# Original Research Article
# Evaluation of Fungicides against *Fusarium pallidoroseum* (Cooke) Sacc. causing Wilt of Coriander *in vitro*


## ABSTRACT

Coriander (*Coriandrum sativum* L.) is one of the most important spice crop known to affect by various diseases. Among them, coriander wilt causes serious problems and is mainly caused by *F. solani* (Mart.) Sacc. or *F. oxysporum* f. sp. *coriandrii* or it is also caused by a newly reported causal agent *Fusarium pallidoroseum* (Cooke) Sacc. Looking to the importance of disease, a laboratory experiment was conducted to study the efficacy of different non-systemic fungicides at 1000, 1500 and 2000 ppm; systemic fungicides at 100, 250 and 500 ppm and ready-mix fungicides at 500, 750 and 1000 ppm concentrations against *F. pallidoroseum* using Poisoned Food Technique. The results revealed that, among non-systemic fungicides, copper oxychloride 50 WP at all concentration found significantly superior with cent per cent mycelial growth inhibition. In contrast, propineb 70 WP found least effective at 1000 ppm concentration (2.71%). Among systemic fungicides, flusilazole 40 EC and thiophanate methyl 70 WP each at 500 ppm concentration gave cent per cent mycelial growth inhibition of *F. pallidoroseum*. While, kresoxim methyl 44.3 SC found least effective at 100 and 250 ppm concentration (9.74 and 12.95%). Among ready-mix fungicides, prochloraz 5.7 + tebuconazole 1.4 ES at all concentration and azoxystrobin 18.2 + difenoconazole 11.4 SC at 1000 ppm concentration found effective and showed cent per cent mycelial growth inhiition of *F. pallidoroseum*. While, fluxapyroxad 25 + pyraclostrobin 25 SC at 500 ppm found least effective (18.34%).



***Keywords:*** *Coriander; wilt; Fusarium pallidoroseum; fungicides; mycelial growth inhibition*.


## 1. INTRODUCTION

Coriander [*Coriandrum sativum* L. (2n=22)] is one of the most important spice crop and is native to Mediterranean and Middle Eastern regions. It is regularly used in Indian Kitchen. It contains an essential oil called “coriandrol” which is responsible for pleasant aroma in the crop (Chahal *et al*., 2017) [1]. Coriander also called as Cilantro, Arab parsley or Chinese parsley is cultivated for its seeds and foliage in India. Its seed is an ingredient of garam masala and pudding spices. Medicinally coriander is a valuable herb for treating digestive disorders (Lal *et al*., 2014) [9].

It contains water (7.3 g), food energy (279 kcal), protein (21.83 g), fat (4.76 g), carbohydrates (52.10 g), ash (14.02 g), calcium (1.246 mg), iron (42.46 mg) and vit.-A (566.7 mg) (Singh *et al*., 2015) [15]. Coriander is a tropical crop. It is sown generally in the month of October-November. It can be grown in loamy or black soil. Saline, alkaline and sandy soils are not suitable for its cultivation (Lal *et al.,* 2014) [9]. Coriander is known to affect by many fungal diseases. Among them, coriander wilt causes serious problems and results in yield losses upto 60 per cent (Manoranjitham *et al*., 2003) [10]. The wilt disease of coriander is mainly caused by *F. solani* (Mart.) Sacc. or *F. oxysporum* f. sp. *coriandrii* or it is also caused by a newly reported causal agent *Fusarium pallidoroseum* (Cooke) Sacc. in coriander crop (Pithiya and Kanzaria, 2024)

[12]. Looking to the importance of disease, the current investigation on "Evaluation of Fungicides against *Fusarium pallidoroseum* (Cooke) Sacc. causing Wilt of Coriander *in vitro*" is being undertaken.

## 2. MATERIALS AND METHOD

The experiment was conducted in laboratory condition at Department of Plant Pathology, College of Agriculture, Junagadh Agricultural University, Junagadh during the year 2023-24. The non-systemic, systemic and ready-mix fungicides each with three different concentrations were tested against *F. pallidoroseum* using Poisoned Food Technique. The experiment was laid out in Completely Randomized Design (factorial concept) with three repetitions.

