obtained from the seeds treated with *P. fluorescens* and *T. viride* showed good shoot and root length as compared to that of seedlings obtained from healthy seeds (Table 1). The effect of thiram on enhancing germination of molded seeds was on par with the treatment with *T. viride,* but it did not enhance the vigor of the seedlings when compared to *P. fluorescens* and *T. viride.* This suggests that chemicals used to suppress the growth of pathogens may not act in favor of growth and establishment of the crop. The role of rhizobacteria and fungal bioagents in favoring crop growth in addition to suppression of parasitic as well as saprophytic pathogens has been reported by other researchers (Alka Gupta 2000, Kurze 2001). However, the results of using the fungal bioagents *T. hamatum* and *T. koeningii* were less favorable when compared to those of *P. fluorescens, T. viride* and *T. harzianum.* The reduced efficiency of *T. hamatum* and *T. koeningii* may be attributed to the non-adaptation of these pathogens to the exposed environment in the area of the current study. However, the role of these bioagents cannot be underestimated because genetic improvement of biological control agents is a well established field of commercial application. Thus the biocontrol agents proved to show an edge over the routine chemical seed treatment to ward off seedborne diseases. Though the efficacy of *P. fluorescens* and *T. harzianum* against grain mold pathogen *F. moniliforme* was reported by Raju et al. (1999), this is the first report comparing four well known species of *Trichoderma* with common chemicals used for seed treatment.

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Effects of Pounding and Garlic Extract on Sorghum Grain Mold and Grain Quality

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Introduction

Of the many fungi associated with sorghum (*Sorghum bicolor)* grain mold complex, species of *Alternaria, Curvularia, Drechslera, Fusarium* and *Phoma* are particularly widespread (Navi et al. 1999). Grain infection by mold fungi can also reduce storage quality and seed germination. Apart from affecting grain quality, species of *Fusarium* produce mycotoxins leading to several chronic ailments in humans and animals (Bhat et al. 2000). To improve the quality of molded grain, Stenhouse et al. (1998) suggested dehulling to minimize mold damage observed on the pericarp.

In our limited survey during the 1996 rainy season in Bidar district, Karnataka, India people who consumed molded grain without prior treatment complained of itching, fever, dysentery, loss of appetite and feeling of enhanced body heat particularly in the eyes. Inexpensive and safe method of reducing moldiness would greatly help the use of sorghum grains both for food and feed. Therefore, use of biopesticide, such as garlic extract, was tried along with grain pounding to reduce grain mold infection, as was used in controlling sorghum ergot (Singh and Navi 2000).

Materials and Methods

Collection of sorghum samples. During a survey in 1996, six molded grain samples were collected from farmers' stores in two villages of Karnataka. These samples were from the 1995 rainy season harvest from three sorghum cultivars CSH 1, CSH 9 and Local yellow sorghum.

Identification of fungi. From each sample, 200 grains were surface sterilized in 1% sodium hypochlorite (NaOCl), and washed in sterilized distilled water three times. The grains were plated on blotter paper in sterilized petri dish humid chambers (25 grains per petri dish) and incubated for 5 days at 28±1°C with 12 h light

cycle. Grains were examined under stereoscopic microscope for fungal colonization and under compound microscope for identification. Another set of 200 grains plated without sterilization was observed as detailed above.

Preparation of garlic extract. Peeled garlic cloves (500 g) were crushed in 500 ml sterilized distilled water using pestle and mortar. The crushed suspension was filtred through muslin cloth and the filtrate was considered as 100% stock solution of crude garlic extract. The solution was diluted with water to 50%, 25%, 12.5%, 6.25% and 3.12% concentrations for the study.

Grain pounding and incubation periods. A representative sample of 250 g heavily molded grain of CSH 9 was soaked in lukewarm water for 25 min; the excess water was drained out and the sample was dried under sunlight at ~36°C for 4 h. From this, 125 g grain was pounded using pestle and wooden mortar and remaining 125 g was not pounded. Both the pounded and 'un-pounded' grains were aseptically transferred to sterilized humid chambers (25 grains per petri dish) and incubated at 28±1°C with 12 h light cycle for 24,48 and 72 h. The number of grains colonized in both the lots and their severity on a 1-9 scale (where 1 = no mold and 9 = >75% molded grain) were recorded after each incubation period. The experiment was repeated three times, each time with two replications, with two petri dishes in each replication, and 25 grains per petri dish.

