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Allelopathic Effects of Wheat and Rye Straw on Some Weeds and Crops

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Abstract: In this study the effects of different rye and wheat straw treatments on weeds and on crop species were investigated under field, screen house and laboratory conditions. In field studies wheat and rye were sown for crop rotation and were incorporated to the soil in different densities at harvest time. Wheat or rye plants were incorporated to the soil in the following forms, in order to have different densities of straws: a. straw after normal harvest; b. straw of the half plant; c. straw of all plant without spike. After that plots treated with different straw applications were divided into the subplots and sown with sunflower, maize and tomato. The effect of straw treatments on weeds and crops were observed by the comparison with non treated plots. In Screen house studies pots were filled with soil-straw mixtures collected from experimental plots and the same observations as in field study were done. On the other hand, some experiments were carried out to determine the effect of the water extract of wheat and rye straws (dry rye and wheat with 10 g and fresh ones with 20 g was grinded in 100 ml distilled water) on germination of crops and weed seeds under laboratory conditions. As the result of this study, rye and wheat are though to be as suitable crops for rotation in our region, because they affected the most important annual weed species (*Portulaca oleracea*, *Amaranthus retroflexus* and *Echinochloa colonum*) occurring in summer crops, while they showed no toxic effects on crop species under field conditions. However all straw treatments were unsuccessfully for the control of *Cyperus rotundus*.

Key words: Rye, wheat, *Portulaca oleracea, Cyperus rotundus,* sunflower, maize, tomato, weed control in rotation

Introduction

Wheat (*Triticum aestivum* L.) and rye (*Secale cereale* L.) are the important species used in crop rotation in many cropping systems and due to their allelopathic chemical contents, they have weed suppressing ability. Rye is also considered as a suitable cover crop because it grows rapidly, is tolerant to low temperatures, poor soil conditions and drought (Wilson *et al.,* 2001). Several researches have studied and demonstrated the allelopathic ability of rye and wheat in crop rotation (Mohler and Teasdale, 1993; Perez and Ormeno-Nunez, 1993; Przepiorkowski and Stanley, 1994; Anderson and Milberg, 1998; Williams *et al.,* 1998; Cromar *et al.,* 1999; Doucet *et al.,* 1999; Jordan *et al.,* 1999; Kegode, 1999; Unger *et al.,* 1999; Barberi and Locascio, 2001; Reddy 2001; Shrestha *et al.,* 2002).

Wheat and rye are main winter crops produced in Aegean Region of Turkey and are sown in November-December and harvested in June. In the crop rotation sunflower, maize and tomato are grown as late sown (second) crop after wheat and rye. As *Portulaca oleracea*, *Cyperus rotundus*, *Amaranthus retroflexus*, *Echinochloa colonum* and *Echinochloa crus-galli* are important weeds (Öngen *et al.,* 1996; Boz, 2000) in these summer crops, it was aimed in this study to investigate the influence of rye and wheat straw residues on the germination and growth of the weeds and maize, sunflower and tomato under controlled conditions in laboratory, in pot trials and under field conditions.

Materials and Methods

Field Studies: A field trial was conducted with a completely randomized block design with four replications at the Research and Application Center of the Faculty of Agriculture, Adnan Menderes University. Plot size was 14 x 4=56 m^{-2}. Rye (cv. Local) and wheat (cv. Basribey) seeds were sown (250 kg ha^{-1}) on December 30, 1998 and grown until the harvest time. An unseeded plot was left on each block as control. Plots were harvested on 30 June, 1999 and plant residues were incorporated to soil as shown in Table 1.

After incorporating the residues to soil, all plots were separated into three subplots and maize (cv.3394 Pioneer), sunflower (cv.AS-503 Asgrow) and tomato (cv.Challenger) seeds were sown on each subplot. Maize and sunflower were sown on July 8, 1999, in 4 rows and tomato was sown on July 13, 1999, in 2 rows.

The features of soil were 60.0% sand, 19.2% silt, 20.8% clay, 1.88% organic matter, 7.89 pH and texture SCL. Common cultural practices were applied during growing season.

The number of weeds was determined on July 19, 1999 and August 05, 1999 for maize and sunflower and July 26, 999 and August 9, 1999 for tomato. At each counting time two sites of each subplot, each in 0.25 m^2 area, were considered for weeds. At harvest time, 10 plants of maize and sunflower were harvested in order to determine the height of plants, their yield and yield components. Efficacy of residues on weeds and crops was evaluated by the comparison with plants grown on control plots.

