project funded by E.U. Commission, named “Biology and control of red rice (Bicorer).

I – Control in rice pre-planting

1. Red rice pre-emergence

This technique normally represents the best management system of the weed, as it does not require any delay in rice planting or choice of early or short varieties, and relies mainly on the use of pretilachlor, an antigerminative herbicide that is, at present, the only herbicide authorised in Italy, for this kind of application. Pretilachlor shows a variable performance in relation to the soil characteristics and weather conditions but its efficacy against the weed does not commonly exceed, on average, 50% of the germinable seeds.

A two-year research was carried out in Italy to find herbicides more effective than pretilachlor in pre-emergence red rice control. The following treatments were tested: pretilachlor (1.5 kg a.i. ha^{-1}), pretilachlor + dimethenamid (1.25+0.64 kg a.i. ha^{-1}), dimethenamid (0.96 kg a.i. ha^{-1}) and fluthiamide (0.7 kg f.p. ha^{-1}). Treatments were carried out on soils flooded with 5-7 cm of water. Inlet and outlet floodgates were kept closed for 5 days after the treatments and rice was planted 25 days after the treatment.
As reported in Figure 1 the mixture of pretilachlor + dimethenamid showed good and constant results (83% efficacy) while the activity of pretilachlor was quite lower (46% efficacy). Temporary phytotoxic effects on the crop were observed in the plots treated with pretilachlor + dimethenamid. These phytotoxicity symptoms were no longer visible at the stem elongation stage of the crop.

2. Red rice post-emergence

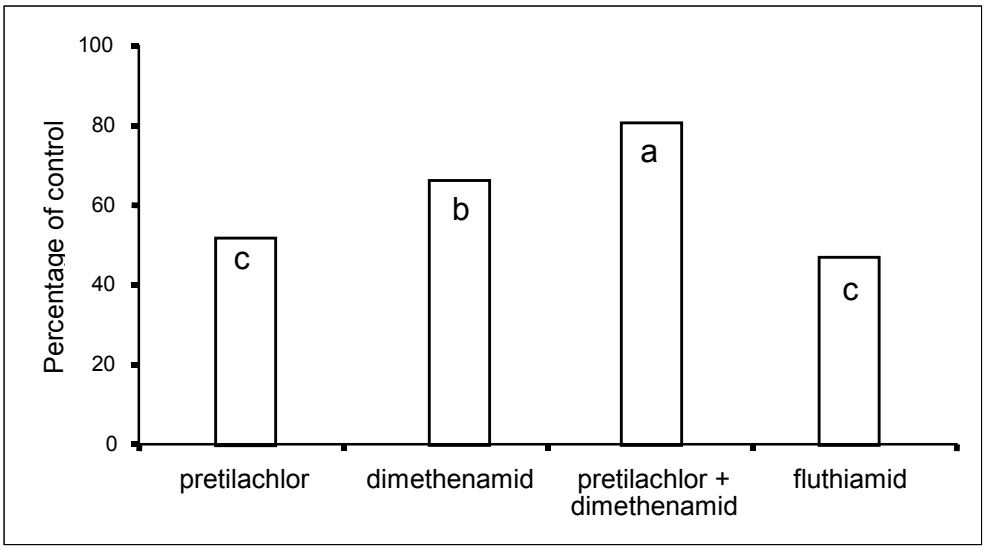
In Italy red rice control in post-emergence is mainly performed in combination with the stale seed bed technique. This practice, commonly known as “false seeding”, results to be applicable only if weather conditions allow the weed to reach the 2-3 leaf stage in the first ten days of May, in order to be in a position to plant an early and still profitable variety.

Cultural practices are primarily represented by early seed bed preparation, followed by field flooding to stimulate red rice germination, and a weed control treatment. Control of red rice seedlings can be performed either mechanically by harrowing or by the application of non residual systemic herbicides, 2 days before rice planting. After weed destruction the soil is regularly flooded and planted, in 2-3 days, with early varieties (e.g. Loto, Selenio, etc.). The most used herbicide in Italian conditions for this kind of application is Dalapon which requires high dosages (10-13 kg a.i ha^{-1}) and raises environmental concerns.

