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# Effect of substrate physical factor on mass multiplication of *Trichoderma harzianum* in management of seedling blight of jute

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**ABSTRACT:** Four substrates (wheat bran, rice bran, pulse bran and orange peel) singly and in combination with four oil cakes (mustard cake, groundnut cake, neem cake and linseed cake) were tested under variable temperature, moisture and pH levels to determine the best-suited physical conditions for the growth and sporulation of *Trichoderma harzianum*. The temperature of 30°C, moisture level of 60 per cent and 5.5 of substrates pH has been found to best suited conditions, irrespective of substrates tested. Among the substrates, the wheat bran (agricultural byproducts), mustard cake (oil cakes) and wheat bran + mustard cake at 20 per cent has been shown to highly promising with highest number of population of antagonist. The formulation of *T. harzianum* has also found promising in increasing the germination of jute seeds and reduction in disease incidence of seedling blight disease. The wheat bran + mustard cake preparation was found superior over other combination of products.

**KEY WORDS:** Agricultural byproducts, growth and sporulation, *M. phaseolina*, oil cakes, seedling blight, *T. harzianum*

## INTRODUCTION

Jute (*Corchorus capsularis* L.; *C. olitorius* L.) is an important fibre yielding commercial crop. The fibre is used for manufacturing Hessian, sacking, carpet backing cloth and other diversified products. In India, the jute is cultivated extensively in many parts of north India, and most intensively grown in West Bengal, Bihar and Uttar Pradesh. However, the crop suffers from many diseases that causes serious set back to jute fibre production, which in turn severely affects the industry and trade in terms of foreign exchange earning . The seedling blight and stem rot of jute (*Macrophomina phaseolina*) has always been considered to be an important disease and limiting factor for jute cultivation both at seedling and mature crop stage.

Besides the nature and properties of organic wastes, different physical factors like temperature, moisture content and pH of the substrate are considered to be the important determinants for

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the mass multiplication of the *T. harzianum*. The species of *Trichoderma* typical to cool geographic regions, possess lower temperature optima than the species from warm climatic regions (Reddy and Khowles, 1965; Komatsu and Hashioka, 1966; Danielson and Davey, 1973). The growth and sporulation of *Trichoderma harzianum* has been reported high in the substrate at 30°C than 20°C (Bandopadhyay *et al.*, 2003).

Moisture content of substrate is another key factor in determining the growth of *Trichoderma* spp. As these species are neither able to tolerate high moisture level nor survive under deficit of moisture in natural ecosystems. *T. harzianum* grew and sporulated better when the moisture content of wheat bran + saw dust was 35 per cent (Elad *et al.*, 1980).

*Trichoderma* isolate produces optimum biomass under acidic pH ranges between 4.6 to 6.3 (Jackson *et al.*, 1991; Singh *et al.*, 1998) with few exception of *T. harzianum* and *T. hamatum*, the growth of other species were severely affected with very little growth at near neutral pH (Sreenivasaprasad and Manibhusanrao, 1990). Therefore, present study was undertaken to find out the best-suited temperature, moisture and pH levels in the different substrates for mass multiplication of *T. harzianum* and *in vivo* efficacy of bran/peel-oilcakes products for the management of seedling blight of jute caused by *Macrophomina phaseolina*.

## MATERIALS AND METHODS

### Moisture content of substrate

The present investigation was carried out at laboratory (Department of Plant Pathology) and Instructional farm, Bidhan Chandra Krishi Viswavidyalaya (BCKV), West Bengal. The bioagent, *T. harzianum* was isolated from the rhizosphere soil of Jute on Trichoderma selective medium (TSM), purified and preserved at 5°C in the freeze for subsequent use. The greenhouse test was conducted in a wooden flat measuring 70 x 50 x 10 cm in the *kharif* season, 2005 and 2006. The jute variety 'JRO- 632' was used in greenhouse study, which is highly susceptible to seedling blight and stem rot. All the experiments were subjected to Complete randomized design (CRD) for lab studies and Random block design (RBD) for greenhouse test. Each treatment was replicated four times. The data have been given subjected to log transformation before statistical analysis and comparison was made as per DMRT test.

