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Evaluation of fungitoxicity of ginger (*Zingiber officinale*) extracts against some fungal pathogens

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Abstract
Ginger (*Zingiber officinale Rosc*) is a perennial herbaceous plant in the *Zingiberaceae* family whose rhizomes are used as a spice. Ginger has analgesic, sedative, cardiotonic, and antifungal properties. Phytochemical present in medicinal plant have benefits and antimicribiol activity against some plant pathogenic fungi. However little research has been undertaken on the antifungal activity of these extracts. This research aim at testing the antifungal activity of crude, powdered, boiled and ethanol extracts of ginger against test pathogens. The fungitoxicity of *Zingiber officinale* rhizome was evaluated in the form of powdered (20%), boiled (20%), crude (20%) and ethanol (2%) extracts against ten fungal pathogens *viz*., *Rhizoctonia solani, R. bataticola, Phoma sorghina, Colletotrichum gloeosporioides, Fusarium pallidorosem, F. oxysporum f. sp. ciceri, Sclerotium rolfsii, Sclerotinia sclerotiorum, Alternaria solani* and *A. alternata* under *in vitro* condition. The concentration of effective form was standardized and compared with the recommended chemical. The results reveals that all the four forms of *Z. officinale* rhizome extracts significantly inhibited the growth of all above test organisms but none of the forms could absolutely inhibit the growth of any one of the test fungus.

Keywords: Ginger, fungitoxicity, extracts, fungal pathogens

Introduction
Ginger (*Zingiber officinale* Rosc) is a perennial herbaceous plant in the *Zingiberaceae* family whose rhizomes are used as a spice. Ginger has analgesic, sedative, cardiotonic, and antifungal properties. India is the world's leading producer of ginger, producing 702.00 lakh tonnes from an area of 149.10 lakh hectares. Plant extracts have been shown to be a practical, safe, and cost-effective method of controlling plant diseases. Furthermore, their use in agriculture could be a suitable option for inclusion in disease control systems, acting as either primary or adjuvant antimicrobial compounds. The rhizomes of ginger comprise both scented and pungent compounds (McGee, 2004) [7]. Ginger contains from 0.25 to 3 percent volatile oil of light yellow colour (Herout, pliva 1953) [5] containing camphene, phellandrene, zingiberine, cineol, and borneol; gingerol 6-gingerol [5-hydroxy-1-(4'-hydroxy-3'-methoxyphenyl)-3-decanone] a yellow pungent body; an oleoresin-"gingerin" the active principle (combination of vol Gingerols are the main pungent compounds found in ginger. Ginger's nutritional profile includes protein, lipids, carbohydrates, minerals, vitamins, and trace nutrients. Ginger also contains capsaicin, curcumin, limonene, and proteolytic enzymes. It is also one of the best carrier herbs, with the potential to increase digestive absorption by up to 200 percent (Belewu, 2006) [3]. Component of gigeroil (zingiberon, bisabolen, camphene, geranial, linalool and borneol) possess beneficial antimicrobial properties. Phytochemical present in medicinal plant have benefits and antimicribiol activity against some plant pathogenic fungi. However little research has been undertaken on the antifungal activity of these extracts. This research aim at testing the antifungal activity of crude, powdered, boiled and ethanol extracts of ginger against test pathogens.

Method and Material
(A) Respective pathogen will be isolated from infected plant parts and there after the culture will be purified for evaluation study.
The pure culture of following test organism will be made -

Organism
Ten organism's *viz*., *Rhizoctonia solani*, *R. bataticola*, *Phoma sorghina*, *Colletotrichum*

gloeosporioides, Fusarium pallidorosem, F. oxysporum f. sp. ciceri, Sclerotium rolfsii, Sclerotinia sclerotium, Alternaria solani and *A. alternata* will be used in the form of following extracts.

Details of treatment

(B) *Zingiber officinale* rhizome and leaf extract form-05

1. Powdered extract.
2. Crude extract (Rhizome Extract).
3. Boiled extract.
4. Ethanol extract.

Result

The fungicidal properties of *Z. officinale* rhizome were evaluated against *R. solani* in crude (20%), powdered (20%), boiled (20%), and ethanol extract (2%) forms, and data are presented in table 1. All four forms are significantly effective in inhibiting the growth of the fungus. The powdered form had the lowest growth (30.00mm), followed by boiled (40.70mm), crude extract (43.80mm), and ethanol form (47.9mm), and control had the highest growth (88.70mm). The powdered form outperformed the boiled, crude, and ethanol forms.