The experiment comprises with seven non-systemic fungicides *viz*., chlorothalonil 75 WP, copper oxychloride 50 WP, mancozeb 75 WP, metiram 70 WG, propineb 70 WP, wettable sulphur 80 WP and zineb 75 WP at 1000, 1500 and 2000 ppm concentrations; seven systemic fungicides *viz*., carbendazim 50 WP, difenoconazole 25 EC, flusilazole 40 EC, fosetyl-Al 80 WP, kresoxim-methyl 44.3 SC, propiconazole 25 EC and thiophanate methyl 70 WP at 100, 250 and 500 ppm concentrations and seven ready-mix fungicides *viz*., azoxystrobin 18.2 difenoconazole 11.4 SC, carbendazim 25 + mancozeb 50 WS, carboxin 37.5 + thiram 37.5 WS, fluxapyroxad 250 g/l + pyraclostrobin 250 g/l SC, kresoxim-methyl 15 + chlorothalonil 56 WG, metiram 55 + pyraclostrobin 5 WG and prochloraz 5.7 + tebuconazole 1.4 ES at 500, 750 and 1000 ppm concentrations were evaluated against *F. pallidoroseum in vitro*.

Appropriate quantity of each fungicide required was incorporated into autoclaved 100 ml PDA medium in 250 ml conical flask before solidification. After thoroughly shaking on the vertex, the medium was poured into sterilized Petri plates (90 mm dia.) in equal quantity (20 ml per Petri plate) to form a uniform layer. The plates were then allowed to solidify. After solidification, an actively growing mycelial bit of *F. pallidosoreum* of 4 mm diameter cut with the help of sterilized cork-borer were transferred under aseptic conditions in an inverted position in the center of the plate to make a direct contact with solidified PDA medium. Then Petri plates were incubated at 28±1 C till the control plate attains full growth and observations were recorded on radial mycelial growth in treated and control plates. Inoculated Petri plates containing PDA medium without fungicides were served as control (Grover and Moore, 1962) [3].

The per cent mycelial growth inhibition of the fungus in each of the treatments were calculated by using the following formula (Vincent, 1947) [16].

Where,
I = Per cent inhibition of mycelial growth
C = Mean radial growth of fungus in control plate (mm)
T = Mean radial growth of fungus in treated plate (mm)

### 2.1 Statistical analysis

Statistical analysis was carried out as per standard methods as suggested by Panse and Sukhatme (1985) [11].

## 3. RESULTS AND DISCUSSION

The observations on mycelial growth inhibition exerted by non-systemic, systemic and ready-mix fungicides were recorded after nine days of inoculation. The results obtained are communicated hereunder.

### 3.1 *In vitro* efficacy of non-systemic fungicides against *F. pallidoroseum*

The data presented in Table 1, Plate I-A and Figure 1 revealed that all non-systemic fungicide were capable of reducing the mycelial growth of *F. pallidoroseum in vitro* as compared to control. Among different non-systemic fungicides tried *in vitro*, cent per cent mean mycelial growth inhibition was observed in copper oxychloride 50 WP. Whereas, the least effective fungicides found were propineb 70 WP (12.87%) and wettable sulphur 80 WP (19.52%).

As the concentration of fungicides increases, the mycelial growth inhibition of *F. pallidoroseum* also increases. Among the three concentrations, 2000 ppm concentration remained significantly superior with mycelial growth inhibition of 59.08 per cent.

While, looking to the interaction effect between the non-systemic fungicides and various concentrations, copper oxychloride 50 WP at all concentration found significantly superior with cent per cent mycelial growth inhibition. The next effective treatment in order of merit was zineb 75 WP (76.72%) at 2000 ppm concentration. Among different treatments, propineb 70 WP found the least effective at 1000 ppm concentration (2.71%).

The results obtained were in accordance with the findings of Satyanarayan *et al*. (2021) [14] as copper oxychloride 50 WP observed highly effective in mycelial growth inhibition. Whereas, wettable sulphur 80 WP remained less effective in mycelial growth inhibition as per findings of Kadri and Kanzaria (2018) [7] while working with *Rhizoctonia solani* Kuhn.

### 3.2 *In vitro* efficacy of systemic fungicides against *F. pallidoroseum*

The data presented in Table 2, Plate I-B and Figure 2 revealed that all the systemic fungicide were capable of reducing the mycelial growth of *F. pallidoroseum in vitro* as compared to control. Among different systemic fungicides, flusilazole 40 EC found significantly superior over rest of the treatments with 95.95 per cent mean mycelial growth inhibition. The treatment with minimum mean mycelial growth inhibition was observed in kresoxim methyl 44.3 SC (30.61%) followed by fosetyl AL 80 WP (44.35%).