Four agricultural waste materials *viz.*, rice bran, wheat bran, pulse bran, orange peel and four oil cakes *viz.*, mustard cake, neem cake, groundnut cake and linseed cake were used singly or in combination. Three moisture levels (dry weight basis) in each substrate were adjusted to 40, 60 and 80 per cent by adding sterile distilled water and mixing in lots, following the method of Jacob and Sivaprakasan (1993). The population of *T. harzianum* was determined by analyzing the substrates (1 g) on Trichoderma selective medium (T.S.M.) after 21 days of incubation. The population in terms of colony forming unit (c.f.u.) per gram of incubated substrates were recorded.

### Temperature of the substrate

The above-mentioned substrates were sterilized at 9.07 kgs. for 30 min twice in consecutive days and inoculated with three mycelial discs (6 mm diam) of *T. harzianum*. These inoculated substrates were incubated in a BOD incubator at 20°, 25° and 30 ± 1°C separately for a period of 21 days. The samples were periodically drawn from these incubated substrates and enumerated for the growth in terms of c.f.u. of *T. harzianum* and data were recorded at 21 days of incubation.

### pH of the substrate

The pH of wheat bran + mustard cake (20 %) were adjusted at 5.0, 5.5, 6.0, 6.5, 7.0, 7.5 and 8.0 by adding bufferised solution of either monobasic or dibasic phosphate salts, into the substrate mixtures. The pH of different substrates were checked by E-Merck pH paper, before moist sterilization and while adding of bufferised solution into the substrates, care should be taken to ensure 50-60 per cent of moisture level in it.

### Greenhouse study

The earthen pots were filled with a mixture of non-sterilized soil and Farm Yard Manure (2:1, v/v) and 10 sclerotia were incorporated into the potting mixture 2 - 5 cm deep before addition of different formulated products of *T. harzianum*. The seeds of jute variety JRO-632 (20-25) were sown 2 - 5 cm deep in the potting mixture and were irrigated whenever required to maintain the moisture holding capacity of the potting mixture above 20 per cent. The experiment was laid out in RBD and replicated four times. Per cent seedling mortality due to infection of *Macrophomina phaseolina* was scored at 15 days interval and per cent reduction in disease incidence was calculated for each treatments.

## RESULTS AND DISCUSSION

### Effect of moisture

The result presented in Table 1 revealed that wheat bran with 60 per cent moisture produced highest growth of *T. harzianum* (205.2 x $10^6$ c.f.u./g) whereas lowest growth in orange peel (146.6 x $10^6$ cfu/g) followed by the moisture level of 40 and 80 per cent, which were not statistically significant. Very poor growth was recorded in all the substrates at 80 per cent moisture level.

Among the four oil cakes tested (Table 1), *T. harzianum* grew profusely (130.2 x $10^6$ c.f.u./g) on mustard cake medium at 80 per cent moisture level, which does not differ significantly from the population at 60 per cent moisture (115.2 x $10^6$ c.f.u./g). Growth of *T. harzianum* on mustard cake at 40 per cent moisture level (91.40 x $10^6$ c.f.u./g) was similar with those on groundnut cake at 80 per cent moisture. Minimum growth was noticed in case of linseed cake (70.80 x $10^6$ c.f.u./g) at 80 per cent moisture. The overall results of oil cake media indicated that growth of *T. harzianum* was much more at 80 per cent than those at 60 per cent moisture content.