Extracts of *Z. officinale* rhizome significantly inhibited the mycelial growth of *R. bataticola* but none of them completely inhibited the growth. Minimum mycelial growth (41.6mm) was recorded under powdered form @ 20% followed by crude extract @ 20% (60.8mm), boiled extract (62.6mm) and ethanol extract 2% (65.8mm). While the maximum growth (88.9mm) was recorded in control. In respect of growth inhibition the powdered extract was significantly superior over other forms.

The fungicidal properties of *Z. officinale* rhizome was evaluated under its powdered (20%), boiled (20%), crude (20%) and ethanol extract (2%) forms against *C. gloeosporioides* and the data are presented in table 1. which clearly indicate that all the four forms are effective in inhibiting the growth of the fungus. The minimum growth was recorded in powdered form (32.1mm) followed by boiled (41.9mm), crude extract (44.7mm) and ethanol form (48.6mm). While the maximum growths (89.1mm) was recorded in control. The powdered form was found most effective and it was significantly superior over other form.

It is clear from the data shown that all the four forms of *Z. officinale* rhizome extracts *viz.* powdered, boiled, crude and ethanol significantly inhibited the mycelial growth of *F. pallidorosum* but none of them absolutely inhibited the growth, however minimum growth was recorded under its boiled form @ 20% (40.4 mm). While the maximum of 88.3 mm growth was recorded in control. Boiled extract was significantly superior over crude, powdered and ethanol form.

It is obvious from the all the four forms of *Zingiber officinale* extracts significantly inhibited the growth of *Fusarium* but none of them completely inhibited the same, the minimum growth of the fungus was recorded under its boiled form (48.9 mm) followed by powered (62.7 mm), crude (66.5 mm), and ethanol form (61.1 mm), while a maximum of 89.0 mm growth was recorded in control. In respect of growth inhibition the boiled extract was significantly superior over the other forms.

All the four forms of *Z. officinale* extracts *viz.* powdered, boiled, crude and ethanol significantly inhibited the growth of *Phoma sorghina.* The minimum growth was recorded in its powdered form (59.6 mm), followed by boiled, ethanol and crude extract. (70.1 mm, 71.2 mm and 71.7 mm respectively), while the maximum of 89.2 mm growth was recorded by control. The powdered extract was significantly superior over three forms. However the boiled, ethnol and crude extract were statistically at par which each other.

It is obvious from the statistically analyzed data of table 1, that all the four forms of *Z. officinale* rhizome extracts *viz* powdered, boiled, crude and ethanol significantly inhibited the growth *of Sclerotium rolfsii* but none of them completely inhibited the same, however minimum growth was recorded under its boiled form @ 20% (60.1mm) followed by powdered (80.3 mm), ethanol (82.8mm) and crude extract (84.6 mm), The maximum of 87.9 mm growth was recorded in control. Boiled extract was significantly superior over powdered, ethanol and crude forms.

Zingiber officinale rhizome in the form of powdered, boiled, crude extract @ 20% and ethanol extract @ 2% significantly inhibited the growth of *S. slerotiorum* but none of them could show the complete inhibition of the growth. The minimum mycelial growth (57.8 mm) was recorded under its boiled form followed by crude extract (69.9 mm), powdered extract (71.8 mm) and ethanol @ (74.1mm). While the maximum of 87.9 mm growth was recorded in control. The boiled extract were significantly superior over crude, powdered and ethanol extract.

It is clear from the four extracts of *Z. officinale viz.* powdered, boiled, crude and ethanol significantly inhibited the growth of *A. solani* but none of them completely inhibited the growth, however minimum fungal growth (51.8 mm) was recorded under its boiled form @ 20%, followed by ethanol extract (64.1 mm), crude extract @ 20% (66.9mm) and powdered extract (69.0 mm), while the maximum of 89.4 mm growth was recorded in control. Boiled extract was significantly superior over ethanol, crude and powdered form.

Four forms of *Z. officinale* rhizome extracts *viz.* powdered, boiled, crude and ethanol extracts significantly inhibited the mycelial growth of *A. alternata* but none of them could absolutely inhibited the growth, however minimum growth of fungal mycelial (48.9 mm) was recorded under its boiled form @ 20%, followed by crude extract @ 20% (64.4 mm), powdered extract @ 20% (67.1mm) and ethanol extract @2% (69.2 mm), while the maximum of 89.4 mm growth was recorded in control. In respect of growth inhibition the boiled extract was significantly superior over the other three forms.