Statistical Analyses: Data from trial was subjected to the variance analysis and means were compared according to Duncan's multiple comparison and standard errors for each analyze were given in tables. Means with non-significant differences were shown with same letters in tables.

Pot Experiment: A pot experiment was carried out in a screen house in order to determine the effect of rye and wheat straw on maize, sunflower and tomato. Pots 25*25=625 cm^{-2} was filled with straw soil mixtures taken from plots used for field trial. Then 10 seeds of maize (cv. 3396 Pioneer), sunflower (cv. AS-503 Asgrow) and tomato (cv. Challenger) were sown and the germination of seeds was determined. Each treatment was replicated with four pots.

In separate pots filled with straw-soil mixtures taken from plots used in field study two seedlings of *Portulaca oleracea* and *Echinochloa colonum* were planted in order to determine the effects of rye and wheat straw on the growth of these weeds.

Laboratory Studies: In this study the water extracts of dried and fresh straw of rye and wheat were prepared and their effects on some weeds and crops were investigated. Dry rye and wheat samples (each 10 g) and fresh rye and wheat samples (each 20 g) were grinded in 100 ml distilled water and stored at room temperature for 24 hours. Two layers of Whatmann papers were placed inside 10 cm-diameter-petri dishes (Przepiorkowski and Stanley, 1994). Seeds and/or tubers were placed in petri dishes with four replicates. The number of seeds/tubers per petri dish is shown in Table 2. After adding 5 ml of each extract, petri dishes were covered and placed in an incubator at 25°C.

Seeds/tubers were checked for germination after 1, 3, 5, 7, 14, 21, 28 days, germinated seedlings were counted and removed from the petri dishes.

Results and Discussion

Field Studies

Effect of treatments on *P. oleracea* and *C. rotundus* in Maize: At the first counting (Fig. 1a), there were four different categories for density of *P. oleracea*. RS and WSH applications increased the number of *P. oleracea* significantly, whereas WST application reduced the number of this weed significantly. In case of *C. rotundus,* none of the treatments affected the number of this weed. At 2nd counting (b) no significant effect of all applications was observed on both weed species. Therefore, it can be concluded that the straws did not show any effectiveness on these weed species.

As far as maize plants are concerned, no significant effect of treatments on yield and yield components was observed (Table 3).

Effect of treatments on *P. oleracea* and *C. rotundus* in Sunflower: In subplots, where sunflower is grown after straw applications, the effects of treatments on *P. oleracea* were grouped in five different categories. As compared with the untreated check plot, all applications increased the number of this weed, except for WST. With WST application the number of this weed was reduced significantly as in the case of subplots, where maize is grown. On the other hand, there were no significant differences at the 1st counting in the number of *C. rotundus* (Fig. 2a).

At the second observation (Fig. 2b) it was observed that only the effect of WSH treatment on *P. oleraceae* was significantly different from untreated control. All other treatments are not different from untreated control, whereas their efficacy in each other was different. In case of *C. rotundus* all applications reduced the number of this weed, except for RST. However, only the reduction with RSH, WSH and WST treatments were significantly different from control plot.

As far as sunflower plants are concerned, no significant effect of treatments on yield and yield components was observed (Table 4).

Table 1: Characteristics of treatments

Treatments	
Control (Unseeded Check)	No residues of rye or wheat
RS	Rye straw incorporated in the soil after harvesting (normal harvest)
RSH	Rye straw incorporated in the soil after cutting half of the plant (½ meter)
RST	Rye straw incorporated in the soil after removing the spike
WS	Wheat straw incorporated in the soil after harvesting (normal harvest)
WSH	Wheat straw incorporated in the soil after cutting half of the plant
WST	Wheat straw incorporated in the soil after removing the spike

Table 2: Seed numbers of the crop and weed species treated with extract of the rye and wheat straw

Plants	Number of seeds/petri dish
Maize (cv.Pioneer-3394)	40
Sunflower (cv.AS-503)	50
Tomato (cv.Challenger)	100
Amaranthus retroflexus L.	100
Cyperus rotundus L. (Tuber)	15
Portulaca oleracea L.	100

Effect of treatments on *P. oleracea* and *C. rotundus* in Tomato: In with tomato sown subplots, all treatments resulted with increased number of *P. oleracea*, but only the increase by RSH treatment was significant. In case of *C. rotundus* there were no significant differences among all treatments. At the 2nd counting there were no significant differences among the efficacies of treatments on both weed species.

