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Short communication

Inhibitory effects of rice straw on the germination and seedling growth of some major weeds of wheat

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Wheat [*Triticum aestivum* (L.) emend. Fiori and Paol.] faces severe competition from weeds leading to yield losses up to 34.3% which is more than the combined losses caused by insects, pests and disease (Dangwal *et al*. 2010). The rice-wheat cropping system, which is the backbone of India's food security, produces a huge quantity of rice straw. Management of this bulk of rice straw is a major challenge as it is considered to be a poor feed for the animals owing to high silica content. Aqueous extract of rice residue suppressed the growth of lettuce and *Phalaris minor* (Khan *et al*. 2001) while both aqueous and organic solvent extracts of rice plants inhibited the growth of several plant species (Das and Goswami 2001). Phenols such as *p*-salicylic acid, *p*-coumaric acid, vanillic acid, syringic acid, ferulic acid, and mandelic acid present in the rice straw are reported to be responsible for its inhibitory influences (El- Shahawy *et al*. 2006).Therefore, the present work was conned out to study the effect of rice straw on the germination and seedling growth of four major weed species of wheat crop.

A laboratory experiment was conducted in the Department of Plant Physiology, G.B. Pant University of Agriculture & Technology, Pantnagar, India. Straw of three rice genotypes *viz. 'Pant Dhan 16, UPR 2962-6-2-1* and *UPR 2992-17-3-1'* were used in the experiment, because these are allelopathic varieties of rice. The straw was dried and ground in a grinder separately for each genotype. This straw powder was added on to germination paper laid in Petri dishes. The treatments consisted of supplementing one and two grams of powdered straw of each genotype in separate Petri dishes. Pure distilled water served as control. The germination paper was wetted by 10 ml of distilled water. Seeds of four weed species such as *Phalaris minor*, *Vicia sativa*, *Medicago denticulata* and *Lathyrus aphaca* were surface sterilized in 10% (v/v) hydrogen peroxide solution for 10 minutes, followed by their rinsing with deionized water and subsequent washing with distilled water for 4-5 times. Ten seeds of each species were laid over the wet rice straw and allowed to germinate at room temperature. The Petri dishes were watered intermittently to keep them moist. Data on germination (%) and shoot and root length of the weed seedlings were recorded at 21 days after incubation (DAI).

The phenolics in rice straw were analyzed by HPLC by following the method of Tarnawski *et al.* (2006). The dried phenolic residue was dissolved in 2 ml of water: methanol (75: 25, v/v). Prior to analysis, the samples were filtered through 0.22 mm flouropore filters (Millipore) before injecting into the HPLC column. Twenty ml samples were injected using a micro Hamilton syringe into the HPLC column (C18) for analysis. Absorbance was recorded at 280 nm with the help of a UV- Vis detector. Standards of phenolics acids such as ferulic acid, gallic acid and p-hydroxybenzoic acid were used for detecting the compounds in rice straw.

The data was analyzed statistically by using completely randomized design (CRD). Standard error of means (SEm ±) and critical difference (CD) was evaluated at 5% level of significance.

Effect of rice straw on weeds germination

Phalaris minor*:* The germination of *Phalaris minor* seeds was about 50% under control condition. Upon addition of rice straw in the medium, the germination per cent was reduced significantly except for the treatment '*Pant Dhan 16*' (1 g straw). It ranged from 13.3% to 46.7% in the presence of rice straw. The lowest germination (13.3%) was observed in the treatment '*Pant Dhan 16*' (2 g) followed by 16.67% in the presence of '*UPR 2992 17-3-1'* (2 g) (**Figure 1a**).

Vicia sativa*: Vicia sativa* seeds recorded about 60% germination under control condition (**Figure 1b**). Addition of rice straw to the germination medium significantly reduced the germination except for the treatments '*UPR 2962 6-2-1*' (2 g) and 'UPR 2992

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17-3-1' (1 g). The lowest germination rates of about 26.7% to 33.3% were observed in the treatments *'Pant Dhan 16'* (1 and 2 g) and '*UPR 2962 6-2-1'* (1 g).