Table 1: Efficacy of different forms of *Zingiber officinale* rhizome extracts against different fungal pathogens

Treatments	*Rhizoctonia solani*	*Rhizoctonia bataticola*	*Colletorichum gloeosporioides*	*Fusarium paliidorosum*	*Fusarium oxysporum*	*Phoma sorghina*	*Sclerotinia sclerotiorum*	*Alternaria solani*	*Alternaria alternata*	*Sclerotium rolfsii*
Powdered @ 20%	30.0	41.6	32.1	55.3	62.7	59.6	71.8	69.0	67.1	80.3
Boiled @ 20%	40.7	62.6	41.9	40.4	48.9	70.1	57.8	51.8	48.9	60.1
Crude @ 20%	43.8	60.8	44.7	52.8	66.5	71.7	69.9	66.9	64.4	84.6
Ethanol @ 2%	47.9	65.8	48.6	57.1	68.1	71..2	74.1	64.1	69.2	82.8
Control	88.7	88.9	89.1	88.3	89.0	89.2	87.9	89.4	89.4	87.9
SE(m)±	0.60	0.36	0.29	0.34	0.39	0.32	0.33	0.30	0.41	0.39
CD at 5%	1.82	1.09	0.87	1.03	1.17	0.96	1.00	0.91	1.25	1.16

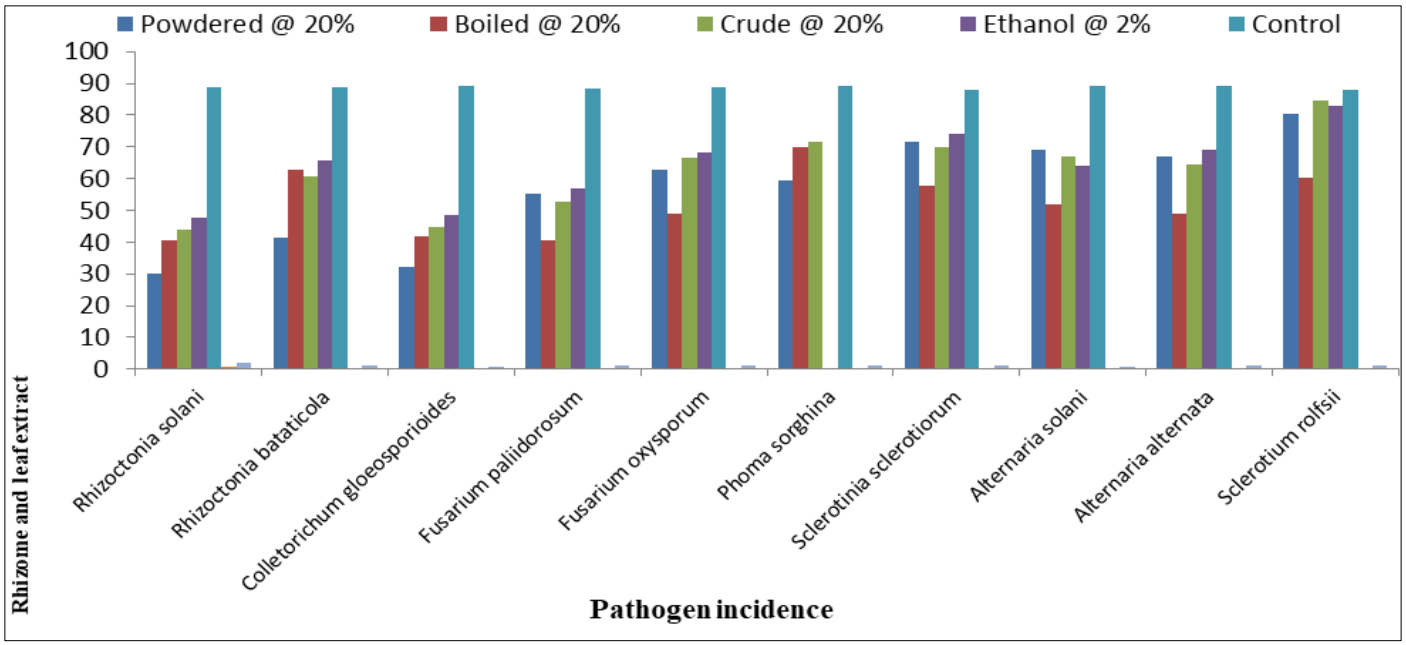

Fig 1: Efficacy of different forms of *Zingiber officinale* rhizome extracts against different fungal pathogens