It can be seen from (Fig. 1-3) that, the effectiveness of straw applications on weeds were different for the first and second counting date. However it is thought that the results recorded from first counting could give more satisfactory information, because the weed density (number per m^2) was higher at this period, especially for *P. oleracea*. In general the sensitivity of *P. oleracea* against treatments was higher than of *C. rotundus. C.rotundus* was only affected by RSH, WSH and WST treatments in the case of subplots sown with sunflower at second counting. In other plots the number of this weed was not influenced by the treatments significantly. The effect of treatments on *P. oleracea* was variable, so that with most straw applications the number of this weed was increased, but only with WST treatment a decrease in the number of *P. oleracea* was observed.

It can be concluded from results that only WST could be used for the control of *P. oleracea*, which is an important weed species in Aydın province of Turkey (Boz, 2000). As the reason for herbicidal effect of WST, the allelopathic chemicals contained in the wheat straw can be given, as explained by Kilung *et al.* (1997) and the higher concentration of allelochemicals in WST than in other straws.

Pot studies

Effect of different straw treatments on crops: As shown in Fig. 4, all rye straw treatments didn't affect the emergence rates of maize, sunflower and tomato seedlings significantly. However a slight increase by the treatments was observed, which shows that these rye treatments are safe to crops. By the wheat straw treatments there was a reduction in the emergence rates of tomato and sunflower, but this reduction was not significant for tomato, whereas the reduction was significant for sunflower (Fig. 4).

Effect of different straw treatments on weeds: Effect of rye straws on *P.oleracea* and *E. colonum* is shown in Fig. 5. Although there was a reduction in the fresh weight of both weed species by all rye straw treatments, this reduction was significant only for *E. colonum* but not for *P. oleracea*.

By the treatment of wheat straws, no significant fresh weight reduction of *E. colonum* was provided. Fresh weight of *P. oleracea* by WSH and WST treatments was reduced, but this reduction was not significantly different from control treatment. By WS application fresh weight of *P. oleracea* was increased, so that this increase was not significant as compared to control, but significant comparing with WSH and WST applications.

From the results it is clear that only rye straws suppressed fresh weight of *E. colonum* significantly in pot conditions. In similar pot experiments Muminovic (1991) found that straws of rye and wheat could not inhibit the growth of *Echinochloa cruss-galli*.

Laboratory studies

Germination of sunflower, maize and tomato seeds: As shown in Fig. 6, all treatments increased the germination of sunflower seeds significantly, except for fresh rye. On the contrary the germination of maize seeds was reduced by all treatments, but only the reduction by fresh rye was significant comparing with the control. The germination of tomato seeds was not affected by all treatments significantly. From the results it can be concluded that the straw treatments did not affect the germination of sunflower and tomato seeds negatively, whereas the germination of maize seeds was reduced slightly.

Table 3: Effect of different straw applications on yield and yield components of maize

Treatments	Yield (g plant^{-1})	Height of maize (cm)	Ear diameter (cm)	Ear length (cm)	Number of rows on ear	Thousand kernel weight (g)
Control	164.5±16.39*	171.7±4.38	3.71±0.35	13.45±1.92	13.85±0.93	102.3±8.19
RS	137.8±20.90	181.2±3.48	3.71±0.13	11.96±1.05	14.13±0.59	105.6±6.30
RSH	151.3±25.37	186.7±6.11	3.72±0.23	12.35±0.64	13.55±0.49	101.9±9.90
RST	155.3±13.76	183.1±5.86	3.81±0.09	12.55±0.69	13.58±0.39	101.0±6.89
WS	144.1±26.14	180.0±10.71	3.84±0.05	12.45±0.91	14.00±0.18	102.8±3.89
WSH	184.5±28.17	175.9±8.82	4.04±0.04	15.01±0.37	13.98±0.13	101.0±1.00
WST	195.0±48.47	181.5±7.59	3.64±0.07	12.33±0.82	14.00±0.47	99.5±8.06