It is clear from the data presented in Table 2 that irrespective of type of cakes used 60 per cent moisture level has shown best result followed by 40 and 80 per cent, respectively. In case of wheat

**Table 1. Effect of moisture content on *T. harzianum* grown on organic byproducts**

| Substrate | Population at different moisture regimes (c.f.u. x $10^6$/g of substrate) | | |
|---|---|---|---|
| | 40 % | 60 % | 80 % |
| Wheat bran | 199.4 (2.299) | 205.2 (2.312) | 190.2 (2.279) |
| Orange peel | 150.6 (2.177) | 146.6 (2.166) | 130.6 (2.116) |
| Rice bran | 168.8 (2.227) | 182.8 (2.262) | 163.2 (2.212) |
| Pulse bran | 142.8 (2.154) | 165.4 (2.218) | 150.4 (2.177) |
| Groundnut cake | 63.40 (1.800) | 78.60 (1.893) | 91.60 (1.961) |
| Neem cake | 58.60 (1.764) | 72.80 (1.861) | 80.80 (1.906) |
| Mustard cake | 91.40 (1.960) | 115.20 (2.061) | 130.20 (2.114) |
| Linseed cake | 43.20 (1.631) | 65.60 (1.813) | 70.80 (1.848) |

Figures in parentheses are log - transformed values

**Table 2. Effect of moisture level on growth of *T. harzianum* grown on various amended media**

| Substrate | Concentration of cake (%) | Population at different moisture regimes (c.f.u. x $10^6$/g substrate) | | |
|---|---|---|---|---|
| | | 40 % | 60 % | 80 % |
| Wheat bran + Neem cake | 5 | 120.6 (2.080) | 201.0 (2.303) | 100.8 (2.002) |
| | 10 | 137.2 (2.137) | 218.2 (2.339) | 109.6 (2.039) |
| | 20 | 141.8 (2.151) | 224.2 (2.351) | 120.0 (2.078) |
| Wheat bran + Groundnut cake | 5 | 160.6 (2.205) | 228.8 (2.359) | 148.6 (2.163) |
| | 10 | 171.6 (2.234) | 243.0 (2.385) | 138.6 (2.140) |
| | 20 | 182.8 (2.260) | 268.4 (2.429) | 149.2 (2.173) |
| Wheat bran + Mustard cake | 5 | 171.6 (2.234) | 244.6 (2.388) | 158.6 (2.200) |
| | 10 | 180.6 (2.256) | 256.8 (2.409) | 161.6 (2.208) |
| | 20 | 196.8 (2.294) | 291.2 (2.464) | 173.8(2.240) |
| Wheat bran + Linseed cake | 5 | 108.8 (2.036) | 191.2 (2.281) | 100.6 (2.002) |
| | 10 | 126.8 (2.103) | 218.2 (2.339) | 112.2 (2.049) |
| | 20 | 139.8 (2.145) | 224.8 (2.352) | 123.4(2.091) |
| Rice bran + Neem cake | 5 | 134.6 (2.128) | 181.2 (2.258) | 140.4 (2.147) |
| | 10 | 143.4 (2.156) | 204.4 (2.310) | 145.2 (2.162) |
| | 20 | 147.2 (2.167) | 210.8 (2.324) | 162.2(2.210) |
| Rice bran + Groundnut cake | 5 | 127.6 (2.105) | 221.6 (2.345) | 156.8(2.195) |
| | 10 | 137.8 (2.139) | 231.6 (2.365) | 170.2 (2.231) |
| | 20 | 156.6 (2.194) | 248.2 (2.394) | 183.2(2.263) |
| Rice bran + Mustard cake | 5 | 170.2(2.230) | 226.4(2.355) | 179.6(2.254) |
| | 10 | 177.2 (2.248) | 243.8 (2.387) | 189.2 (2.276) |
| | 20 | 185.0 (2.267) | 266.6 (2.426) | 198.2 (2.297) |
| Rice bran + Linseed cake | 5 | 114.8 (2.059) | 176.6 (2.247) | 125.2 (2.096) |
| | 10 | 122.4 (2.086) | 196.4 (2.293) | 138.2 (2.140) |
| | 20 | 133.2 (2.214) | 202.6 (2.306) | 149.2 (2.173) |
| Pulse bran + Neem cake | 5 | 115.8 (2.063) | 170.8 (2.232) | 144.2 (2.158) |
| | 10 | 122.4 (2.086) | 185.8 (2.269) | 154.2 (2.188) |
| | 20 | 131.4 (2.188) | 195.2 (2.290) | 162.6 (2.211) |
| Pulse bran + Groundnut cake | 5 | 145.2 (2.161) | 192.6 (2.284) | 176.4 (2.246) |
| | 10 | 154.8 (2.189) | 216.8 (2.336) | 180.2 (2.255) |
| | 20 | 163.6 (2.213) | 225.4 (2.353) | 195.2 (2.290) |
| Pulse bran + Mustard cake | 5 | 131.6 (2.119) | 195.4 (2.291) | 181.6 (2.259) |
| | 10 | 147.4 (2.168) | 208.8 (2.319) | 192.6 (2.285) |
| | 20 | 160.8 (2.206) | 236.2 (2.373) | 203.0 (2.307) |