As the concentration of fungicides increases, the mycelial growth inhibition of *F. pallidoroseum* also increases. Among the three concentrations, 500 ppm concentration remained significantly superior over rest of the concentrations with 85.30 per cent mean mycelial growth inhibition.

The interaction effect between systemic fungicides and concentrations shows that, flusilazole 40 EC and thiophanate methyl 70 WP at 500 ppm concentration found significantly superior over rest of the treatments with cent per cent inhibition of mycelial growth of *F. pallidoroseum*. Whereas, kresoxim methyl 44.3 SC found least effective at 100 and 250 ppm concentration with minimum mycelial growth inhibition of 9.74 and 12.95 per cent, respectively.

The present findings closely coincides with the results of Jat *et al*. (2017) [6]. They reported thiophanate methyl 70 WP as highly effective treatment in mycelial growth inhibition of *Fusarium* spp. The effectiveness of carbendazim 50 WP against *Fusarium* spp. was also reported by Ghaghara (2019) [2], Jadav *et al*. (2022) [4] and Jangir *et al*. (2022) [5].

### 3.3 *In vitro* efficacy of ready-mix fungicides against *F. pallidoroseum*

The data presented in Table 3, Plate I-C and Figure 3 revealed that all the ready-mix fungicides were capable of reducing the mycelial growth of *F. pallidoroseum in vitro* as compared to control. Among all ready-mix fungicides, prochloraz 5.7 + tebuconazole 1.4 ES found significantly superior over rest of the treatments with mean mycelial growth inhibition of cent per cent. The next effective treatment was carbendazim 25 + mancozeb 50 WS with 87.57 per cent mean mycelial growth inhibition. The treatment with minimum mean mycelial growth inhibition was recorded in metiram 55 + pyraclostrobin 5 WG (23.76%) followed by fluxapyroxad 25 + pyraclostrobin 25 SC (39.10%).

As the concentration of fungicides increases, the mycelial growth inhibition of *F. pallidoroseum* also increases. Among the three concentrations of ready-mix fungicides, 1000 ppm concentration remained significantly superior over rest of the concentrations with 78.85 per cent mean mycelial growth inhibition.

The interaction effect between the ready-mix fungicides and concentrations revealed that, prochloraz 5.7 + tebuconazole 1.4 ES at all the three concentration and azoxystrobin 18.2 + difenoconazole 11.4 SC at 1000 ppm concentration found significantly superior and cent per cent inhibited the mycelial growth of *F. pallidoroseum in vitro*. Whereas, fluxapyroxad 25 + pyraclostrobin 25 SC at 500 ppm and metiram 55 + pyraclostrobin 5 WG at all concentration found less effective as compared to other treatments and had minimum mycelial growth inhibition of 18.34, 20.91, 23.51 and 26.86 per cent, respectively.

More or less similar type of trend using ready-mix fungicides were also reported by different scientists while working with *Fusarium* spp. The effectiveness of carbendazim 25 + mancozeb 50 WS against *F. oxysporum* in fenugreek had been recorded by Rani (2015) [13]. The effectiveness of carboxin 37.5 + thiram 37.5 DS also reported by Kala *et al*. (2013) [8] and Jat *et al*. (2017) [6] while working with *Fusarium* spp.

## 4. CONCLUSION

Based on the present study on “Evaluation of fungicides against *Fusarium pallidoroseum* (Cooke) Sacc. causing wilt of coriander *in vitro*”, it can be concluded that copper oxychloride 50 WP at 1000, 1500 and 2000 ppm concentrations among non-systemic fungicides; flusilazole 40 EC and thiophanate methyl 70 WP each at 500 ppm concentration among systemic fungicides and prochloraz 5.7 + tebuconazole 1.4 ES at 500, 750 and 1000 ppm concentrations and azoxystrobin 18.2 + difenoconazole 11.4 SC at 1000 ppm concentration among ready-mix fungicides found significantly superior over rest of the treatments and gave cent per cent mycelial growth inhibition of *F. pallidoroseum* under laboratory condition.