Table 2: Comparative efficacy of powdered extract of *Z. officinale* rhizome under four concentrations against pathogens

Powdered rhizome extract (per cent)	*Rhizoctonia solani*	*Rhizoctonia bataticola*	*Colletorichum gloeosporioides*	*Phoma sorghina*
20	28.9	38.6	31.7	59.8
30	25.6	29.0	25.55	50.7
40	17.6	19.9	15.4	23.9
50	7.65	10.8	8.45	11.9
Control	88.65	88.9	87.7	89.1
SE(m)±	0.41	0.40	0.38	0.41
CD at 5%	1.23	1.21	1.14	1.23

It is obvious from the data summarized all the four concentrations *viz*., 20, 30, 40 and 50% of *Z. officinale* extract under powdered form significantly inhibited the growth of *R. solani*. Fungitoxity of the extract increases with the gradual increases in the concentration from 20% to 50% but the maximum concentration (50%) could not completely inhibited the growth and showed, minimum growth (7.65. mm), followed by 40% (17.6) mm), 30% (25.6 mm) and 20% (28.9 mm), while the maximum of 88.65 mm growth was recorded in control (Table-2, Fig.-2). The maximum concentration i.e. 50% was found significantly superior over 40%, 30% and 20% concentrations.

It is obvious from the four concentrations *viz*., 20, 30, 40 and 50% of *Z. officinale* extract under powdered form significantly inhibit the growth of *R. bataticola* but none of the concentration could completely inhibited the growth. However, minimum growth was recorded in 50% concentration (10.8 mm), followed by 40% (19.9 mm), 30% (29.0 mm) and 20% (38.6 mm), while the maximum of 88.9 mm growth was recorded in control (Fig.-2). The maximum concentration i.e. 50% was found significantly superior over rest of the three concentrations. 40% concentration was significantly superior over 30 and 20% concentration.

It is four concentrations *viz*., 20, 30, 40 and 50% of *Z. officinale* rhizome extract in powdered form significantly inhibited the growth of *C. gloeosporioides* but none of the concentration could completely inhibited the growth, however minimum growth was recorded under its 50% concentration (8.45 mm), followed by 40% (15.4 mm), 30% (25.5 mm) and 20% (31.7 mm), while the maximum of 87.7 mm growth was recorded in control. The maximum concentration i.e. 50% was found statistically significantly superior over 40, 30 and 20% concentration (Fig.-3).

It is obvious from the data summarized in the table 3, that all the four concentrations *viz*., 20, 30, 40 and 50% of *Z. officinale* rhizome under its powdered form significantly inhibited the growth of *P. sorghina*. The minimum growth was recorded under its 50% concentration (11.9 mm), followed by 40% (23.9 mm), 30% (50.7 mm) and 20% (59.08 mm), while the maximum of 89.1 mm growth was recorded in control. The highest tested concentration i.e. 50% was found significantly superior over other three concentrations. The 40% concentration was significantly superior over 20% and 30%. 30% was also significantly superior over its 20% concentration.