| | | | | |
|---|---|---|---|---|
| Pulse bran + Linseed cake | 5 | 96.80 (1.984) | 147.8 (2.169) | 132.2 (2.120) |
| | 10 | 102.6 (2.003) | 163.8 (2.214) | 143.4(2.156) |
| | 20 | 125.8 (2.099) | 170.4 (2.231) | 152.6(2.183) |
| Orange peel + Neem cake | 5 | 103.8 (2.015) | 137.4 (2.137) | 116.4 (2.066) |
| | 10 | 110.8 (2.044) | 157.0 (2.195) | 130.6 (2.116) |
| | 20 | 122.6 (2.088) | 161.0 (2.207) | 140.0 (2.146) |
| Orange peel + Groundnut cake | 5 | 109.8 (2.040) | 147.0 (2.167) | 117.6 (2.070) |
| | 10 | 114.4 (2.057) | 162.4 (2.210) | 122.2 (2.087) |
| | 20 | 137.0 (2.136) | 184.6 (2.266) | 140.4(2.147) |
| Orange peel + Mustard cake | 5 | 119.6 (2.077) | 153.2 (2.185) | 126.0(2.100) |
| | 10 | 129.6 (2.112) | 176.4 (2.246) | 135.4 (2.131) |
| | 20 | 146.8 (2.166) | 190.4 (2.279) | 161.2 (2.207) |
| Orange peel + Linseed cake | 5 | 81.2 (1.909) | 133.2 (2.124) | 105.8 (2.024) |
| | 10 | 93.0 (1.966) | 143.0 (2.155) | 121.8 (2.085) |
| | 20 | 109.4 (2.038) | 161.2 (2.207) | 136.8 (2.135) |

Figures in parentheses are log- transformed values

bran + groundnut cake and wheat bran + mustard cake, population significantly differ with increase in concentration of the oil cake even at the same level of moisture content. Same population of *T. harzianum* was recorded (224.8 x $10^6$ c.f.u./g) in both wheat bran + neem cake (20 %) and wheat bran + linseed cake (20 %) combination both at 60 per cent moisture level.

When rice bran was amended with different oil cakes, rice bran + mustard cake (20 %) produced highest growth (266.6 x $10^6$ c.f.u./g) of *T. harzianum* at 60 per cent moisture which differ significantly from the population recorded at 80 per cent moisture (198.2 x $10^6$ c.f.u./g) and also at 40 per cent moisture (185.0 x $10^6$ c.f.u./g) (Table 2). Lowest growth was recorded in rice bran + linseed cake (5 %) combination especially at 40 per cent moisture level (114.8 x $10^6$ c.f.u./g).