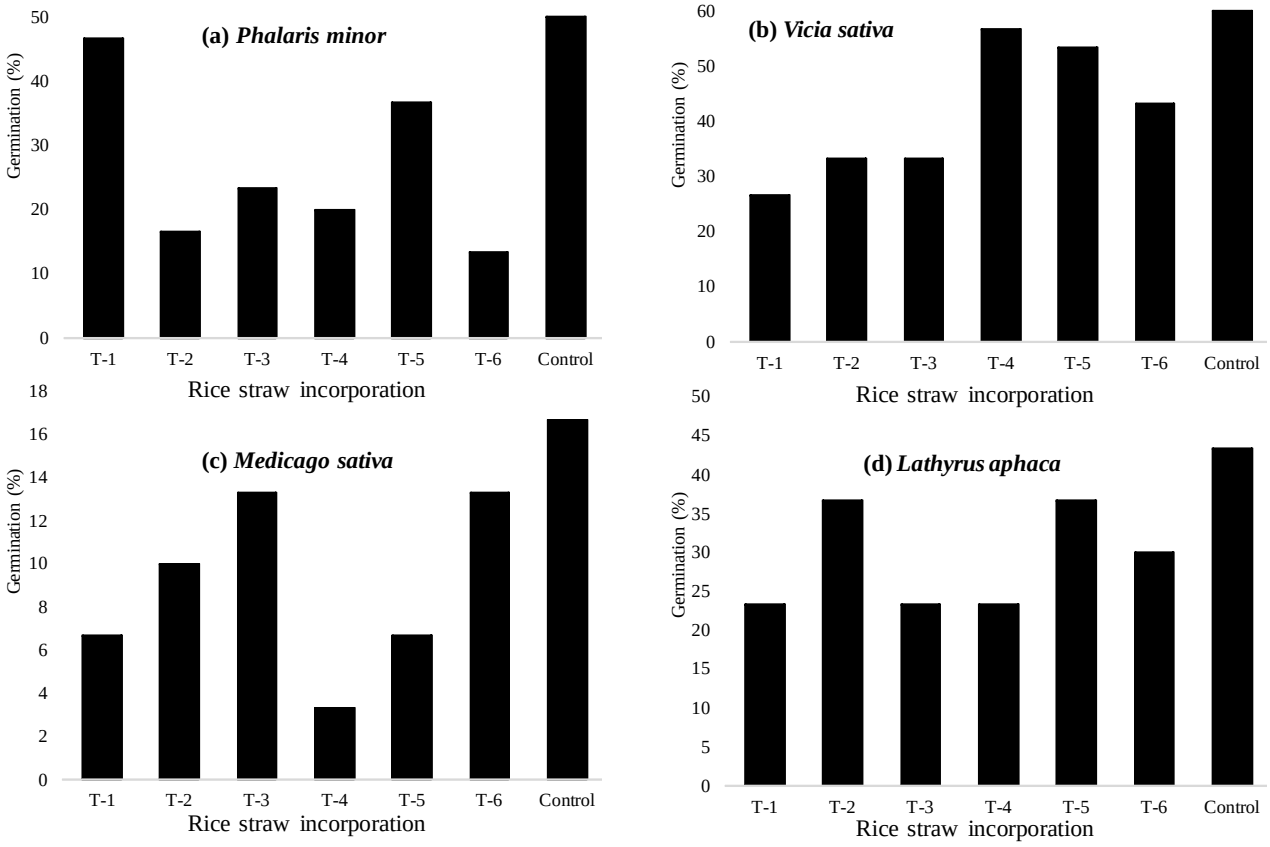
Medicago denticulata: In the control, the germination of *Medicago denticulata* seeds was very poor. It was about 16.7% (**Figure 1c**).Significant reductions in germination were observed in the treatment '*UPR 2962 6-2-1'* (2 g) followed by that in Pant Dhan 16 (1g) and '*UPR 2992 17-3-1*' (1 g).

Lathyrus aphaca*:*The germination of *Lathyrus aphaca* seeds was about 43.3% under control condition. '*Pant Dhan 16*' (1 g) and '*UPR 2962 6-2-1* (1 and 2 g) recorded significantly lowest germination (23.3%) as compared to all other treatments. The germination per cent in rest of the treatments ranged from 30 to 36.7% (**Figure 1d**).

Among the weed species, *Phalaris minor* recorded 60.0 to 73.3% reduction in germination in the presence of 2 g straw of all the three rice genotypes. *Vicia sativa* recorded maximum reductions in germination when straw of Pant Dhan 16 was added to the medium. *Medicago denticulata* recorded 60 to 80% reductions in germination due to straw of all the three genotypes. *Lathyrus aphaca* was more sensitive to the straws of the genotypes '*Pant Dhan 16* and *UPR2962 6-2-1'* with about 46.6 % inhibition in germination. Among the weed species, *Phalaris minor* and *Medicago denticulata* were more sensitive to rice straw. Thus, it is evident that incorporation of rice straw in the medium reduces germination of problematic weed species, both grasses and BLWs. Differential sensitivity of weed species to plants extracts (Perez 1990, Koloren 2007) further support the current findings.

