Paper 25

[Accueil] [Remonter] [Intro 1] [Paper 2] [Paper 3] [Paper 4] [Paper 5] [Paper 6] [Paper 7] [Paper 8] [Paper 9] [Paper 10] [Paper 11] [Paper 12] [Paper 13] [Paper 14] [Paper 15] [Paper 16] [Paper 17] [Paper 18] [Paper 19] [Paper 20] [Paper 21] [Paper 22] [Paper 23] [Paper 24] [Paper 25] [Paper 26] [Paper 27] [Paper 28] [Paper 29] [Paper 30] [Paper 31] [Paper 32] [Paper 33] [Paper 34] [Paper 35] [Paper 36] [Paper 37] [Paper 38] [Paper 39] [Paper 40] [Paper 41] [Paper 42]

Influence of the rotation on seed bank evolution of red rice (Oriza Sativa [l] Var Sylvatica)

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Abstract

Two experiments were carried out near Vercelli over the 1993-1997 period to evaluate the influence of different management methods on rotational crops in a red rice seed bank. In experiment 1, the rotation was rice-rice-soyabean-rice. In the 2 years of rice cultivation, two red rice management conditions were considered : chemical control with dalapon at 13 kg ha^{-1} a.i. in pre-planting and no-control. Soyabean was planted in the seedbed which had been prepared with a minimum tillage and treated in post-emergence against red rice with cycloxydim at 1.5 L ha^{-1}. In the fourth year, rice was again planted and the red rice was controlled over the whole surface with dalapon at 13 kg ha^{-1} a.i., in pre-planting. In experiment 2, the rotation was rice-soyabean-rice. In the first and third years of rice cultivation the red rice was controlled with dalapon at 13 kg ha^{-1} a.i., in pre-planting. Three treatments were compared for the soyabean :a) mouldboard ploughing and planting in April ; b) harrowing and planting after red rice emergence at the end of May ; c) no-tillage, glyphosate treatment after the red rice emergence and planting at the end of May.

After 2 years of rice cultivation the seed bank of the dalapon-treated plots increased by about 65% in the 0-10 cm, and by 20% in the 10-20 cm layers. In the untreated plots, the seed bank increased by about 10 fold both in the 0-10 and 10-20 cm layers. After the soyabean cultivation, the red rice seeds sampled in the 0-10 cm layer decreased by about 97% in all the plots. In the fourth year, the residual seed bank of the 0-10 cm layer reduced in the plots which had previously been treated and untreated by about 100 and 67%, respectively.

In experiment 2, the greatest decrease in the seed reserve was recorded after the soyabean cultivation, in the plots with the minimum tillage and delayed planting, where the seed bank decreased by 99 and 75% in the 0-10 and 10-20 cm layers, respectively.

Keywords

- Rotation, red rice, seed bank, weed control
- Italy

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Introduction

The composition of weed communities in most European rice fields has, in the last decade, become quite degraded. Three main floristic scenarios represent this situation : a high presence of Echinochloa spp., the appearance of sulfonylureas resistant weeds (Alisma spp., ciperaceae) and the spread of exotic species (i.e. Heteranthera spp.) and red rice biotypes. Within the 3 groups the most troublesome weed of rice fields is undoubtedly red rice.

Known in Italy for over a century and considered, for some time, a pathological form of cultivated rice, red rice only started to cause severe infestations several years ago (Parker & Dean, 1976; Ferrero & Finassi, 1995). The spread of red rice is strictly related to several favourable conditions : the cultivation of weak, semidwarf indica-type rice varieties (Tarditi & Vercesi, 1993), the planting of commercial rice seeds containing grains of the weed and the difficulty in controlling its infestations with mechanical and chemical means in cultivated rice.