Treatment with garlic extract. A representative sample of 25 g each of sun-dried pounded and un-pounded grain was treated separately using 50%, 25%, 12.5%, 6.25% and 3.12% concentrations of crude garlic extract by slurry method. Controls were maintained with sterilized distilled water treatment. The treated grains were air-dried under shade and 100 grains from each treatment were aseptically transferred to sterilized humid chambers (25 grains per petri dish) and incubated at 28±1°C with 12 h light cycle for 72 h. The grains were evaluated for mold incidence (%) and severity.

Results and Discussion

Effect of pounding on grain mold at different incubation periods. There was a considerable reduction in incidence (%) and severity of grain mold in pounded grains compared with un-pounded grains (Table 1). However, with increased incubation period up to 72 h, both incidence and severity increased in pounded grains.

Effect of garlic extract on grain mold of pounded and un-pounded grains. Treatment with garlic extract was effective in reducing grain mold incidence and severity, both in pounded and un-pounded grains. Higher concentrations of garlic extract was more effective than lower concentrations (Table 2). However, concentrations from 12.5% to 50% were more effective on pounded grain than on un-pounded grain. On pounded grain the incidence varied from 0 to 4% and severity from 1 to 4 compared with 28-44% incidence and 6-8 severity on un-pounded grain.

The cost of treating 10 kg molded grain with 6.25% garlic extract was Rs 40 (cost of 10 kg molded grain Rs 30 + pounding cost Rs 6.50 + garlic cost Rs 3.50 for 1 L of 6.25% extract) while the cost of 10 kg healthy grain was Rs 90 (Rs 10 kg^{-1}). Thus the garlic extract treatment is economical for farmers. In addition, garlic extract treatment improved grain and *rati* or *chapatti* (flat bread) color and is eco-friendly and safe for consumption by humans and poultry birds. Pounding alone reduced 60-80% ergosterol content in molded grain of CSH 1 and CSH 9. Thus, there is a scope for treating pounded grain for use in poultry feed. To store molded grain for a month or two, treating with 12.5% garlic extract is effective, and for longer storage 25% garlic extract would be desirable

Table 1. Effect of pounding on sorghum grain mold incidence and severity at different incubation periods in sterilized humid chambers'.

	Incidence (%)		Severity[2]	
Incubation period (h)	Pounded grain	Un-pounded grain	Pounded grain	Un-pounded grain
24	28	100	2	7
48	56	100	3	9
72	68	100	6	9
LSD (*P* <0.05)	21.14	0.00	1.15	0.45

1. Mean of 3 repetitions each with 2 replications, two petri dishes per replication and 25 grains per petri dish.
2. 1-9 scale, where 1 = no mold and 9 = >75% mold.

Table 2. Effects of different concentrations of crude garlic extract on mold incidence and severity of pounded and un-pounded molded sorghum grains in sterilized humid chambers'.

Crude garlic extract concentration (%)	Incidence (%)		Severity[2]	
	Pounded grain	Un-pounded grain	Pounded grain	Un-pounded grain
50	0	28	1	6
25	4	44	3	8
12.5	4	44	4	8
6.25	16	56	5	8
3.12	48	80	6	8
Control	84	100	7	9
LSD (P <0.05)	11.62	9.63	0.33	0.41

1. Mean of 3 repetitions each with 2 replications, two petri dishes per replication and 25 grains per petri dish.
2. 1-9 scale, where 1 = no mold and 9 = >75% mold.

(Singh 1996). The pounding and garlic extract treatment could be applied together at large-scale for better utilization of molded grain for human consumption and for poultry feed.

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Application of *Pseudomonas fluorescens* for Enhanced Seed Germination and Seedling Emergence in Sorghum

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Introduction

Seedborne fungi in sorghum *(Sorghum bicolor)* reduces seed germination and emergence (Mathur and Sehgal 1964). Beneficial rhizospheric microorganisms especially bacteria termed as plant growth promoting rhizobacteria (PGPR) affecting plant growth had been studied in various crop plants (Burr and Caesar 1983). Fluorescent pseudomonads have emerged as the most potential group for promoting plant growth and biological control of plant diseases. *Pseudomonas fluorescens* is reported as antagonistic to various plant pathogens and is also recommended for seed dressing (Vidyasekaran and Muthamilan 1995). Attempts were therefore made to assess efficacy of native *P. fluorescens* strains for seed dressing and its effect on seedborne fungal incidence, seed germination, and seedling emergence in sorghum.

Material and Methods

Untreated sorghum seeds of CSH 9, CSH 5 and SPV 86 were used in this study. The seeds were stored in paper bags at room temperature and used as and when required.