Effect of rice straw on seedling growth of weed

Seedling growth of all the four weed species was reduced in presence of rice straw (**Table 1**). '*Pant Dhan 16*' (2 g) had maximum inhibitory effect on shoot length of *Phalaris minor* while '*Pant Dhan 16*' (2 g) followed by '*Pant Dhan 16*' (1 g) had maximum inhibitory effect on shoot and root length of *Vicia sativa*. It has been reported that the rice straw inhibited the germination and seedling growth



T-1 - *Pant Dhan 16* (1 g); T-2 - *Pant Dhan 16* (2 g); T-3 - *UPR 2962 6-2-1* (1 g); T-4 - *UPR 2962 6-2-1* (2 g); T-5 - *UPR 2992 17-3-1* (1 g); T-6 - *UPR 2992 17-3-1* (2 g)

Figure 1. Effect of rice straw incorporation in the germination medium on the germination (%) of four weed species (a. *Phalaris minor*, b. *Vicia sativa*, c. *Medicago denticulate*, d. *Lathyrus aphaca*)

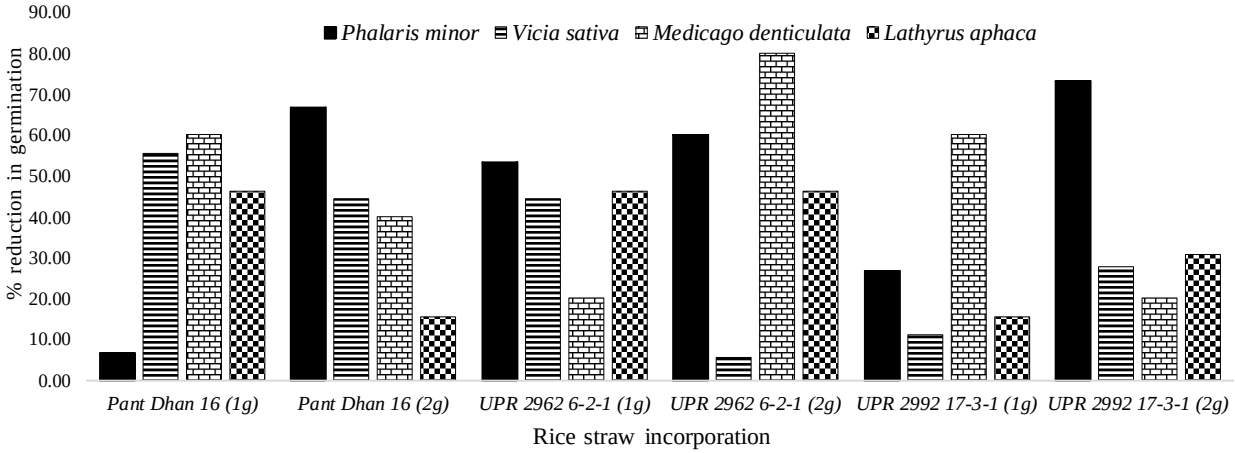


Figure 2. Effect of rice straw incorporation on per cent reduction in germination of four weed species

Table 1. Effect of rice straw on shoot length and root length of seedlings of four weed species at 21 days after incubation

Treatment (Rice straw, g/Petri plate)	*Phalaris minor*		*Vicia sativa*		*Medicago sativa*		*Lathyrus aphaca*	
	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)
Pant Dhan 16 (1g)	3.96	1.06	0.78	0.40	0.00	0.002	3.68	1.12
Pant Dhan 16 (2g)	0.83	0.33	0.67	0.51	0.48	0.250	1.95	0.54
UPR 2962 6-2-1 (1g)	1.93	0.51	1.86	1.43	0.76	0.330	1.51	0.68
UPR 2962 6-2-1 (2g)	1.14	0.36	2.14	1.39	0.00	0.001	1.56	0.44
UPR 2992 17-3-1 (1g)	3.73	1.12	1.86	1.18	0.00	0.002	3.51	0.87
UPR 2992 17-3-1 (2g)	0.96	0.32	1.14	1.10	0.56	0.220	1.78	0.59
Control	4.23	1.73	2.84	1.66	0.89	0.380	5.34	1.13
LSD (p=0.05)	0.65	0.25	0.16	0.09	0.23	0.010	0.50	0.13

of weed plants by 70% and increased crop yield by 20% (Xuan *et al.* 2005). The water extract of rice husk have suppressive effects on germination and seedlings growth of barnyard grass (Ko *et al.* 2005). The rice root exudates and rice leachate contain water-soluble allelochemicals which could inhibit the seed germination and reduce seedling growth of *Sisybrium officinale* (Mahmoodzadeh *et al.* 2011).