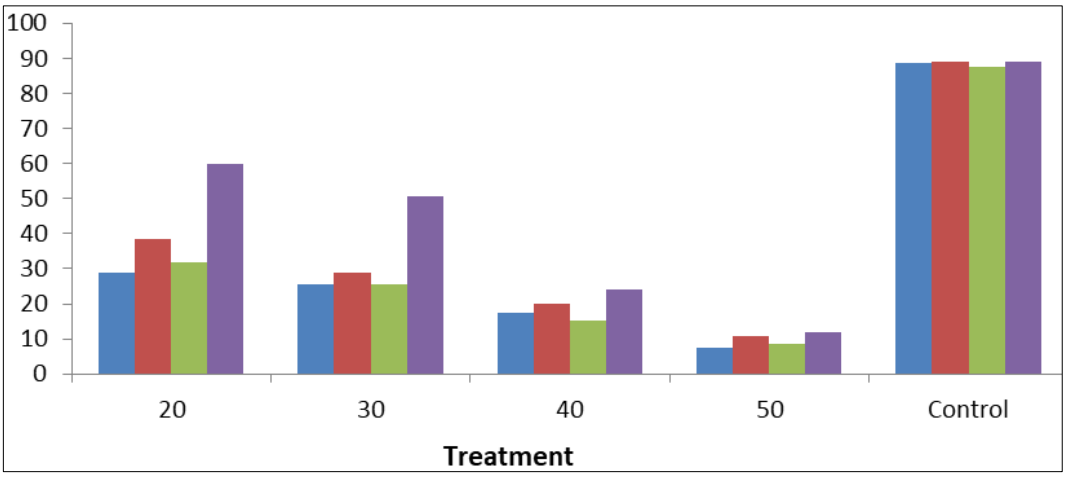

Fig 2: Efficacy of powdered extract of *Z. officinale* rhizome under four concentrations against pathogens

Table 3: Comparative efficacy of Boiled rhizome extract (per cent) of *Z. officinale* rhizome under four concentrations against pathogens

Boiled rhizome extract (per cent)	*Fusarium paliidorosum*	*Fusarium oxysporum*	*Sclerotium rolfsii*	*Sclerotinia sclerotiorum*	*Alternaria solani*	*Alternaria alternata*
20	55.3	60.3	59.8	57.7	51.8	48.8
30	40.4	49.9	48.9	45.8	39.0	39.8
40	52.8	27.4	25.9	28.1	22.4	20.7
50	57.1	10.6	11.0	11.1	10.0	8.1
Control	88.3	89.5	87.65	88.2	88.9	89.1
SE(m)±	0.34	0.39	0.37	0.30	0.37	0.28
CD at 5%	1.03	1.16	1.11	0.92	1.12	0.83

It is clear from the data presented that none of the tested concentrations of boiled rhizome extract of *Z. officinale viz*., 20, 30, 40 and 50% could completely inhibited the growth, of *F. oxysporum* but all the four concentrations significantly inhibited the growth. The minimum growth was recorded under its 50% concentration (10.6 mm), followed by 40% (27.4 mm), 30% (49.9 mm) and 20% (60.3 mm) as compared to 89.5 mm of control. The maximum concentration i.e. 50% was found significantly superior over *viz*.40%,30%,20% concentrations, the 40% concentration was also significantly superior over 30% and 20% concentrations. The 30% concentration was significant by superior over 20% concentration.

The tested concentrations of boiled rhizome extract of *Z. officinale viz*., 20, 30, 40 and 50% could completely inhibited the growth, of *F. oxysporum* but all the four concentrations significantly inhibited the growth. The minimum growth was recorded under its 50% concentration (10.6 mm), followed by 40% (27.4 mm), 30% (49.9 mm) and 20% (60.3 mm) as compared to 89.5 mm of control. The maximum concentration i.e. 50% was found significantly superior over *viz*. 40%, 30%, 20% concentrations, the 40% concentration was also significantly superior over 30% and 20% concentrations. The 30% concentration was significant by superior over 20% concentration.

The effectivity of *Zingiber officinale* rhizome in the form of boiled extract was gradually increased against *S. rolfsii* with the increase in its concentration from 20 to 50 per cent. All the four concentrations significantly inhibited the growth. The minimum growth was recorded under its 50% concentration (11.0 mm), followed by 40% (25.9 mm), 30% (48.9 mm) and 20% (59.8 mm) as compared to 87.6 mm growth in control. The 50%. Concentration was found significantly superior over, 40%, 30% and 20% concentrations.

It is obvious from the data summarized in table 3, that the effectivity of *Zingiber officinale* rhizome in the form of boiled extract was gradually increased against *Sclerotinia sclerotiorum* with the increase in its concentration from 20 to 50 per cent. All the four concentrations significantly inhibited the growth. The minimum growth was recorded under its 50% concentration (11.1 mm), followed by 40% (28.1 mm), 30% (45.8 mm) and 20% concentration (57.7 mm) as compared to 83.2 mm in control. The 50% concentration was found significantly superior over, 40%, 30% and 20% concentrations.