*: Non-significant differences for LSD at 0.05 level

Table 4: Effects of different straw applications on yield and yield components of sunflower

Treatments	Diameter of disc (cm)	Weight of disc (g plant^{-1})	Yield. (g plant^{-1})
Control	10.3±0.46*	467±64.51ab	279±25.78*
RS	9.67±0.34	449±50.01ab	233±20.67
RSH	10.4±0.91)	429±63.14ab	257±33.17
RST	9.1±0.35)	409±41.48b	233±20.80
WS	10.4±0.62)	454±65.0ab	229±41.59
WSH	10.3±0.27)	486±62.48ab	307±47.41
WST	11.1±0.39)	581±46.72a	257±47.02

*: Non-significant differences for LSD at 0.05 levels

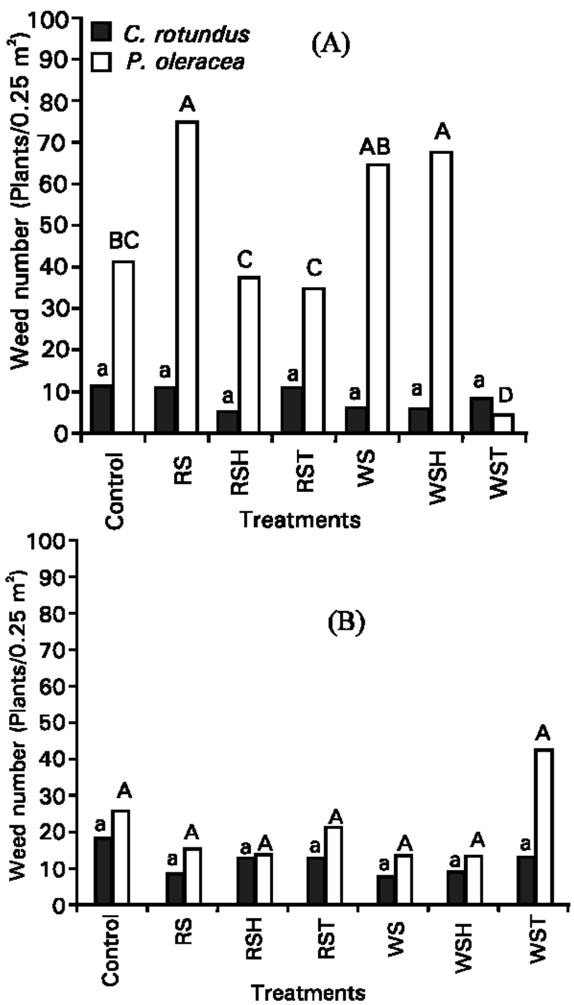

Fig. 1: The number of *Cyperus rotundus* and *Portulaca oleracea* at 1st (a) and 2nd counting (b) in maize after different straw treatments

*: Similar letters indicate non-significant differences for LSD at 0.05 levels

According to Burgos and Talbert (2000) crops with smaller seeds, such as tomato are more sensitive to rye straw treatments than crops with larger seeds, such as maize and they found that the germination of tomato seeds was negatively affected by water extract of rye straw treatment. But in this study, contrasting results were recorded. From these results it can be concluded that the inhibition of the seed germination does not depend on the size of seeds.