Total phenol and phenolic acid content in straw of three rice varieties

Total phenol content differed significantly among the rice varieties (**Table 2**). *'UPR 2962 6-2-1'* had the highest total phenol content (25.97 µg/g FW) followed by that in '*UPR 2992-17-3-1'*while it was the lowest in the genotype '*Pant Dhan 16*' (19.40 µg/ g FW).

In the present investigation, profiling of phenolic acids through HPLC revealed three phenolic compounds such as caffeic acid, p-hydroxybenzoic acid and gallic acid in the straw of the three rice genotypes. While both '*Pant Dhan 16* and *UPR 2962 6-2-1'* had all the three phenolics acids, the genotype 'UPR 2992 17-3-1' had only two phenolic acids such as p-hydroxybenzoic acid and gallic acid (**Figure 3**).

Table 2. Phenol content (mg/g FW) in the straw of three rice genotypes

Genotype	Phenol content (µg/g FW)
Pant Dhan 16	19.40
UPR 2962-6-2-1	25.97
UPR 2992-17-3-1	21.85
LSD (p=0.05)	0.61

Among the phenolics, the concentration of gallic acid was highest in all the three genotypes, which ranged between 18.2 to 24.0 ppm. In the genotype '*UPR 2962- 6-2-1'*, para-hydroxy benzoic acid was present in highest concentration (26.4 ppm). The concentration of caffeic acid was very low as compared to the other phenolics (**Figure 3**).

Extensive studies of allelochemicals in rice plants have led to identification of a range of phenolic compounds, including p-hydroxybenzoic, vanillic, p-coumeric and syringic acids (Kong *et al.* 2004). Certain phytotoxins are released by rice during their growth or even after dying via straw degradation (Chung *et al.* 2001). It was reported that p-coumaric acid was released in the greatest amount from decomposition of rice straw (Kuwatsuka and Shindo

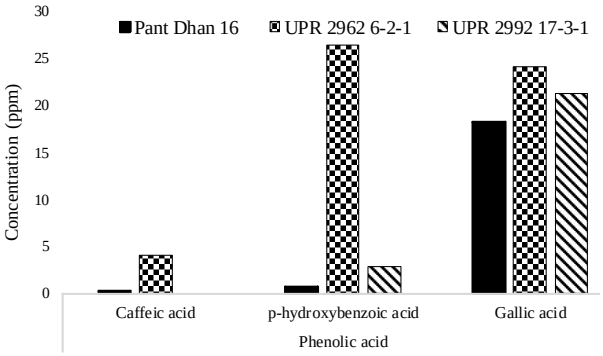


Figure 3. Concentration of caffeic acid, p-hydroxybenzoic acid and gallic acid in the straw of three rice genotypes

1973). Six simple phenols e.g. p-salicylic acid, p-coumaric acid, vanillic acid, syringic acid, ferulic acid, and mandelic acid were responsible for the inhibitory influences in rice straw (Chou 1980). In the present study, the inhibitory effects of rice straw on germination and seedling growth of weed species is attributed to gallic acid and p-hydroxybenzoic acids, which were present in higher levels in the straw. Genotypes, *'UPR 2962-6-2-1'* was found having maximum inhibitory effects on the germination of the weed seeds due its phenolic acid profile.

SUMMARY

A laboratory experiment was conducted to study the effect of rice straw on the germination and seedling growth of four major weed species of wheat *viz. Phalaris minor, Vicia sativa, Medicago denticulata* and *Lathyrus aphaca*. Straw of three rice genotypes, Pant Dhan 16, UPR 2962-6-2-1 and UPR 2992-17-3-1, was added to petri dishes at two different doses (1g and 2g) on which weed seeds were allowed to germinate. It was observed that germination and seedling growth of all the four weed species was adversely affected by rice straw. Straw of the rice genotype UPR 2962-6-2-1 had maximum inhibitory effect and among the weed species *Phalaris minor* and *Medicago denticulata* were more sensitive to rice straw. Analysis of phenolics content of rice straw revealed maximum phenolics in the genotype UPR 2962- 6-2-1. This shows the potential of rice straw incorporation in soil for weed management.

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