Red rice, which is botanically classified as the same species as cultivated rice (Oryza sativa L.), shows a wide variability of anatomical, biological and physiological characteristics (Craigmiles, 1978; Coppo & Sarasso, 1990; Kwon et al., 1992). Weedy biotypes can easily be distinguished from the crop above all after tillering (Hoaghland & Paul, 1978). From this stage, the weed generally shows some particular characteristics which makes it different from cultivated plants : numerous and slender tillers, hispid, light green leaves, tall plants and shattering capacity of the grains (Baker et al., 1986; Kwon et al., 1992). The caryopsis of many weedy biotypes have a pigmented pericarp, due to the presence of antocyanin, which can be removed with an extra milling that results in broken grains and grade reduction (Smith, 1981; Diarra et al., 1985a; Diarra et al., 1985b).

Weed control strategies are mainly based on a combination of prevention, cultural and chemical practices (Ghesquière et al., 1995; Tarditi & Vercesi, 1993; Ferrero et al., 1996). Preventive methods alone are often inadequate as it is difficult to obtain rice seed that is completely free from weed grains. Rotation is frequently the best way to reduce severe red rice infestation, but shows some constraints in particular environmental conditions where this practice cannot be adopted because of the presence of saline and hydromorphic soils (Sagarra, 1987; Català, 1995).

Normally the length of the rotation is established in relation to the degree of the infestation, the market of the crops used in the rotation and the farm organization. A successful application of this rotation requires the knowledge of the seed bank evolution and means, or techniques that are more suited to control the weed within rotational crops.

The objective of this research was to evaluate the influence in time of different management methods on rotational crops in a weed seed bank.

Material and methods

The study was conducted over the 1993-1997 period with 2 experiments carried out at locations near Vercelli, the heart of rice cultivation area in Italy.

Experiment 1

The research was conducted in 1993-1996 at S.Germano on a sandy-loam soil (5.6 pH, 2.4% organic matter), which has continuously been cultivated with rice under flooding conditions for 20 years.

The rotation studied in this trial was rice for two years (1993, 1994), soyabean (1995) and rice (1996), cultivated in the same plots.

In the first two years, two red rice management conditions were taken into consideration :

a) control with dalapon (13 kg ha^{-1} a.i.) before rice planting, adopting a false seeding technique;
b) no-control.

The management policies applied in practice for red rice in the cases of high and low infestation where those of chemical control and no-control.

For both management conditions the field was conventionally ploughed at the beginning of April to a depth of 20-22 cm and harrowed a few days later.

In the case of the weed control after tillage, the soil was flooded with about 2,000 m^3 of water ha^{-1} and gradually dried. In the second week of May the plots were treated with dalapon at 2-3 leaves of the weed (for both years). Two days after this treatment the field was flooded and 3 days later an early variety ("Loto") was planted.

At the beginning of the trial the field was naturally infested with a uniform density of red rice.

During the third year, soyabean was planted at the middle of May on the soil which had been prepared with a minimum tillage by means of a rotary harrow. The tillage operation was carried out immediately before planting in order to control the red rice plants which had already emerged.

During the fourth year, the field was again planted with rice. A false seeding technique was applied to control the red rice : in middle of April the field was ploughed with a light plough, harrowed, flooded to a 3-5 cm water depth and then gradually dried to favour red rice emergence. The control of the weed was carried out when the red rice was at the 2-3 leaf-stage with dalapon at 13 kg ha^{-1} a.i.

Conventional crop practices and water management were adopted in order to optimize the rice growth.

The buried seed reserve was sampled prior to the tillages of March and April by randomly taking at least 10 soil samples from each plot.

When the treatment comparison was carried out, the experimental design was that of a randomized complete block with 3 replicates. The dimension of the trial fields was 18,000 m2, divided into 6 plots (3,000 m^2 each).

Experiment 2

The research was carried out during the 1995-1997 period at Prarolo (near Vercelli). The rotation taken into consideration was rice in 1995, soyabean in 1996 and rice in 1997. The field had continuously been cultivated with rice under flooding conditions for 20 years till 1995. In 1995 the field was conventionally ploughed to a depth of 18-22 cm and then harrowed. During the year, conventional crop and water management practices were adopted in order to optimize the rice growth. In autumn, immediately after the crop harvesting and prior to any tillage operation, the buried seed reserve was sampled by randomly taken 10 samples from the field.