It is clear from the data presented in the table 26, that all the four tested concentrations significantly inhibited the growth of *A. solani* but the tested concentrations of boiled rhizome extract of *Z. officinale viz*., 20, 30, 40 and 50% could not completely inhibited the growth of *A. solani*. The minimum growth was recorded under its 50% concentration (10.0 mm), followed by 40% (22.4 mm), 30% (39.0 mm) and 20% (51.8 mm) as compared to 89.9 mm in control. The 50% concentration was found significantly superior over 40%., 30% and 20%. The 40% was significantly superior over 30% and 20% concentrations. The 20% concentration was least effective but it was significantly superior over control.

All the four concentrations *viz*., 20, 30, 40 and 50% of *Z. officinale* rhizome extract in boiled form significantly inhibited the growth of *Alternaria alternata* but none of them could absolutely inhibited the growth. The minimum growth was recorded under its 50% concentration (8.1mm), followed by 40% (20.7 mm), 30% (39.8 mm) and 20% (48.8 mm), while the maximum of 89.1 mm growth was recorded in control. The 50% concentration was significantly superior over the other three tested concentrations. The 40% concentration was found significantly superior over 30% and 20% concentrations. The 20% concentration was significantly superior over control.

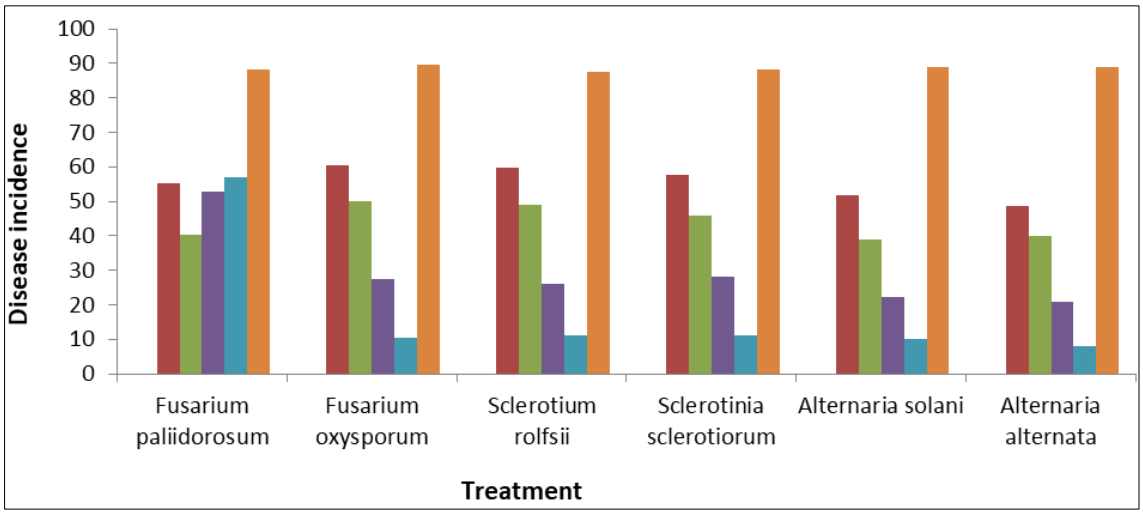

Fig 3: Efficacy of Boiled rhizome extract (per cent) of *Z. officinale* rhizome under four concentrations against pathogens

Discussion

The fungitoxicity of *Zingiber officinale* rhizome was evaluated in the form of powdered (20%), boiled (20%), crude (20%) and ethanol (2%) extracts against ten fungal pathogens *viz*., *Rhizoctonia solani, R. bataticola, Phoma sorghina, Colletotrichum gloeosporioides, Fusarium pallidorosem, F. oxysporum f. sp. ciceri, Sclerotium rolfsii, Sclerotinia sclerotiorum, Alternaria solani* and *A. alternata* under *in vitro* condition. The concentration of effective form was standardized and compared with the recommended chemical. The results reveals that all the four forms of *Z. officinale* rhizome extracts significantly inhibited the growth of all above test organisms but none of the forms could absolutely inhibit the growth of any one of the test fungus.