The success of this strategy is strictly related to the accuracy and timeliness of interventions and greatly depends on the knowledge of the biological behaviour and dynamics of red rice growth in the field. It is very important for this reason to apply appropriate tillage operations and maintain soil humidity which can favour seed germination.

The results of several studies showed that there is a good relationships between red rice emergence and red rice seed bank according to the soil tillage which is adopted. Red rice emergences counted after seed bed preparation with normal mouldboard ploughing and minimum tillage (harrowing) were about 2.5 and 7%, respectively of the number of seeds present in the 0-10 cm layer (Fig. 2) (Ferrero et al., 1996; Ferrero & Vidotto, 1997).

Figure 1. Efficacy of herbicides applied in red rice pre-emergence



Abundant and contemporaneous emergences occurred with good soil moisture conditions but were greatly affected by continuous flood. Red rice seeds placed in the upper soil layer (0-1 cm) germinated for 50% when the soil was continuously kept moist, and 18% when the soil was submerged under 2-3 cm of water. Both in moist and flooded soil conditions there was an emergence reduction according to the increased depth of the seeds. Germination at 4-5 cm depth was only 8% in the moist soil and nil in the flooded soil (Fig. 3).

When adopting the stale seed bed technique it is then advisable to favour red rice germination by applying minimum tillage for seed bed preparation and maintaining the soil wet till control operations.

Many studies were carried out to test the efficacy of mechanical means and herbicides on red rice seedlings.

The equipment used to control mechanically red rice were harrow fitted with curved knives, with several elements adjusted to operate only at a depth of 6-8 cm.

The comparison between the mechanical instruments and dalapon, the main herbicide applied for red rice control at 12.75 ka a.i. ha^{-1}showed, in general, a better performance of the chemical means. Harrow and mouldboard plough gave a red rice control ranging from 73 to 91% and from 69 to 86%, respectively, while dalapon always showed an effectiveness higher than 92%.

The use of mechanical tools had a remarkable influence on soil seed bank evolution.

After 2 years, the seed bank varied considerably according to the treatments (Ferrero et al., 1999). In the ploughed plots, the number of seeds decreased to 14% of the initial value; the harrowing roughly maintained stable the seed bank; dalapon, despite its good activity determined a seed bank increase of about 1.6-fold. In the untreated plots, the number of red rice seeds in the soil increased by about 10 folds. The unexpected seed bank reduction in the plots subjected to shallow ploughing was probably related to a delay of development and ripening of the red rice plants which emerged after the treatment. For this reason most red rice seeds did not shatter and were harvested with the paddy.

Figure 2. Red rice emergences from seed bank in relation to the soil tillage for seed bed preparation