The results presented in Table 2 revealed that pulse bran + mustard cake (20%) combination gave highest population (236.2 x $10^6$ c.f.u./g) at 60 per cent moisture level followed by groundnut cake (225.4 x $10^6$ c.f.u./g) at same concentration which were statistically on par. But other two combinations of pulse bran at the same concentration *i.e.* pulse bran + neem cake showed population (195.2 x $10^6$ c.f.u./g) and pulse bran + linseed cake showed (170.4 x $10^6$ c.f.u./g) population which significantly differ from one another. Irrespective of different oil cake combination with pulse bran, *T. harzianum* at 40 per cent moisture level produced minimum population.

The results of the combination of orange peel with different oil cakes at three different moisture levels are presented in Table 6. Orange peel + mustard cake (20 %) at 60 per cent moisture level gave maximum growth (190.4 x $10^6$ c.f.u./g) which did not differ significantly with orange peel + groundnut cake (20 %) at the same moisture level. Least population was recorded in both orange peel + neem cake (20 %) and orange peel + linseed cake (20 %) combination (161.2 x $10^6$ c.f.u./g). The overall result indicated that growth of *T. harzianum* was highest at 60 per cent than those at 80 per cent moisture content.

Moisture content of substrate plays an important role in determining the growth and sporulation of *T. harzianum*. Elad *et al.* (1980)

observed that when the moisture content of wheat bran + saw dust medium was 35 per cent (v/v) *T. harzianum* grew and sporulated better as compare to 40 per cent moisture content. The lower moisture may adversely affect fungal antagonist directly while higher moisture act indirectly by increasing the activity of bacteria, which hinder the multiplication of fungi. Maintenance of the moisture level at 40 to 60 per cent would be optimum for fast multiplication of antagonists when FYM is used as substrate (Jacob and Sivaprakasam, 1993). This finding is in accordance with the out come of the present study though here some other substrates were used to conduct the experiment.

**Effect of pH**

The effect of different pH levels were tested for the growth and sporulation of *T. harzianum* on wheat bran + mustard cake (20 per cent) substrate (Figure 1). The results indicated that the antagonist could grow satisfactorily at the acidic pH. Highest growth was recorded at pH 5.5 followed by 5.0 producing 342 x $10^6$ c.f.u./g and 321 x $10^6$ c.f.u./g of substrate, respectively, at 21 days after incubation. Compered to pH 8.0