Soyabean was planted in 2 periods and after different soil tillage systems :
- conventional ploughing (20 cm) followed by harrowing at the end of March and planting at the middle of April;
- minimum tillage with harrowing after red rice emergence and planting at the end of May;
- no-tillage and treatment with glyphosate (2.2 L ha^{-1} a.i.) after red rice emergence and planting at the end of May.

The red rice grown in the soyabean was controlled in all the plots with an application of cycloxydim (0.6 L ha^{-1} a.i.), at the tillering stage of the weed.

The densities of the emerged weed seedling were determined in all the plots immediately before the red rice control. The seed banks were assessed in February 1997 before any tillage preparation. At the beginning of April 1997, the field was ploughed to a depth of about 20 cm and the whole surface of the trial area was immediately flooded with 2-3 cm of water for 20-25 days and, after the growth of the red rice seedlings (2-3 leaf-stage), it was treated with dalapon (13 kg ha^{-1} a.i.).

The red rice emergences were determined in each plot prior to the dalapon application, at the middle of May. The seedlings were counted in four 1x1 m quadrates in each plot.

When the treatment comparison was carried out, the experimental design was that of a randomized complete block with 3 replicates. The dimension of the trial fields was 9,000 m^2, divided into 9 plots (1,000 m^2 each).

In both experiments :

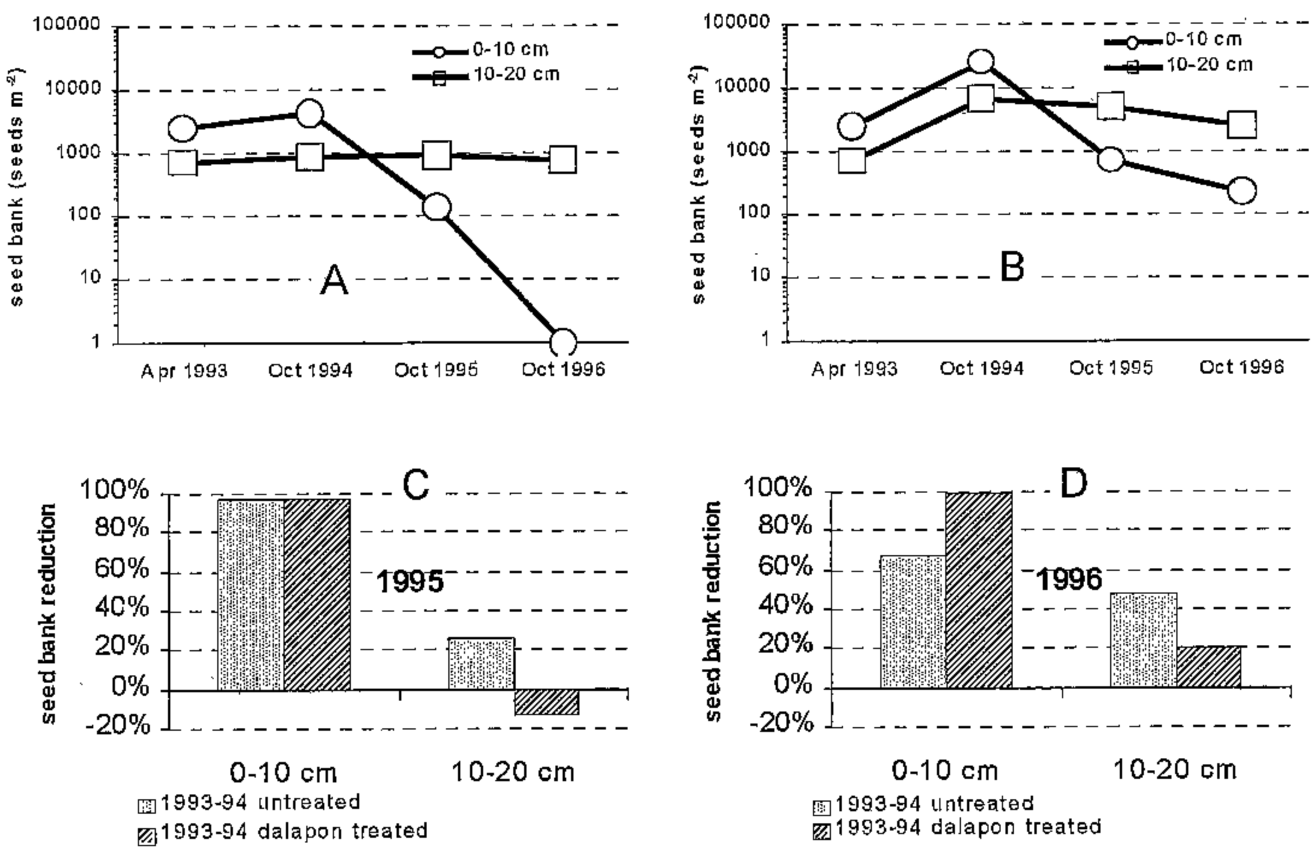
the soil samples were obtained using a sampler which gave 20 cm deep cores. Each core was divided into 2 portions of 0-10 cm and 10-20 cm, considering that only the seeds buried in the upper layer are able to emerge (Ferrero & Finassi, 1995). The soil samples were placed in plastic bags and stored at 4°C until processing. The extraction of the seeds from the soil was carried out using a high water pressure based equipment and the separation of the seeds using sieves as described by Ferrero & Vidotto (1997).