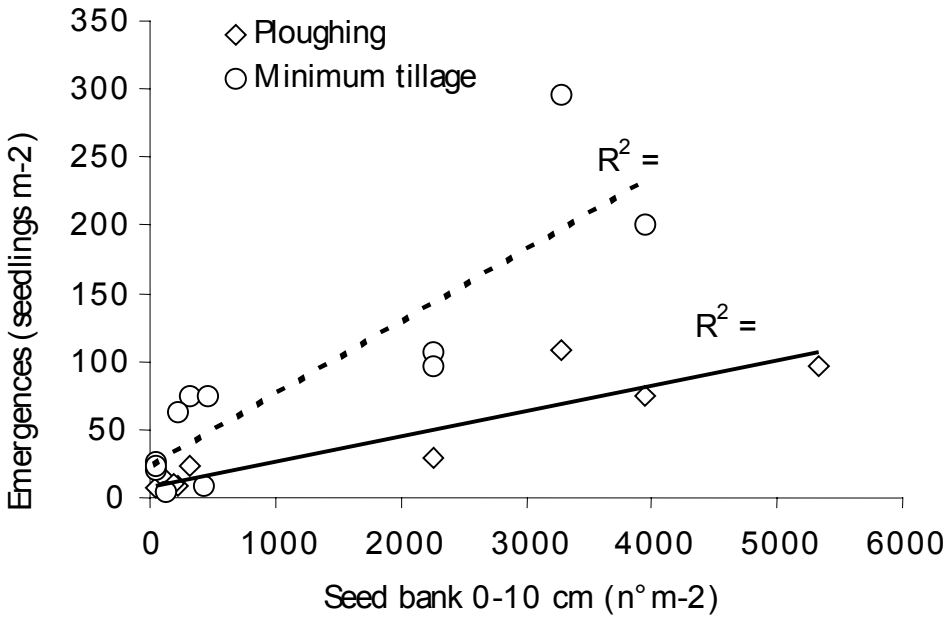
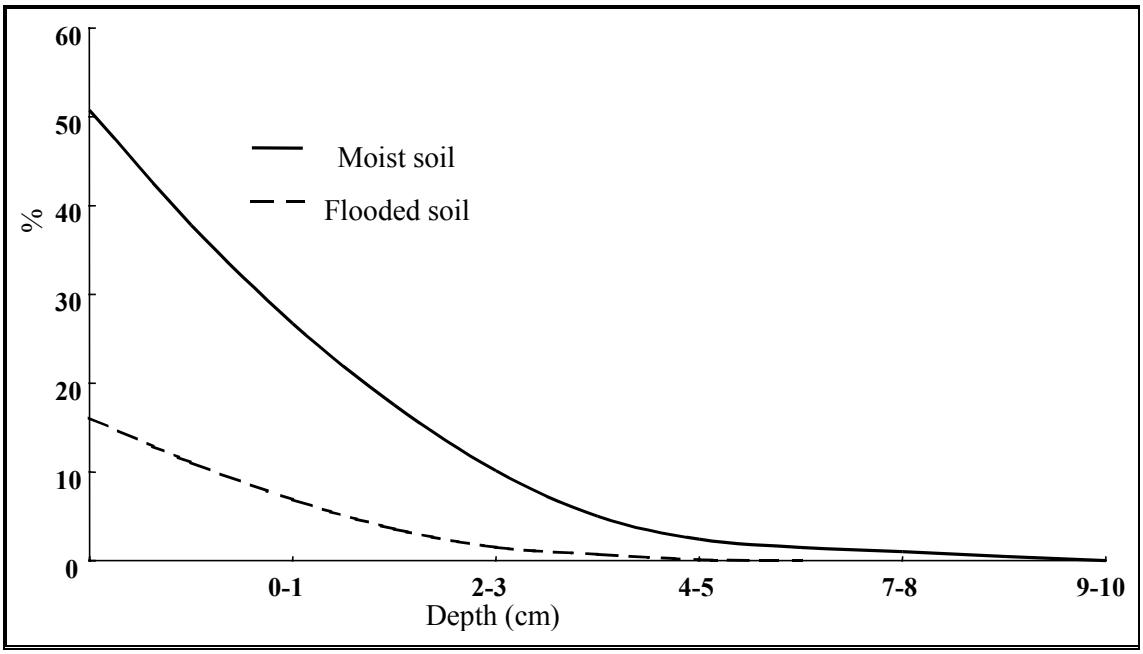
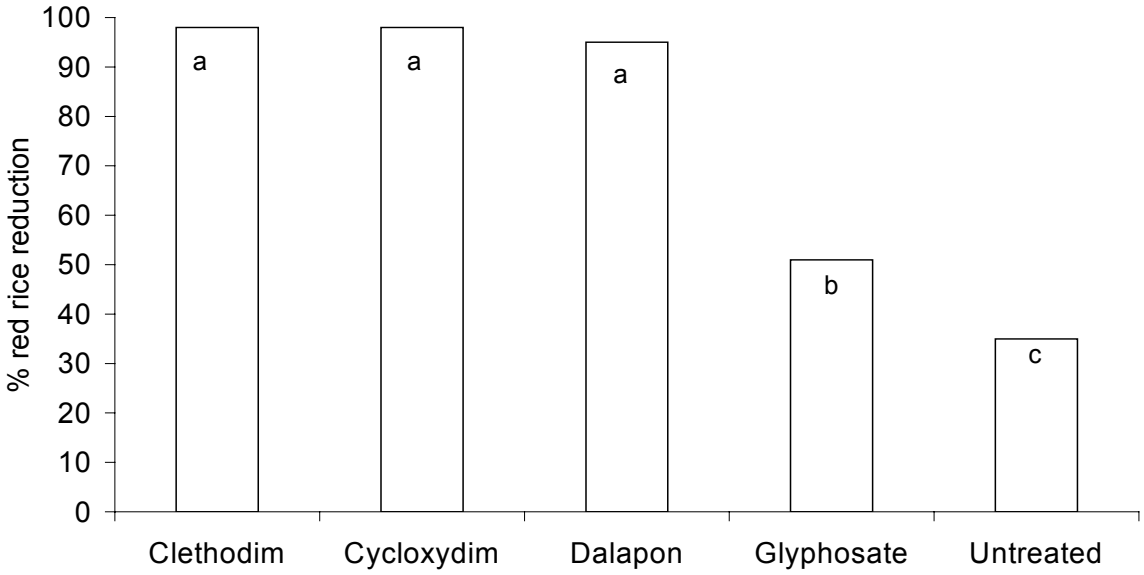