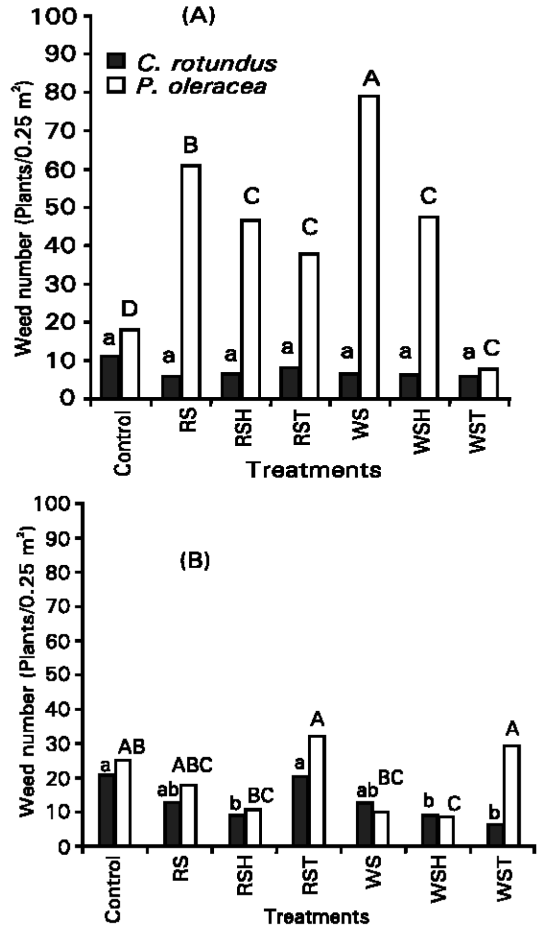

Fig. 2: The number of *Cyperus rotundus* and *Portulaca oleracea* at 1st (a) and 2nd counting (b) in sunflower after different straw treatments

Germination of the seeds of *P. oleracea*, *C. rotundus* and *A. retroflexus*: Except for fresh rye, all water extracts of rye and wheat inhibited the germination of *P. oleracea* significantly. Especially seeds of *A. retroflexus* were inhibited by all rye and wheat extracts. There is no inhibition of tuber germination of *C. rotundus* in petri dishes. So it can be said that the tuber is less sensitive to straw applications comparing with seeds. It could be said that extract of these crops could inhibit *P. oleracea* and *A. retroflexus* in laboratory conditions efficiently.

There are some studies in accordance with our study. Rambakudzibga (1991) stressed that the water extract of wheat inhibited the germination of *P. oleracea* and

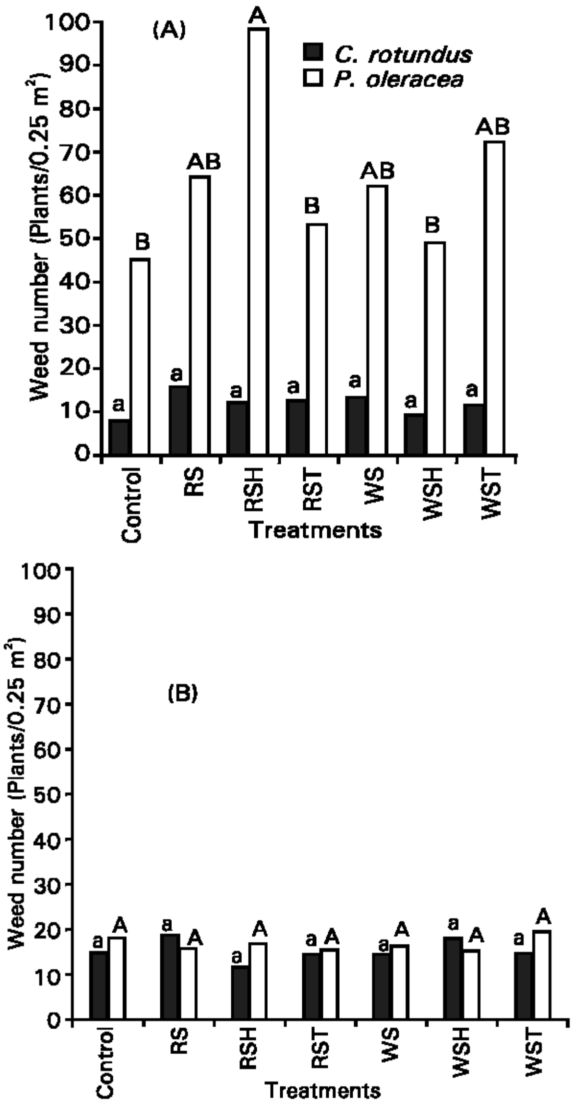

Fig. 3: The number of *Cyperus rotundus* and *Portulaca oleracea* in 1st (a) and 2nd (b) counting in tomato growing areas after treatments

