**Table 1.** Growth inhibition of *Macrophomina phaseolina, Rhizoctonia solani, Fusarium solani* and *F. oxysporum* in dual culture plate assay by the endophytic fungi isolated from different wild and cultivated plants.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Fungi | Host name | *M. phaseolina* | *R. solani* | *F. solani* | *F. oxysporum* |
| Zone of inhibition (mm) | | | |
| *Chaetomium* sp*.*  (KUCC-1359) | *Momordica charantia* L.  (G.H.No. 94618) | 29c±4.9 | 15a±3.5 | 25bc±2.1 | 31f±2.9 |
| *Talaromyces assiutensis* | *Euphorbia hirta* L.  (G.H.No. 12615) | 20ab±1.6 | 24c±3.8 | 27bc±1.4 | 15a±1.8 |
| *Talaromyces trachyspermus* | *Haloxylon stocksii* (Boiss.)  (G.H.No. 93479) | 25bc±2.4 | 26c±3.1 | 33d±3.1 | 20cd±1.8 |
| *Curvularia lanata* | *Allium cepa L.*  (G.H.No. 95608) | 18a±3.1 | 16ab±1.6 | 30a±1.8 | 25ab±2.1 |
| *Curvularia hawaiiensis* | *Euphorbia hirta* L. | 20ab±1.6 | 16ab±3.1 | 18a±1.9 | 27e±0.81 |
| *Fusarium solani* | *Chenopodium album* L.  (G.H.No. 89235) | 25bc±2.4 | 16ab±3.1 | 16a±2.1 | 20cd±1.4 |
| *Macrophomina phaseolina* | *Indigofera hochstetteri* Baker  (G.H. No. 38211) | 17c±4.9 | 19bc±2.1 | 18b±3.0 | 27d±2.2 |
| *Aspergillus terreus* | *Sida ovata* Forssk.  (G.H. No. 12278) | 15a±3.5 | 20abc±4.7 | 15a±1.9 | 18bc±1.8 |
| *Fusarium solani* | *Corchorus olitorius* [L.](https://en.wikipedia.org/wiki/Carl_Linnaeus)  (G.H. No. 50663) | 18a±4.3 | 26c±1.6 | 29cd±3.0 | 25e±2.4 |
| *Talaromyces assiutensis* | *Solanum melongena L.*  (G.H. No. 82045) | 21ab±2.0 | 26c±3.2 | 17cd±2.4 | 28cd±0.81 |

Values in column bearing same superscript letter are not significantly different at p<0.05 according to Duncan’s multiple range test