Fig 3. Percentage of red rice emergences in relation to different seed depth into the soil and water conditions



A study carried out from 1996 and 1998 for red rice control at 2-3 leaf-stage showed that graminicides such as cycloxydim and clethodim applied at 0.95 and 0.28 kg a.i. ha^{-1}, respectively, were more effective than dalapon at 12.75, while glyphosate isopropylammo-nium at 1.26 0.28 kg a.i. ha^{-1} gave an insufficient activity in the control of the weed. (Fig. 4).

Figure 4. Percentage of red rice reduction of different herbicides applied at 2-3 leaf stage of the weed



II – Control in rice post-planting

Red rice control in post-planting mainly relies upon the cultivation of short size varieties in order to allow panicle cutting or the localised application of systemic herbicides. Both systems need to be applied at the complete growth in height of the plant but prior to shattering or the acquisition of seed germinability. On this purpose several experiments were carried out to assess the acquisition of shattering ability and germinability after flowering in order to establish the appropriate time to control the weed in post-emergence by means of panicle cutting or systemic herbicides, applied with wiping bar equipment.

It was apparent from these studies that red rice seeds started to become viable at 9 days from the beginning of flowering with a germinability of about 20% (Fig. 5) (Ferrero & Vidotto, 1998 a and b). This value increased quickly and already reached about 85% at 12 days after flowering (DAF).

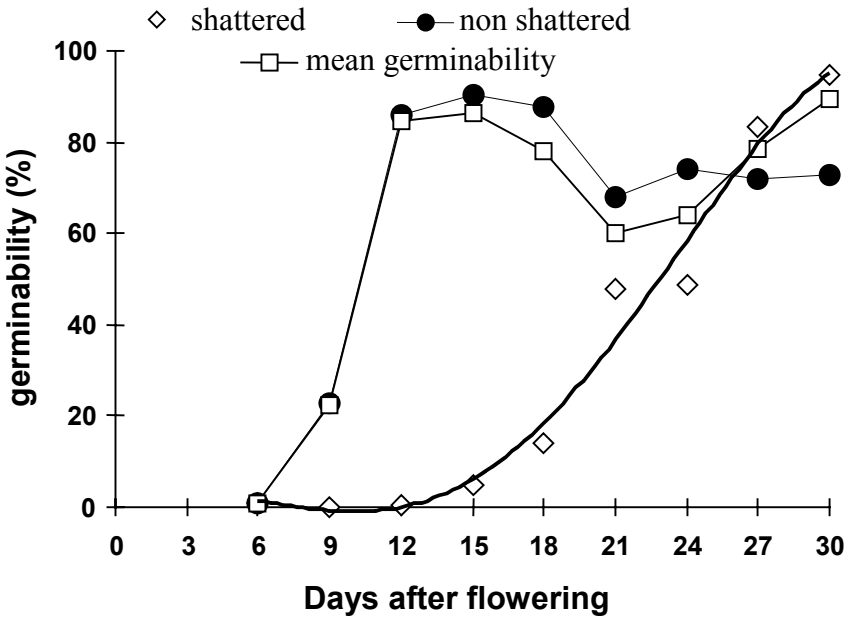
The shattered grains showed a lower germinability till 24 DAF in comparison to that of the non-shattered ones. From this time on, the germinative capacity of the two groups of seeds was different. In particular, the germinability of the shattered seeds was very low during the first 15 DAF, with a maximum value of about 5%.