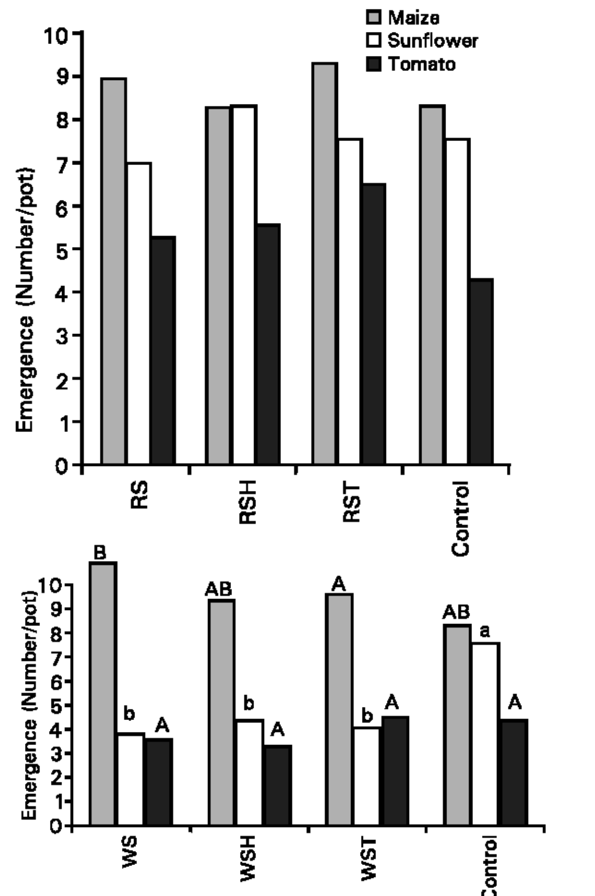

Fig. 4: The number of emerged seedlings after treatments rye and wheat straws

A. hybridus seeds. In another study, Narwal and Sarmah (1996) found that the water extract of wheat inhibited the seed germination of *Amaranthus* spp. under laboratory conditions.

Crop rotation takes an important place in weed control strategies. As some crops produce allelopathic chemicals,

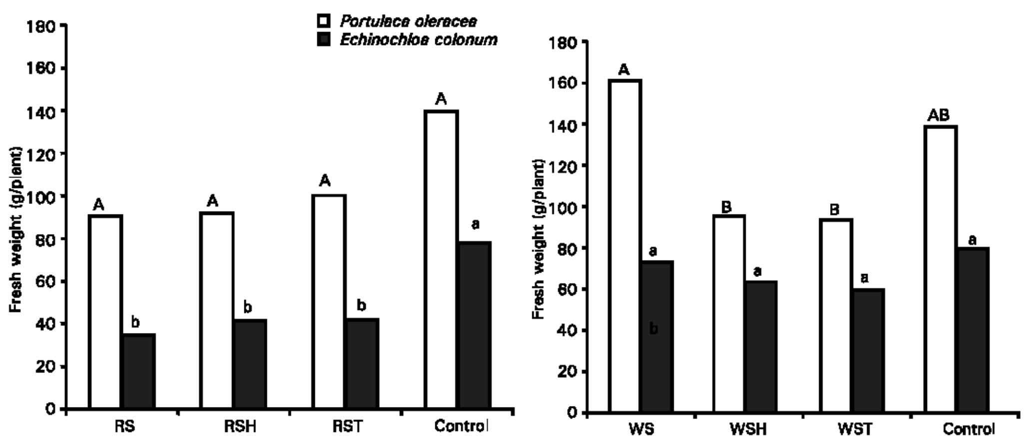

Fig. 5: Fresh weight of *P. oleracea* and *E. colonum* as affected by rye and wheat straw treatments in pots