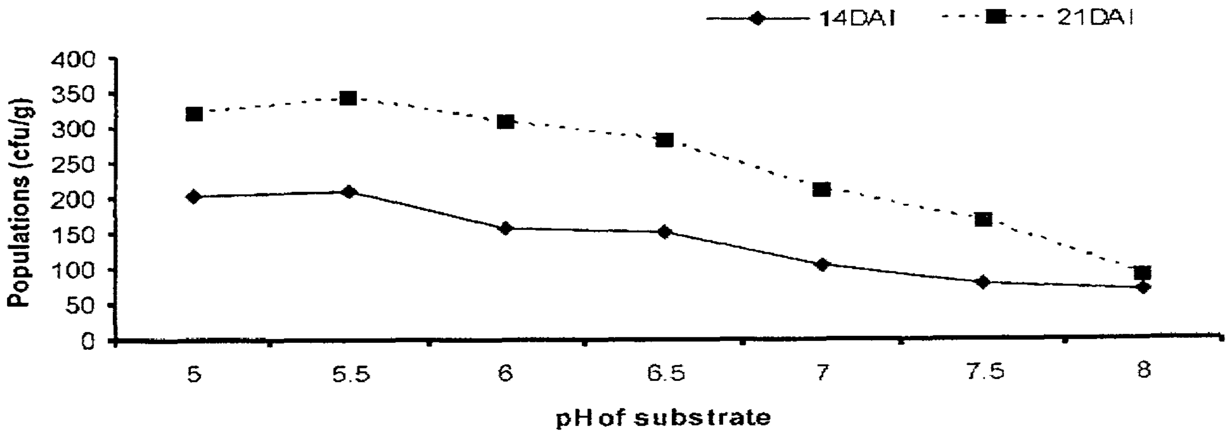


**Fig.1. Effect of pH levels in the substrates for mass multiplication of *T. harzianum***

**Table 3. Growth of *T. harzianum* on various mediaat variable temperature**

| Substrate | Population (c. f. u. x $10^6$ / g of substrate) | | |
|---|---|---|---|
| | 20°C | 25°C | 30°C |
| Wheat bran | 150.0 (2.176) | 175.8 (2.245) | 183.4 (2.263) |
| Orange peel | 129.8 (2.113) | 144.4 (2.159) | 142.2 (2.153) |
| Rice bran | 142.2 (2.152) | 172.4 (2.236) | 176.2 (2.246) |
| Pulse bran | 137.8 (2.139) | 162.8 (2.211) | 161.4 (2.208) |
| Neem cake | 60.60 (1.781) | 72.80 (1.862) | 85.60 (1.932) |
| Groundnut cake | 69.40 (1.839) | 74.40 (1.869) | 91.60 (1.961) |
| Mustard cake | 71.80 (1.854) | 87.80 (1.943) | 108.4 (2.034) |
| Linseed cake | 42.20 (1.620) | 58.60 (1.743) | 60.80 (1.783) |

Figures in parentheses are log-transformed values

**Table 4. Growth of *T. harzianum* grown on various amended media at variable temperature**

| Substrate | Concentration of cake (%) | Population (c.f.u. x $10^6$/g substrate) | | |
|---|---|---|---|---|
| | | 20 % | 25 % | 30 % |
| Wheat bran + Neem cake | 5 | 182.2 (2.261) | 212.4 (2.327) | 220.8 (2.344) |
| | 10 | 195.4 (2.291) | 220.2 (2.343) | 224.2 (2.351) |
| | 20 | 203.4 (2.308) | 216.2 (2.335) | 214.2 (2.331) |
| Wheat bran + Groundnut cake | 5 | 172.8 (2.238) | 214.4 (2.331) | 226.2 (2.354) |
| | 10 | 179.4 (2.254) | 222.2 (2.347) | 233.2 (2.368) |
| | 20 | 215.8 (2.334) | 246.2 (2.391) | 249.6 (2.397) |
| Wheat bran + Mustard cake | 5 | 203.8 (2.309) | 231.8 (2.365) | 237.8 (2.376) |
| | 10 | 227.8 (2.358) | 241.2 (2.382) | 249.8 (2.398) |
| | 20 | 238.4 (2.377) | 266.2 (2.425) | 290.4 (2.463) |
| Wheat bran + Linseed cake | 5 | 147.6 (2.169) | 163.2 (2.213) | 180.2 (2.256) |
| | 10 | 152.2 (2.182) | 174.4 (2.242) | 195.6 (2.291) |
| | 20 | 176.20 (2.246) | 195.2 (2.290) | 211.4 (2.325) |
| Rice bran + Neem cake | 5 | 141.8 (2.151) | 183.8 (2.264) | 193.8 (2.287) |
| | 10 | 165.4 (2.218) | 191.6 (2.282) | 198.2(2.297) |
| | 20 | 174.4 (2.241) | 199.2 (2.299) | 204.2 (2.310) |
| Rice bran + Groundnut cake | 5 | 166.2 (2.220) | 196.2 (2.292) | 215.6 (2.333) |
| | 10 | 175.6 (2.244) | 203.6 (2.308) | 228.6(2.359) |
| | 20 | 186.0 (2.269) | 218.6 (2.339) | 253.4 (2.403) |
| Rice bran + Mustard cake | 5 | 177.8(2.250) | 205.6 (2.312) | 216.8 (2.336) |
| | 10 | 192.4 (2.284) | 223.4 (2.349) | 238.4 (2.377) |
| | 20 | 217.6 (2.337) | 241.2 (2.382) | 264.6 (2.422) |
| Rice bran + Linseed cake | 5 | 142.6 (2.163) | 161.4 (2.207) | 186.4(2.270) |
| | 10 | 151.6 (2.180) | 178.6 (2.252) | 196.2 (2.293) |
| | 20 | 158.4 (2.199) | 178.8 (2.252) | 194.8(2.289) |
| Pulse bran + Neem cake | 5 | 144.6 (21.59) | 161.8 (2.209) | 171.8 (2.235) |
| | 10 | 172.2 (2.236) | 200.8 (2.303) | 193.2 (2.286) |
| | 20 | 174.2(2.241) | 185.6 (2.268) | 182.0 (2.260) |
| Pulse bran + Groundnut cake | 5 | 162.8 (2.211) | 178.4 (2.251) | 194.6 (2.289) |
| | 10 | 166.8 (2.222) | 186.8 (2.271) | 206.2 (2.314) |
| | 20 | 173.2 (2.238) | 203.2 (2.308) | 238.2 (2.377) |
| Pulse bran + Mustard cake | 5 | 145.2 (2.161) | 163.4 (2.213) | 181.2 (2.258) |
| | 10 | 152.6 (2.183) | 171.2 (2.233) | 197.8 (2.296) |
| | 20 | 183.8 (2.264) | 207.4 (2.316) | 242.6(2.385) |