Results and discussion

Experiment 1

The number of red rice seeds counted at the beginning of the experiment was 2,504 and 686 in the 0-10 and 10-20 cm layers, respectively. After two years of rice cultivation, the seed bank varied quite remarkably according to the treatment (Fig. 1A, B; Table 1). In the plots where the weed was controlled with dalapon, the seed bank showed a slight increase in comparison to the initial value. Even with a control of about 95% of the seedlings, the seed reserve increased, for both years (data not presented), on average by 65 and 20% in the 0-10 and 10-20 cm, respectively.

Fig. 1. Experiment 1.Red rice seed bank evolution for different management systems.



A) 1993-94 rice cultivation with dalapon control, 1995 soyabean, 1996 rice;
B) 1993-94 rice cultivation without dalapon control, 1995 soyabean, 1996 rice;
C) annual decrease rate of the red rice seed bank in the 1995 soyabean cultivation and
(D) 1996 rice cultivation.

As expected, the greatest increase in the seed bank was recorded in the untreated plots, where 24,453 seeds m-2 were counted in the 0-10 cm layer (Fig. 1; Table 1).

After one year of soyabean cultivation, the seed bank in the 0-20 cm layer decreased quite remarkably both in the plots which were treated with dalapon and the plots which were untreated for the 1993-94 period (Fig. 1C). The red rice seed reserves in the soil of the untreated and dalapon-treated plots decreased by 83.5 and 78.5 %, respectively, in comparison to the values estimated before the soyabean planting. The largest reduction was recorded in the upper layer (0-10 cm), where the seed bank decreased both in the treated and untreated plots by about 97% when referring to the initial estimates. The discrepancies between the seed bank reduction in the 0-10 and 10-20 cm layers could be explained by the fact that the seeds buried at more than 10 cm were unable to germinate, as reported in previous studies (Ferrero & Finassi, 1995).

Table 1. Experiment 1. Seed bank evolution of red rice in the 1993-1996 period.

	average seed bank before experiment (seeds m^{-2})		weed management		average seed bank at the end of 1994 (seeds m^{-2})		1995	average seed bank after 1995 soyabean (seeds m^{-2})		1996	average seed bank after 1996 rice (seeds m^{-2})	
	0-10 cm	10-20 cm	1993-1994		0-10 cm	10-20 cm		0-10 cm	10-20 cm		0-10 cm	10-20 cm
20 years of rice	2,504	686	false seeding (control of red rice seedlings with dalapon)	2 years	4,125	825	SOYABEAN	133	932	RICE	1	740
			no control	2 years	24,453	6435		693	4,719		222	2442