## REFERENCES


- Chahal KK, Singh R, Kumar A, Bhardwaj U. Chemical composition and biological activity of *Coriandrum sativum* L.: A review. Indian Journal of Natural Products and Resources. 2017;8(3):193-203.
- Ghaghara A. Characterization of *Fusarium oxysporum* f. sp. *coriandrii* causing wilt of coriander and its management. M. Sc. (Agri.) Thesis. Junagadh Agricultural University, Junagadh; 2019.

- Grover RK, Moore JD. Toximetric studies of fungicides against the brown rot organisms, *Sclerotinia fruticola* and *S. laxa*. Phytopathology. 1962;52(9):876-880.
- Jadav AH, Akbari LF, Barad AJ, Bhaliya CM. Efficacy of different fungicides for the management of castor wilt (*Fusarium oxysporum* f. sp. *ricini*). The Pharma Innovation Journal. 2022;11(6):2322-2325.
- Jangir H, Ram D, Choudhary A. Management of wilt disease of cumin caused by *F. oxysporum* f. sp. *cumini* with fungicides *in vitro* and *in vivo*. The Journal Research PJTSAU. 2022;50(1):101-107.
- Jat MK, Ahir RR, Kakraliya GL. Evaluation of fungicides as seed treatment against coriander wilt disease caused by *Fusarium oxysporum* f. sp. *corianderii*. International Journal of Plant Protection. 2017;10(1):92-95.
- Kadri NI, Kanzaria KK. *In vitro* efficacy of non-systemic and systemic fungicides against *Rhizoctonia solani* Kuhn causing root rot of coriander. International Journal of Chemical Studies. 2018;6(1):1992-1995.
- Kala C, Gangopadhyay S, Godara SL. Efficacy of fungicides in suppressing chickpea wilt caused by *Fusarium oxysporum* f. sp. *ciceri*. Plant Disease Research. 2013; 28(1):71-73.
- Lal G, Saran PL, Devi G, Bijarniya D, Raj R. Seed Production Technology of Coriander (*Coriandrum sativum*). *In*: Advances in vegetable agronomy. Chaudhary AK, Rana K S, Dass A, Srivastav M (Ed.). PGS, IARI and DARE, ICAR, New Delhi; 2014. p. 214-222.
- Manoranjitham SK, Rabindram R, Doraiswamy S. Management of seed borne pathogens and wilt disease of coriander. Madras Agricultural Journal. 2003;90:4-6.
- Panse VG, Sukhatme PV. Statistical methods for Agricultural workers. ICAR Publication, New Delhi; 1985. p. 361.
- Pithiya DG, Kanzaria KK. First report of *Fusarium pallidoroseum* (Cooke) Sacc. causing wilt disease in coriander (*Coriandrum sativum* L.). Archives of Biological Forum – An International Journal. 2024;16(7):29-32.
- Rani N. Studies on root rot/wilt of fenugreek with special reference to *Fusarium oxysporum* Schlecht. M. Sc. (Agri.) Thesis. University of Agricultural Sciences, Dharwad; 2015.
- Satyanarayana MSV, Gopal K, Ruth C, Sadarunnisa S, Bhaskar VV. Management of Fusarium root rot of coriander with chemical and bio-control agents. Indian Phytopathology. 2021;74(1):229-233.
- Singh D, Tanwar A, Agrawal P. An overview on coriander. Journal of Biomedical and Pharmaceutical Research. 2015;4(2): 67-70.
- Vincent JM. Distortion of fungal hyphae in the presence of certain inhibitors. Nature. 1947;159(4051):850.


**Table 1. *In vitro* efficacy of non-systemic fungicides against *F. pallidoroseum***

| Tr. No. | Non-systemic fungicides | Mycelial growth inhibition (%) | Mean mycelial |
|---|---|---|---|