| | | | | |
|---|---|---|---|---|
| Pulse bran + Linseed cake | 5 | 138.4 (2.140) | 155.8 (2.192) | 165.6 (2.219) |
| | 10 | 154.8 (2.189) | 169.6 (2.229) | 179.8 (2.254) |
| | 20 | 168.6 (2.226) | 175.8 (2.245) | 186.6 (2.271) |
| Orange peel + Neem cake | 5 | 101.2 (2.004) | 121.2 (2.083) | 132.6 (2.122) |
| | 10 | 109.6 (2.039) | 133.6 (2.125) | 146.6 (2.166) |
| | 20 | 115.8 (2.063) | 137.8 (2.139) | 148.6 (2.171) |
| Orange peel + Groundnut cake | 5 | 122.2 (2.086) | 136.2 (2.134) | 144.4 (2.159) |
| | 10 | 151.4 (2.180) | 168.6 (2.227) | 179.6 (2.254) |
| | 20 | 154.8 (2.190) | 172.2 (2.236) | 196.8 (2.294) |
| Orange peel + Mustard cake | 5 | 125.2 (2.097) | 140.0 (2.146) | 147.6 (2.168) |
| | 10 | 151.6 (2.180) | 165.8 (2.219) | 190.8 (2.280) |
| | 20 | 167.4 (2.223) | 183.2 (2.263) | 204.4 (2.310) |
| Orange peel + Linseed cake | 5 | 98.8 (1.994) | 118.8 (2.047) | 119.6 (2.077) |
| | 10 | 106.8 (2.027) | 131.8 (2.119) | 139.4 (2.144) |
| | 20 | 119.2 (2.076) | 132.8 (2.122) | 152.8 (2.184) |

Figures in parentheses are log- transformed values

producing only 67 x $10^6$ and 89 x $10^6$ c.f.u./g at 14 and 21 days after incubation, respectively. *Trichoderma* spp. has selectivity at a particular pH, some can grow at acidic range and few are at neutral alkaline reaction depending upon the ecological habitat from where it was isolated. Most of the *Trichoderma* isolate prefer acidic environment, some prefer neutral pH inhabiting in alkaline condition. Jackson *et al.* (1991) found that *Trichoderma* isolate produced optimum biomass at acidic to neutral range between pH 4.0 and pH 6.3. The results obtained in this study is in the line of the findings of Singh *et al.* (1998) who showed that maximum population density of *T. harzianum* and *T. viride* at pH 5.5 to 6.0.