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 2** *In vitro* growth inhibition of *Macrophomina phaseolina*, *Rhizoctonia solani*, *Fusarium solani* and *F. oxysporum* by culture filtrates of PGPEF isolated from healthy plants | | | | | | | | | | | | | | | | | | | | | | |
| Fungi | | | | Culture filtrates | *M. phaseolina* | | | | | | *R. solani* | | | | *F. solani* | | | | *F. oxysporum* | | | | | |
|  | | | Zone of inhibition(mm) | | | | | | | | | | | | | | | | | |
| Control | | | |  | | | | 0a±0.0 | | | 0a±0.0 | | | | 0a±0.0 | | | | 0a±0.0 | | | |
| +ve Control | | | | Carbendazim(20µg/disc) | | | | 5bc±0.8 | | | 7bcd±1.8 | | | | 10cdef±2.0 | | | | 9cdef±2.9 | | | |
| *Chaetomium* sp*.* | | | |  | | | | | | | | | | | | | | | | | | |
|  | | | | 20µl/disc | | | | 11efghi±2.1 | | | 10defg±2.0 | | | | 9cdef±2.1 | | | | 8bcd±1.8 | | | |
| 40µl/disc | | | | 14hijk±2.2 | | | 15klmn±2.9 | | | | 15hijk±2.4 | | | | 11efg±1.9 | | | |
| 60µl/disc | | | | 19lmn±4.6 | | | 19lm±3.1 | | | | 21mn±2.1 | | | | 19ijk±2.3 | | | |
| *Talaromyces assiutensis* | | | |  | | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | | 5bc±0.8 | | | 4b±1.4 | | | | 5bc±0.8 | | | | 7bcd±0.8 | | | |
| 40µl/disc | | | | 10cdef±2.0 | | | 13ghi±3.1 | | | | 14hij±2.1 | | | | 19ijk±2.2 | | | |
| 60µl/disc | | | | 18lmn±2.1 | | | 18mn±2.1 | | | | 19lmn±2.3 | | | | 23mn±3.1 | | | |
| *T. trachyspermus* | | | |  | | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | | 8bcdef±1.8 | | | 9cdef±2.0 | | | | 6bc±1.8 | | | | 10cde±2.0 | | | |
| 40µl/disc | | | | 15ijkl±3.6 | | | 17jkl±2.4 | | | | 15hijk±1.6 | | | | 19ijk±2.5 | | | |
| 60µl/disc | | | | 20mn±2.5 | | | 23n±2.6 | | | | 21mn±2.0 | | | | 24n±2.9 | | | |
| *Curvularia lanata* | | | |  | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | 4b±1.4 | | | 0b±0 | | | | 4cdef±2.3 | | | | 5bcd±1.8 | | | |
| 40µl/disc | | | 11cdef±2.9 | | | 8cdef±2.9 | | | | 7efghi±1.8 | | | | 9cde±1.9 | | | |
|  | | | | 60µl/disc | | | 16jkl±2.4 | | | 10hij±2.2 | | | | 11jkl±2.1 | | | | 12ghi±2.2 | | | |
| *Curvularia hawaiiensis* | | | |  | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | 8bcde±1.8 | | | 4d±1.0 | | | | 5bc±0.8 | | | | 8bcd±1.8 | | |
| 40µl/disc | | | 15jkl±3.6 | | | 7bcd±1.8 | | | | 8bcde±1.8 | | | | 13fgh±2.1 | | |
| 60µl/disc | | | 17lmn±2.9 | | | 12fghi±1.8 | | | | 16ijkl± | | | | 14fgh±2.2 | | |
| *Fusarium solani* |  | | | | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | | | | 6bcd±1.8 | | | 5bc±0.8 | | | | 7bcd±1.4 | | | | 8bcd±1.8 | | | |
| 40µl/disc | | | | | | 9cdef±2.9 | | | 8bcde±1.8 | | | | 10cdef±1.8 | | | | 9def±2.4 | | | |
| 60µl/disc | | | | | | 13ghij±3.1 | | | 11efgh±1.9 | | | | 15hijk±1.6 | | | | 16hij±2.5 | | | |
| *Macrophomina phaseolina* | |  | | | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | | 5bcde±1.8 | | | 0a±0 | | | | 7b±2.1 | | | | 7bc±0.8 | | | | |
| 40µl/disc | | | | 9fghi±1.8 | | | 6bcde±1.6 | | | | 11cde±1.4 | | | | 9bcde±1.5 | | | | |
| 60µl/disc | | | | 11ijkl±2.1 | | | 12ghi±1.9 | | | | 11fgh±2.1 | | | | 18ghi±1.9 | | | | |
| *Aspergillus terreus* | | |  | | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | | 5bc±0.8 | | 4b±1.4 | | | | 5bc±1.9 | | | | 5bc±0.8 | | | | |
| 40µl/disc | | | | 11efgh±1.9 | | 9cde±1.9 | | | | 11def±0.8 | | | | 10cdef±1.7 | | | | |
| 60µl/disc | | | | 15ijkl±2.2 | | 14hij±2.1 | | | | 16ijk±2.0 | | | | 14fgh±2.0 | | | | |
|  | | |  | | | |  | |  | | | |  | | | |  | | | | |
| *Fusarium solani* | | |  | | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | | 4b±1.4 | | 5bc±0.8 | | | | 7bcd±2.1 | | | | 4b±1.4 | | | | |
| 40µl/disc | | | | 10d±2.0 | | 12fgh±1.6 | | | | 9cdef±0.8 | | | | 8bcde±1.8 | | | | |
| 60µl/disc | | | | 17klmn±2.9 | | 11efg±2.0 | | | | 15hijk±1.3 | | | | 12defg±1.8 | | | | |
| *T. assiutensis* | | | |  | | | | | | | | | | | | | | | | | | | |
| 20µl/disc | | | | 10defg±2.0 | | | | 6bc±1.8 | | | | 7bcd±0.8 | | | | 7bcd±0.8 | | | |
| 40µl/disc | | | | 17klmn±2.9 | | | | 15m±2.1 | | | | 17jkl±1.3 | | | | 16hij±1.4 | | | |
| 60µl/disc | | | 21n±2.1 | | | | | 22n±2.5 | | | | 22n±1.8 | | | | 20jk±1.8 | | | |

Values in column bearing same superscript letter are not significantly different at p<0.05 according to Duncan’s multiple range test