The phenolic compounds such as Gingerol, cedrene, zingiberene and α-curcumene present in *Z. officinale* extract play the vital role in growth inhibition of phytopathogenic fungi. Gingerol, cedrene and zingiberene were determined as the most effective antimicrobial component in *Z. officinale* extract (Mostafa *et al.*, 2011) [6]. Some researchers have suggested that antimicrobial components of the plant extracts cross the cell membrane interacting with the enzymes and proteins of the membrane, so producing a flux of protons towards the cell exterior which induces change in the cell and ultimately their death (Pane et al., 2011 and Omidbeygi *et al.*, 2007) [10, 9]. Other researcher attributed the inhibitory effect of these plant extracts to hydrophobicity characters of these plant extracts and their components. This enables them to partition in the lipids of the fungal cell wall membrane and mitochondria disturbing their structure and rendering them more permeable. Leaking of ions and other cell contents can then occur causing cell death (Burt, 2004) [2]. All the four forms are significantly effective in inhibiting the growth of the fungus. The minimum growth was recorded in its powdered form followed by boiled, crude extract and ethanol form. While the maximum growths was recorded in control.

The gradual increases in the concentration from 20% to 50% but the maximum concentration (50%) could not completely inhibited the growth. The maximum concentration i.e. 50% was found significantly superior over 40%, 30% and 20% concentrations. These results are in accordance with that of Ramanathan et al. (2004) [11]. All the four concentrations of *Z. officinale* extract under powdered form significantly inhibit the growth of *R. bataticola* but none of the concentration could completely inhibited the growth. The maximum concentration i.e. 50% was found significantly superior over rest of the three concentrations.

Rhizome extract in powdered form significantly inhibited the growth of *C. gloeosporioides* but none of the concentration could completely inhibited the growth, however minimum growth was recorded under its 50% concentration. The maximum concentration was found statisticaly significantly superior over other three concentration. These result supports the result of Somda *et al*. 2007 [12].

Okigbo and Nmeka (2005), Taiga *et al* (2008) [8, 13] control yam rot with leaf of *Zingiber officinale* and inhibited the growth of *Fusarium oxysporum* mycelium with cold extract of *Nicotiana tabacum.* All the four concentrations of *Z. officinale* rhizome under its powdered form significantly inhibited the growth of *P. sorghina*. The minimum growth was recorded under its 50% concentration. The highest tested concentration was found significantly superior over other three concentrations.

All the four forms of *Z. officinale* rhizome extracts *viz* powdered, boiled, crude and ethanol significantly inhibited the growth *of Sclerotium rolfsii* but none of them completely inhibited the same, however minimum growth was recorded under its boiled form. Boiled extract was significantly superior over powdered, ethanol and crude forms. The effectivity of *Zingiber officinale* rhizome in the form of boiled extract was gradually increased against *S. rolfsii* with the increase in its concentration. All the four concentrations significantly inhibited the growth. The 50% concentration was found significantly superior over three concentrations. These finding are supported by Iacomi-Vasilescu *et al*. (2004), Celer (2000), Abdel- Rehim *et al*. (1987) [15, 1].

The tested concentrations of boiled rhizome extract of *Z. officinale* could not completely inhibited the growth of *A. solani.* The 50% concentration was found significantly superior over three form. Vasant *et al*. (2010) [14] ten per cent rhizome extract of *Zingiber officinale*, *Allium sativum* and *Curcuma longa* proved inhibitory to the *Alternaria alternata*, *Aspergillus flavus*, *Curvularia lunata*, *Fusarium roseum* and *Trichoderma viride*. It was interesting to note that *Musa paradisiaca* rhizome *extract* stimulated the growth of *Trichoderma Viride.*

Conclusion

All the four forms powdered (20%), boiled (20%) crude (20%) and ethanol (2%) of *Zingiber officinale* rhizome extracts significantly inhibited the growth of the test organisms *viz., Rhizoctonia solani, R. bataticola, Phoma sorghina, Colletotrichum gloeosporioides, Fusarium pallidorosem, F. oxysporum f. sp. ciceri, Sclerotium rolfsii, Sclerotinia sclerotiorum, Alternaria solani* and *A. alternata*, but none of forms could absolutely inhibit the growth of any one of the test fungus.

The powdered extract was found significantly superior over other forms for inhibiting the growth of *Rhizoctonia solani, R. bataticola Phoma sorghina, Colletotrichum gloeosporioides*.

The growth of the species of *Fusarium pallidorosem, F. oxysporum f. sp. ciceri, Sclerotium rolfsii, Sclerotinia sclerotiorum, Alternaria solani* and *A. alternata* more effectively inhibited under its boiled form than the other three forms.

The effectivity of powdered and boiled extract against the respective fungus was gradually increased with the increase in the concentration from 20 to 50%, but the complete inhibition of the respective test fungus could not be achieved even at maximum concentration i.e. 50%.

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