**Effect of temperature**

It appears from the data presented in Table 3 that irrespective of substrate inoculated with *T. harzianum* when incubated at 30°C produced higher growth and showed at par with 25°C temperatures. The population of antagonist was least when incubated at 20°C.

The experiment was also conducted with different oil cakes and it was observed that except in linseed cake where no variability in population obtained between 25° and 30°C, all other oil cakes supported the growth of antagonist, being highest at 30°C followed by 25° and 20°C (Table 3).

The effect on the incubation temperature in different combination of brans and oil cakes presented in Table 4. The overall trend of results was similar with the population recorded highest at 30°C followed by 25° and 20°C.

The increased growth, sporulation and biomass production of the *Trichoderma* isolate were observed between 25° and 30°C (Malathi and Doraisamy, 2003). In the present study the effect of temperature on growth and sporulation of *Trichoderma harzianum* in different substrates revealed that it was higher at 30°C followed by 25° and 20°C which were not significant in all cases. This may be due to the ability of this isolate to grow in temperature regime of 25° - 30°C.

**Greenhouse study**

The results depicted in Table 5 revealed that the wheat bran + mustard cake (20 %)

**Table 5. Efficacy of different formulations of *T. harzianum* for the control of stem rot of Jute**

| Treatment | Germination (%) | Per cent mortality of jute | | | | Reduction in (%) disease incidence |
|---|---|---|---|---|---|---|
| | | 15 DAS | 30 DAS | 45 DAS | 60 DAS | |
| Wheat bran + mustard cake (20%) | 89.0 (71.4) | 10.0 (18.4) | 21.0 (27.3) | 26.0(30.6) | 29.0(36.1) | 70.0 |
| Rice bran + mustard cake (20%) | 81.0 (64.4) | 12.0 (20.3) | 17.0 (24.3) | 28.0(31.9) | 34.0(37.3) | 64.6 |
| Pulse bran + mustard cake (20%) | 72.0 (58.1) | 17.0 (24.3) | 22.8 (28.6) | 31.0(33.8) | 42.0(38.9) | 55.5 |
| Orange peel + mustard cake (20%) | 63.0 (52.6) | 19.0 (25.8) | 31.0 (33.8) | 34.0(35.6) | 55.0(41.4) | 41.7 |
| Control | 50.0 (45.0) | 30.0 (33.2) | 63.0 (52.6) | 81.0(64.4) | 100.0(77.9) | - |
| CD (0.05%) | 6.418 | 1.532 | 2.545 | 3.664 | 4.643 | |

The values are the average of four replications and figures in parenthesis are angular transformed values

preparation of *T. harzianum*, has shown significantly higher germination (%), lower percent mortality of jute at all the dates observed and highest percentage reduction in stem rot disease than the other treatments. It could also be concluded that all the treatments performed better than control in terms of per cent reduction in disease incidence. The least effect in controlling stem rot of jute, was observed by the orange peel + mustard cake preparation whereas other two preparations were with intermediate effect. The possible reason for the efficacy of different bran/peel – mustard cake preparation of *T. harzianum* against stem rot of jute may be due to most suited food bases and essential nutrients in the substrates which supports early growth and sporulation of above said fungal antagonist and thereby parasitizing the sclerotia and mycelia of *M. phaseolina*. Successful biological control of *M. phaseolina* with *Trichoderma* and *Gliocladium* spp. has been reported (Kousalya and Jeyarajan, 1991; Rajeswari *et al.*, 1999; Pant and Mukhopadhyay, 2001) with different crops and the extent of reduction in disease incidence was quite similar to the present findings. This result is also in the line of findings of Rajeswari *et al.* (1999) who observed that the germination percentage of mung bean was increased up to 96 per cent, plant height by 35.5 cm and 95.3 per cent reduction in disease incidence.

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