The herbicide weed control, performed after the false seeding on the rice planted the year after the soyabean cultivation, allowed to control most of the seedlings that emerged after the seed bed preparation. As a result, the weed control determined an additional reduction of the seed bank, both in the plots with low and high seed reserves related to dalapon treatment and non-treatment in 1993-1994 (Fig. 1D). In the plots with low and high seed banks, the red rice seedlings counted before the dalapon distribution of 1996 were 23 and 141 m^{-2}, respectively. In the same plots, the plants that escaped treatment were 4.2 and 6.5 m^{-2}, respectively. These escaped plants were due to the incomplete effectiveness of the chemical weed control and the growth of the plants after treatment. The soil seed reserves sampled in the 0-10 cm layer of the plots with low and high seed banks, reduced by 100 and about 68%, respectively in comparison to the values recorded in the previous year. A slight reduction of the seed reserve was also recorded in the 10-20 cm layer. At this depth, the red rice seeds were not influenced by the shallow tillage operation and were not able to emerge from the soil. The absence of seeds in the upper layer did not justify the number of plants that escaped to the herbicide treatment which should have contributed to an increase in the seed reserve in the soil and could be explained by the great variation of the seed distribution over short distances in the considered plots. In these conditions, the irregular seed distribution was incorrectly estimated by the sampling of the buried seed reserve, because only a small soil surface was considered.

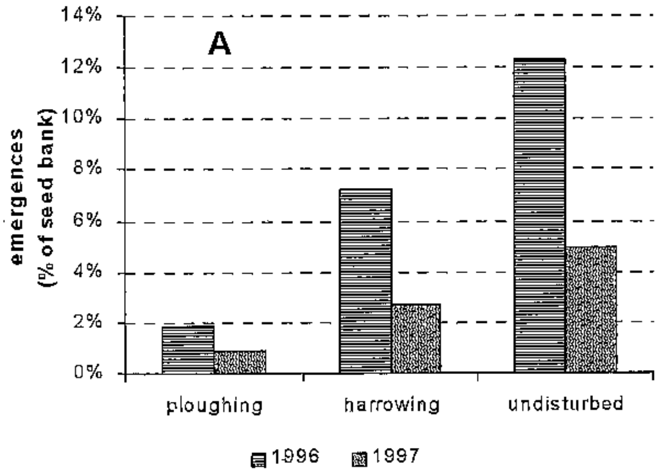
Experiment 2

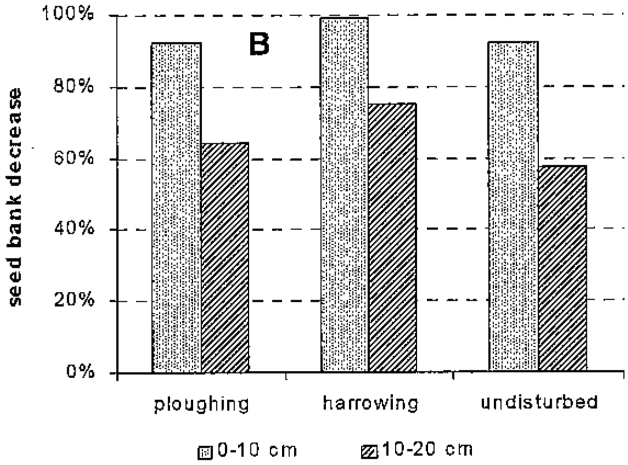
The red rice seeds buried in the 0-10 and 10-20 cm layers of the field cultivated with rice in 1995 were on average 4,958 and 715, respectively.

The emergences counted in soyabean in 1996, before the red rice control, varied remarkably according to the period of planting and the system of soil tillage (Table 2). The greatest seedling densities were recorded in the untilled plots that were planted with soyabean at the end of May. The ratios between the red rice emergences and the number of seeds buried in the 0-10 cm layer showed the following values : 12.3% in plots untilled and treated with glyphosate, 7.2% in plots harrowed and planted at the end of May and 1.8% in conventionally ploughed plots (Fig. 2 A). These results confirmed the findings of previous studies, which showed that ploughing remarkably reduced weed emergences in comparison to minimum or no-tillage (Ferrero & Vidotto, 1997).