| | | 1000 ppm | 1500 ppm | 2000 ppm | |
|---|---|---|---|---|---|
| 1. | Chlorothalonil 75 WP | 40.33 (41.88)* | 40.97 (43.00) | 59.18 (73.75) | 46.83 (52.88) |
| 2. | Copper oxychloride 50 WP | 90.05 (100.00) | 90.05 (100.00) | 90.05 (100.00) | 90.05 (100.00) |
| 3. | Mancozeb 75 WP | 44.17 (48.56) | 49.83 (58.38) | 58.58 (72.83) | 50.86 (59.92) |
| 4. | Metiram 70 WG | 15.73 (7.35) | 34.60 (32.25) | 40.98 (43.00) | 30.44 (27.53) |
| 5. | Propineb 70 WP | 9.47 (2.71) | 19.29 (10.91) | 30.00 (25.01) | 19.59 (12.87) |
| 6. | Wettable sulphur 80 WP | 23.38 (15.75) | 26.97 (20.57) | 28.14 (22.24) | 26.17 (19.52) |
| 7. | Zineb 75 WP | 40.33 (41.88) | 43.64 (47.63) | 61.15 (76.72) | 48.37 (55.41) |
| | **Mean** | 37.64 (36.88) | 43.62 (44.68) | 52.58 (59.08) | - |

| | Fungicide (F) | Concentration (C) | F x C |
|---|---|---|---|
| **S. Em. ±** | 0.31 | 0.20 | 0.53 |
| **C. D. at 5%** | 0.87 | 0.57 | 1.51 |
| **C.V.%** | 2.06 | | |

*Figures outside the parentheses are arcsine transformed, whereas inside are retransformed values

**Table 2. *In vitro* efficacy of systemic fungicides against *F. pallidoroseum***

| Tr. No. | Systemic fungicides | Mycelial growth inhibition (%) | | | Mean mycelial growth inhibition (%) |
|---|---|---|---|---|---|
| | | 100 ppm | 250 ppm | 500 ppm | |
| 1. | Carbendazim 50 WP | 73.84 (92.26)* | 75.07 (93.37) | 76.41 (94.48) | 75.11 (93.37) |
| 2. | Difenoconazole 25 EC | 59.56 (74.32) | 66.53 (84.14) | 71.62 (90.06) | 65.90 (82.84) |
| 3. | Flusilazole 40 EC | 75.07 (93.37) | 76.41 (94.48) | 90.05 (100.00) | 80.51 (95.95) |
| 4. | Fosetyl AL 80 WP | 37.06 (36.32) | 39.03 (39.66) | 49.08 (57.09) | 41.72 (44.35) |
| 5. | Kresoxim methyl 44.3 SC | 18.18 (9.74) | 21.10 (12.95) | 56.25 (69.13) | 31.84 (30.61) |
| 6. | Propiconazole 25 EC | 66.87 (84.57) | 67.87 (85.82) | 68.32 (86.36) | 67.69 (85.58) |
| 7. | Thiophanate methyl 70 WP | 59.80 (74.69) | 71.62 (90.06) | 90.05 (100.00) | 73.82 (88.25) |

| | | | | | |
|---|---|---|---|---|---|
| | **Mean** | 55.77 (66.47) | 59.66 (71.49) | 71.68 (85.30) | - |
| | | **Fungicide (F)** | **Concentration (C)** | | **F x C** |
| **S. Em. ±** | | 0.41 | 0.27 | | 0.71 |
| **C. D. at 5%** | | 1.17 | 0.77 | | 2.03 |
| **C.V.%** | | 1.98 | | | |

*Figures outside the parentheses are arcsine transformed, whereas inside are retransformed values

**Table 3.** ***In vitro*** **efficacy of ready-mix fungicides against *F. pallidoroseum***

| Tr. No. | Ready-mix fungicides | Mycelial growth inhibition (%) | | | Mean mycelial growth inhibition (%) |
|---|---|---|---|---|---|
| | | **500 ppm** | **750 ppm** | **1000 ppm** | |
| 1. | Azoxystrobin 18.2 + Difenoconazole 11.4 SC | 36.29 (35.03)* | 75.51 (93.74) | 90.05 (100.00) | 67.28 (76.25) |
| 2. | Carbendazim 25 + Mancozeb 50 WS | 66.81 (84.49) | 69.58 (87.82) | 71.96 (90.41) | 69.45 (87.57) |
| 3. | Carboxin 37.5 + Thiram 37.5 WS | 35.27 (33.35) | 52.33 (62.65) | 73.12 (91.57) | 53.57 (62.52) |
| 4. | Fluxapyroxad 25 + Pyraclostrobin 25 SC | 25.36 (18.34) | 32.05 (28.17) | 57.29 (70.80) | 38.23 (39.10) |
| 5. | Kresoxim methyl 15 + Chlorothalonil 56 WG | 54.68 (66.57) | 56.02 (68.76) | 58.23 (72.28) | 56.31 (69.20) |
| 6. | Metiram 55 + Pyraclostrobin 5 WG | 27.21 (20.91) | 29.00 (23.51) | 31.22 (26.86) | 29.14 (23.76) |
| 7. | Prochloraz 5.7 + Tebuconazole 1.4 ES | 90.05 (100.00) | 90.05 (100.00) | 90.05 (100.00) | 90.05 (100.00) |
| | **Mean** | 47.95 (51.24) | 57.79 (66.38) | 67.42 (78.85) | - |
| | | **Fungicide (F)** | **Concentration (C)** | | **F x C** |
| **S. Em. ±** | | 0.39 | 0.26 | | 0.68 |
| **C. D. at 5%** | | 1.11 | 0.73 | | 1.93 |
| **C.V.%** | | 2.03 | | | |