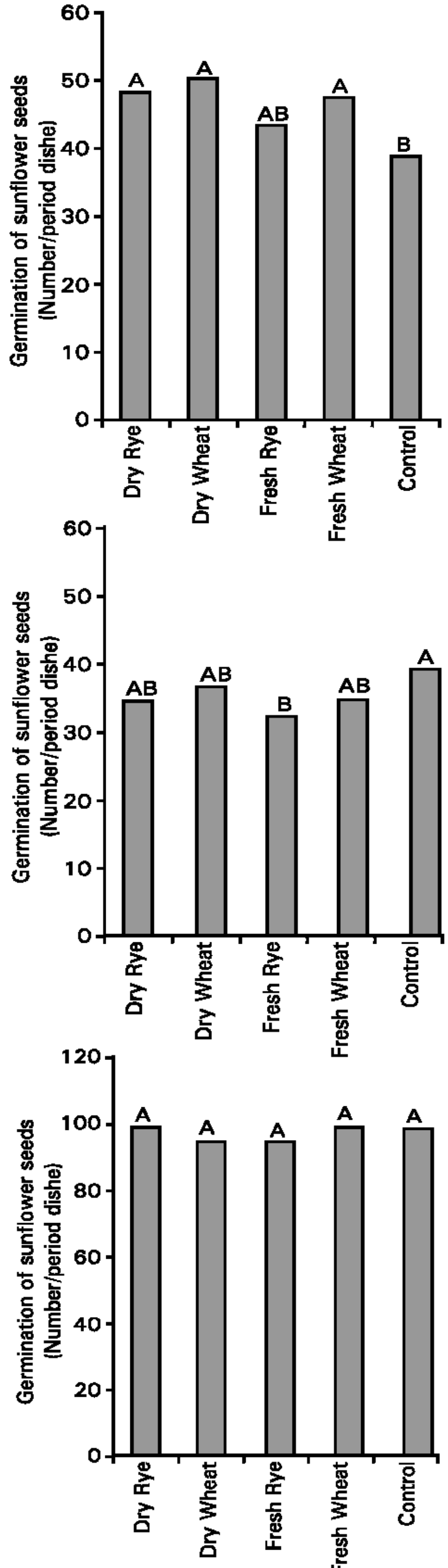

Fig. 6: Germination of sunflower, maize and tomato seeds after rye and wheat straw treatments

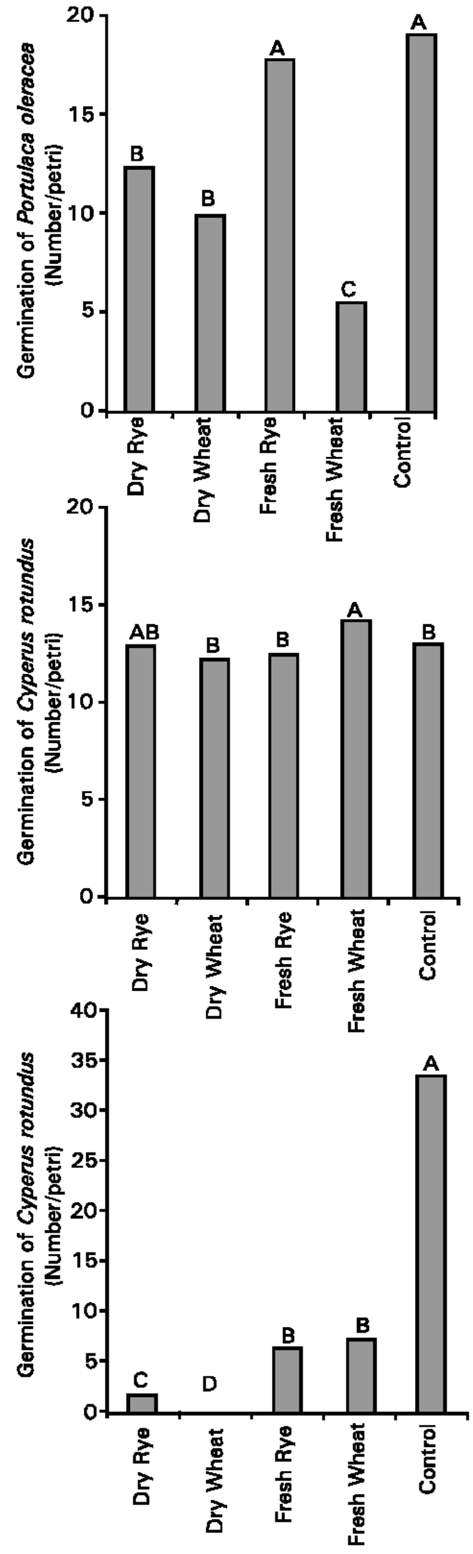

Fig. 7: Germination of *Portulaca oleracea*, *Cyperus rotundus* and *Amaranthus retroflexus* seeds as affected by wheat and rye straw treatments

which are toxic to some other plant species (especially to weeds), their cultivation in the crop rotation results generally with reduced demand to weed control in the following crop. But special attention should be paid for that the chosen crop for rotation should affect only the weeds in following crop, but not the crop itself.

As the result of this study, rye and wheat are though to be as suitable crops for rotation in our region, because they affected the most important annual weed species occurring in summer crops, while they showed no toxic effects on crop species under field conditions.

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