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 3.** *In vitro* antifungal activity of *n*-hexane and chloroform soluble fractions of culture filtrates of endophytic fungi. | | | | | | | | | |
| Endophytic Fungi | Conc. of culture filtrates | Zone of inhibition (mm) | | | | | | | |
| *M. phaseolina* | | *R. solani* | | *F. solani* | | *F. oxysporum* | |
| Hexane | Chloroform | Hexane | Chloroform | Hexane | Chloroform | Hexane | Chloroform |
|  | Control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomium* sp. | +ve control\* | 5 | 10 | 12 | 9 | 10 | 10 | 9 | 15 |
| 20μl/disc | 12 | 10 | 8 | 7 | 9 | 6 | 12 | 9 |
| 40μl/disc | 17 | 12 | 11 | 9 | 12 | 10 | 16 | 13 |
| 60μl/disc | 19 | 15 | 13 | 11 | 17 | 13 | 20 | 16 |
| *Talaromyces assiutensis* |  |  |  |  |  |  |  |  |  |
| 20μl/disc | 9 | 7 | 11 | 8 | 9 | 6 | 8 | 5 |
| 40μl/disc | 13 | 9 | 14 | 11 | 12 | 9 | 10 | 9 |
| 60μl/disc | 17 | 14 | 20 | 14 | 15 | 11 | 16 | 13 |
| *Talaromyces trachyspermus* |  |  |  |  |  |  |  |  |  |
| 20μl/disc | 8 | 5 | 9 | 7 | 11 | 9 | 6 | 4 |
| 40μl/disc | 12 | 9 | 11 | 10 | 13 | 11 | 11 | 8 |
| 60μl/disc | 15 | 10 | 15 | 12 | 15 | 13 | 13 | 11 |

**Table 4.** Effects of endophytic fungi on the infection of *Fusarium solani, F. oxysporum, Rhizoctonia solani* and *Macrophomina phaseolina* of sunflower roots in pots experiments.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | **Infection %** | | | | | | | |
| *F. solani* | | *F. oxysporum* | | *M. phaseolina* | | *R. solani* | |
|  | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| Control | 25 | 31.2 | 25 | 18.75 | 50 | 62.5 | 18.7 | 18.5 |
| Carbendazim | 12.5 | 18.75 | 12.5 | 18.75 | 25 | 25 | 6.2 | 6.25 |
| *Cephalosporium* sp*.* | 18.7 | 6.25 | 18.7 | 0 | 18.7 | 18.75 | 0 | 0 |
| *Chaetomium* sp*.* | 0 | 0 | 0 | 0 | 12.5 | 6.25 | 0 | 0 |
| *Talaromyces assiutensis* | 12.5 | 18.75 | 12.5 | 0 | 25 | 31.2 | 0 | 0 |
| *T. trachyspermus* | 0 | 0 | 0 | 12.5 | 0 | 0 | 0 | 0 |
| \*LSD0.05 |  | Treatments= 9.51 Pathogens= 8.52 | | | | | | |

1In column, mean values showing differences more than LSD value are significantly different at p<0.05

2In row, mean values showing differences more than LSD value are significantly different at p<0.05

**Table 5.** Effects of endophytic fungi on growth of sunflower plants in pots experiment.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | Shoot length  (cm) | | Shoot wt.  (g) | | Root length  (cm) | | Root wt.  (g) | |
|  | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| Control | 29.3 | 30.8 | 5.8 | 5 | 3.9 | 4.2 | 0.4 | 0.3 |
| Carbendazim | 38 | 36 | 9 | 8.3 | 5.4 | 5.4 | 0.6 | 0.5 |
| *Cephalosporium* sp*.* | 43.5 | 45.8 | 11.1 | 11.2 | 7.1 | 8 | 1.1 | 1.4 |
| *Chaetomium* sp*.* | 38.2 | 39.5 | 9.4 | 8.5 | 7.3 | 6.5 | 0.7 | 1 |
| *Talaromyces assiutensis* | 34.1 | 35.7 | 7 | 7.2 | 5.6 | 5.1 | 0.6 | 0.9 |
| *T. trachyspermus* | 41.3 | 40.6 | 9.8 | 8.2 | 6.8 | 6.2 | 0.6 | 1.0 |
| L.S.D(p<0.05) | 4.1 | 6.1 | 2.4 | 1.4 | 1.9 | 1.4 | 0.3 | 0.3 |