*Figures outside the parentheses are arcsine transformed, whereas inside are retransformed values

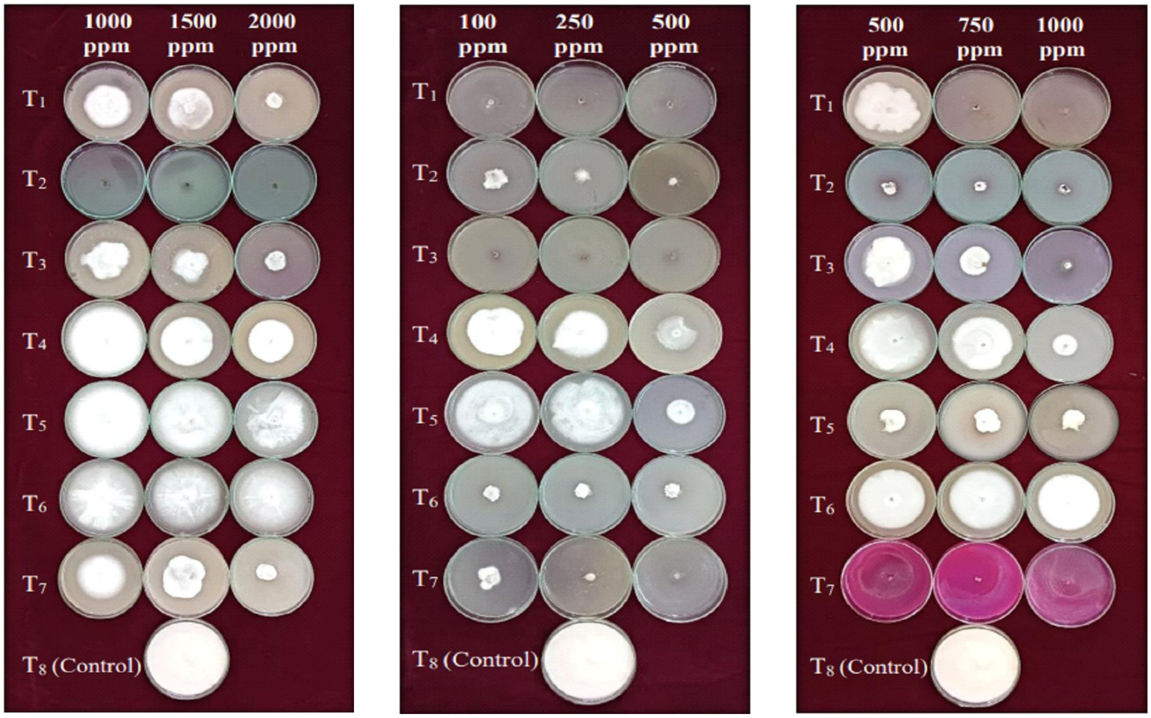


**Plate I.** ***In vitro*** **efficacy of non-systemic [A], systemic [B] and ready-mix [C] fungicides against** ***F. pallidoroseum***

**Figure 1.** ***In vitro*** **efficacy of non-systemic fungicides against** ***F. pallidoroseum***

**Figure 2.** ***In vitro*** **efficacy of systemic fungicides against** ***F. pallidoroseum***

**Figure 3.** ***In vitro*** **efficacy of ready-mix fungicides against** ***F. pallidoroseum***