As expected, in 1996 the lowest seed reserve after harvesting of the soyabean was detected into the soil of the plots that were subject to minimum tillage and delayed planting of the soyabean, where the greatest number of emergences was counted. In these plots the seed bank decreased by 99 and 75%, in the 0-10 and 10-20 cm layers, respectively (Fig. 2 B). The lower reduction of the seed reserve was found in the upper layer of the ploughed and untilled plots and in the deeper layer of the untilled plots. For the ploughed plots this behaviour seemed to be consistent with the low number of emergences that had previously been observed and for the untilled plots with the observation that, with a low content of oxygen, the seeds remained inactive and viable longer (data not published).

Fig. 2. Experiment 2.





A) Percentage of emergences referring to the relative seed bank (in 1997 the emergences were determined after ploughing in plots subject to different tillages of 1996);
B) seed bank decreases (as a percentage of the initial values) recorded after 1 year of soyabean.

The weed plants grown in 1997 before the rice planting were much less than those counted in the previous year for soyabean. The highest percentage of emergences for the relative seed bank was recorded in the plots which, in 1996, were kept undisturbed and showed a high seed bank in the 10-20 cm layer after the soybean cultivation. The great number of emergences counted in these plots could be due to the ploughing performed in 1997 for the rice seed bed preparation. Inversion of the top soil layer buries newly shed seeds thus stimulating their dormancy and, at the same time, returns the seeds that were buried in the previous season to near the soil surface (Moss, 1988; Knab & Hurle, 1986).

Table 2. Experiment 2. Seed bank evolution and emergences of red rice in 1995-1997

1996

	seed bank after 1995 rice (seeds m^{-2})		tillage system		emergences (seedlings m^{-2})	seed bank after 1996 soyabean (seeds m^{-2})	
	0-10 cm	10-20 cm				0-10 cm	10-20 cm
RICE (1995)	5,328 (±0.25)	518 (±1.21)	ploughing (seeding of soyabean in normal period)	SOYABEAN	97 (±0.54)	407 (±1.16)	185 (±0.85)
	7,622 (±0.62)	296 (±1.06)	harrowing (seeding of soyabean in normal period)		551 (±0.50)	74	74
	1,924 (±0.33)	1,332 (±1.02)	no-tillage (seeding of soyabean in normal period)		236 (±0.55)	148 (±0.50)	567 (±1.31)

1997

	seed bank after 1996 soyabean (seeds m^{-2})		tillage system		emergences (seedlings m^{-2})
	0-10 cm	10-20 cm			
SOYABEAN (1196)	407 (±1.16)	185 (±0.85)	false seeding (ploughing + harrowing)	RICE	3.7
	74	74	false seeding (ploughing + harrowing)		2.0
	148 (±0.50)	567 (±1.31)	false seeding (ploughing + harrowing)		7.3

Conclusion

It was apparent from this study that crop rotation provides an increased opportunity for implementing the effectiveness of red rice management strategies.

The results of this research clearly showed that chemical control of the weed seedlings before rice planting, up to now considered the most effective in rice monoculture (Ferrero & Vidotto, 1997), only prevented the infestation from becoming worse. In these conditions, even a small percentage of inefficacy, due to insufficient control or delayed emergences, can maintain or increase the original seed bank. This management strategy gave an acceptable seed bank decrease only when low infestations occurred. A great reduction of the seed bank was obtained with rotation : one year of soyabean cultivation permitted a reduction of the seed bank in the 0-10 cm soil layer of about 97%. The reduction in the same layer was still higher (99%) when soyabean was planted at the end of May, after the spring flush of weed emergence. In the soil managed with a minimum or no-tillage, red rice seed buried in the lower layer (10-20 cm) did not vary remarkably in time.

The results of this study also underlined the difficulty in assessing actual seed bank from core samples, because of the great variability of seed distribution in the soil, as previously shown by Cardina & Sparrow (1996) and Ferrero & Vidotto (1997).

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Figures and tables summary

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