This behaviour can most likely be explained by the incomplete development of the first shattered grains, which broke off mainly because of environmental causes (wind).

The shattering that occurred after 15 DAF concerned more filled and physiologically mature grains.

The knowledge of this behaviour allows one to establish the appropriate time to control the weed in post-emergence by means of panicle cutting or systemic herbicide application with wiping bar equipment which prevents grain dropping or germination. The application of both control systems relies on the cultivation of short height varieties in order to allow the control of the taller weed culms.

Figure 5. Germinability in percentage of shattered, non-shattered and mean of shattered and non-shattered red rice seeds in relation to the days elapsed after flowering



Several experiments were carried out to assess the efficacy of the cutting equipment and wiping bar. Best results with the weed cutting (94% of the panicle reduction) were obtained carrying out a double pass of the equipment fitted with roll crushers. The first pass was performed prior to the 10 days from flowering initiation and the second one 20 days after, in order to control panicle re-growths.

Red rice control by means of systemic herbicides in rice post-emergence is based on the use of moistening bar equipment mounted on a self-moving machine. The machine is equipped with a 6 m long bar covered with a spongy carpet, which is maintained saturated with the herbicide solution through natural drops from a tank positioned above. Good results were obtained by using a solution containing glyphosate or cycloxydim at 12.6 and 4 % a.i., respectively. The experiments carried out for 3 years showed for both herbicides a germinability reduction of red rice seeds by about 95%.

The results obtained with cutting or wiping bar equipments anyway could not avoid the selection of short size biotypes which would escape the control by these means in the following years.

Conclusions

The techniques applied to control red rice in crop pre- and post-planting resulted noticeably influenced by the agronomic practices applied during crop management.

The mixture of dimethenamid + pretilachlor was able to prevent red rice germination when was applied on soil maintained flooded for about 1 month, from before herbicide application to the crop planting.

The results of the control in weed post-emergence, when applying the stale seed bed technique were greatly influenced by the soil tillage adopted for seed bed preparation and soil moisture during weed germination. Minimum tillage and good soil moisture conditions favoured red rice emergence, creating the best conditions for post-emergence control, while ploughing and flooding remarkably affected weed germination. Seed bed preparation with ploughing can be considered helpful as an agronomical control measure where direct weed control means are not planned. Chemical means were more effective than mechanical interventions in post-emergence control of red rice, in combination with stale seed bed technique.

Among the tested herbicides, cycloxydim and clethodim were as effective as Dalapon, and showed the possibility of replacing this herbicide at much lower dosages.

Mechanical and chemical means were also applicable for red rice control in crop post-planting. In this case both control systems have to be carried out within 9 days from the flowering of red rice panicles as from that time onwards the weed seeds start to be able to shatter and germinate. A double pass with the cutting equipment fitted with roll crusher or the application of glyphosate or cycloxydim with a moistening bar reduced by about 95%. the potential increase of the seed bank due to the shattering of the weed seeds.

The post-planting interventions should be considered as means complementary to other measures of red rice control, as they can be applied when red rice competitive effects towards cultivated rice have already occurred.

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