1Mean values in the column showing difference greater than LSD value are significantly different at p<0.05

|  |
| --- |
| **Table 6.** Effects of endophytic fungi on the infection of *Fusarium solani, F. oxysporum,* *Macrophomina phaseolina* and *Rhizoctonia solani* of sunflower plants in field experiments. |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Treatments |  | | | | **Infection %** | | | |  | | | |  | | | | | *F. solani* | | | | *F. oxysporum* | | | | *M. phaseolina* | | | | *R. solani* | | | | | 2017 | | 2018 | | 2017 | | 2018 | | 2017 | | 2018 | | 2017 | | 2018 | | | 45 d | 60 d | 45 d | 60 d | 45 d | 60 d | 45 d | 60 d | 45 d | 60 d | 45 d | 60 d | 45 d | 60 d | 45 d | 60 d | | Control | 25 | 31.2 | 37.5 | 43.7 | 18.7 | 25 | 12.5 | 25 | 43.7 | 50 | 61.2 | 75 | 18.7 | 25 | 12.5 | 25 | | Carbendazim | 25 | 25 | 18.7 | 25 | 12.5 | 12.5 | 6.2 | 18.7 | 25 | 43.7 | 37.5 | 43.7 | 12.5 | 18.7 | 12.5 | 18.7 | | *Cephalosporium* sp*.* | 18.7 | 25 | 6.2 | 12.5 | 0 | 12.5 | 0 | 0 | 18.7 | 25 | 18.7 | 25 | 0 | 0 | 0 | 0 | | *Chaetomium* sp*.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18.7 | 25 | 25 | 31.2 | 0 | 0 | 0 | 0 | | *Talaromyces assiutensis* | 18.7 | 25 | 12.5 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 12.5 | 18.7 | 6.2 | 12.5 | 12.5 | 18.7 | | *Talaromyces trachyspermus* | 0 | 0 | 0 | 0 | 6.2 | 12.5 | 6.2 | 18.7 | 0 | 6.25 | 0 | 12.5 | 0 | 0 | 0 | 0 | | LSD0.05 | Treatments = 4.71; Pathogens2 = 3.8; Time=2.73 | | | | | | | | | | | | | | | |   1In column, mean values showing differences more than LSD value are significantly different at p<0.05  2In row, mean values showing differences more than LSD value for pathogens are significantly different at p<0.05  3In row, mean values showing differences more than LSD value for time are significantly different at p<0.05 |
| **Table 7.** Effects of endophytic fungi on growth of sunflower plants under field condition.   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Treatments | Shoot length (cm) | | | | Shoot weight (g) | | | | Root length (cm) | | | | Root weight (g) | | | | |  | 2017 | | 2018 | | 2017 | | 2018 | | 2017 | | 2018 | | 2017 | | 2018 | | |  | **45 d** | **60 d** | **45 d** | **60 d** | **45 d** | **60 d** | **45 d** | **60 d** | **45 d** | **60 d** | **45 d** | **60 d** | **45 d** | **60 d** | **45 d** | **60 d** | | Control | 57.5 | 73.7 | 64.4 | 74.3 | 37.3 | 48.7 | 36.7 | 61.4 | 7.4 | 8.1 | 7.7 | 9.9 | 7.6 | 11.5 | 10.5 | 12.9 | | Carbendazim | 72.5 | 104.2 | 78.6 | 90.9 | 61.6 | 113.2 | 61.5 | 115 | 11.7 | 11.8 | 10.6 | 14.1 | 12.6 | 16.5 | 14.3 | 18.7 | | *Cephalosporium* sp*.* | 98.7 | 150.1 | 102.5 | 129.8 | 83.6 | 193 | 93.3 | 170 | 14 | 20.5 | 13.8 | 19.9 | 14.7 | 19.1 | 15.2 | 23.2 | | *Chaetomium* sp*.* | 91.7 | 112.5 | 95.5 | 107.3 | 66.6 | 133 | 77.2 | 127 | 11.7 | 12.3 | 12 | 15.8 | 12.5 | 15 | 11.2 | 19.9 | | *Talaromyces assiutensis* | 84.7 | 101 | 88.7 | 100.6 | 56.1 | 98.6 | 60.4 | 113 | 10 | 12.32 | 10.2 | 12.4 | 7.8 | 8.4 | 10.7 | 15.8 | | *Talaromyces trachyspermus* | 92.2 | 131.5 | 99.3 | 112.6 | 74.7 | 143.7 | 77 | 130.5 | 12.2 | 14.7 | 9.5 | 16 | 10.6 | 14.5 | 12 | 20.7 | | LSD0.05 | 7.91 | 10.31 | 8.71 | 8.91 | 10.61 | 27.81 | 7.91 | 29.51 | 2.31 | 2.81 | 3.21 | 4.11 | 1.71 | 2.31 | 2.41 | 2.31 |   1In column, mean values showing differences more than LSD values are significantly different at p<0.05 |