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In vitro management of colocasia (*Colocasia esculenta*) leaf blight caused by *Phytophthora colocasiae*

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Abstract
Leaf blight caused by *Phytophthora colocasiae* Raciborski is the most important disease of colocasia and has become a limiting factor for production in all colocasia growing areas in India. The results revealed that all the seven bioagentstested *in vitro* applying dual cluture technique against *Phytophthora colocasiae* significantly inhibited the mycelial growth of the test pathogen over untreated control. However, *T. harzianum* (Sardarkrushinagar) highest inhibition (69.99) of mycelial growth of *Phytophthora colocasiae* over control followed by *T. harzianum* (Junagadh) with 69.25 per cent inhibition. Results revealed that different fungicides tested *in vitro* applying Poisoned Food Technique against *Phytophthora colocasiae* significantly inhibited the mycelial growth of the test pathogen over untreated control. Among systemic fungicide more than 90% growth inhibition was recorded in azoxystrobin, difenconazole and propiconazole (99.25, 98.14 and 97.77%, respectively) at 500 ppm concentration. The next best in order of merit was Azoxystrobin at 250 ppm concentration with 97.77% growth inhibition. Among non-systemic fungicides more than 90% growth inhibition was recorded in mancozeb, copperoxychloride and chlorothalonil (96.66, 90.73 and 90.73%, respectively) at 2000 ppm concentration. The next best in order of merit was mancozeb at 1500 ppm concentration with 92.22% growth inhibition. Compound fungicides in general revealed that metalaxyl 8% + mancozeb 64% WP recorded significantly highest growth inhibition of 100 and 99.25% at 500 and 250 ppm, respectively followed by carbendazim 12% + mancozeb 63% WP with 98.51% growth inhibition at 500 ppm. Evaluation of different botanicals by Poisoned Food Technique showed that all plant extracts tested *in vitro* were found significantly effective in reducing the per centage mycelial growth of *Phytophthora colocasiae* over control. Effective mean growth inhibition percentages of 51.84, 47.77, 43.69, 43.14 and 43.14 was recorded in aqueous extracts of neem leaf, lantana, NSKE, ardusa and barmasi. Four de oiled cakes at 5, 10, 20 and 30 per cent were tested for its efficacy against the radial growth of *P. colocasiae* using poisoned food technique. More than 85% growth inhibition was recorded in neem cake and castor cake (93.33 and 88.51%, respectively) at 30 per cent concentration.

Keywords: Bioagents, *Colocasia esculenta*, fungicides, plant extract, *Phytophthora colocasiae*, oil Cacks

Introduction
Colocasia (*Colocasia esculenta* (L.) Schott) is perennial monocotyledonous herbaceous root crop widely cultivated in tropical and subtropical world. It belongs to family Araceae and origin of South East Asia (Rashmi *et al*., 2018) [19]. It is widely cultivated in the high rainfall areas and even under flooded condition. It is known by various names in different regions such as taro, colocasia, arvi, cocoyam and dasheen. Two types of colacasia are commonly cultivated throughout the country *viz*., *Colocasia esculenta* var. *esculenta* Plucknett (Dasheen type) and *Colocasia esculenta* var. *antiquorum* Plucknett (Eddoe type) (Misra *et al*., 2008) [11].
The corms, cormels and leaves of colocasia are eaten as fried and cooked vegetable. Various delicious dishes are prepared by using different plant parts. The leaves of *C. esculenta* have been reported to be rich in nutrients, including minerals and vitamins such as phosphorus, calcium, vitamin C, iron, riboflavin, thiamine, and niacin. The fresh edible leaves are also rich source of protein, dietary fiber, ascorbic acid, and some nutritionally important minerals. The corm of colocasia is relatively low in protein (1.5%) and fat (0.2%). It is a good source of starch (70–80 g/100 g dry taro), fiber (0.8%) and ash (1.2%) (Sudhakar *et al.* 2020) [26]. Nutritive value of colocasia is given as per 100 gm fresh tuber include moisture 73.1; Protein 3.0 (g); Fat 0.1 (g); Minerals 1.7 (g); fibre 1.0 (g); Carbohydrate 21.1 (g); Energy 97.0 Kcal; Calcium 40 (mg); Phosphorus 140 (mg); Iron 1.7 (mg); Vitamin A 24 IU; Thiamine 0.09 (mg); Niacin 0.4 (mg) and Riboflavin 0.03 (mg) (Misra *et al.*, 2008) [11].
In India, it is mainly grown in Andhra Pradesh, Uttar Pradesh, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra (Konkan region), Tamil Nadu and West Bengal (Saykar

et al., 2019) [21]. In Gujarat, the crop is grown in isolated pockets.

All the plant parts leaves, stem and tubers shows different medicinal properties. The tubers are rich in starch and used almost everywhere as vegetable, leaves and petiole are also cooked and eaten as vegetable. It is predominantly used to treat cardiovascular, liver, central nervous system (CNS), digestive, and metabolic disorders. Since colocasia are potential to produce significant therapeutic effect, they can be useful as drug or supplement in the treatment or management of various diseases. Some of the properties includes antimicrobial, antihepatotoxic, anti-diabetic, anti-lipid peroxidative action, antimetastatic, antifungal, anti-inflammatory and many more. In addition to its nutritional and economic importance, colocasia also plays a significant role in cultural custom in different parts of India (Pawar *et al.*2018) [16].

As colocasia is nutrient rich vegetable, it is liable to be affected by many biotic and abiotic factors. The crop is reported to be attacked by a minimum of twenty- three pathogens *viz.*, Phytophthora (leaf blight), Pythium(rot), Phyllosticta (leaf spot), Cladosporium (leaf spot), Spongy black rot, Black rot, (rot), Fusarium dry rot, Dasheen mosaic, Bacterial soft rot, Bacterial leaf spot. Of them Phytophthora leaf blight caused by *Phytophthora colocasiae* Raciborski is the most devastating disease which occurs regularly and causes heavy yield losses. Among various diseases, leaf blight of colocasia caused by soil borne fungus *Phytophthora colocasiae* Racib., is the most destructive disease of worldwide occurrence. Leaf blight can reduce colocasia corm yield by 50 per cent or more for highly susceptible colocasia cultivars (Nelson *et al*., 2011) [12].

The disease was reported in Indonesia, India, Sri Lanka, Taiwan, Burma, Philippines, Malaysia, Hawaii, Paua, Solaman Islands, Pacific Islands, Indonasia, Malaysia, Sarawak, Africa and Caribbean countires (Misra *et al*., 2008) [11]. In India, the disease was recorded for first time by Butler and Kulkarni (1913) [2]. The disease has become a limiting factor for production in all colocasia growing areas in India moderate to severe form causing 25 to 50% yield loss (Mishra *et al.*, 2007) [10].

In order to know the cause of the severe brown rot and gummosis of sweet orange and to develop suitable control measures the present research project was undertaken. Looking to seriousness of disease and to develop suitable management measures the present work was undertaken.

Materials and Methods

In vitro efficacy of bioagents against pathogen

The *in vitro* efficacy of promising seven bio-agents *viz*., *Trichoderma viride* (Sardarkrushinagar), *Trichoderma viride* (Junagadh), *Trichoderma harzianum* (Junagadh), *Trichoderma harzianum* (Sardarkrushinagar), *Trichoderma harzianum* (Navsari), *Trichoderma harzianum* (Jagudan) and *Pseudomonas fluorescens* (Sardarkrushinagar) against test pathogen were evaluated by dual culture method.

The test bio-agent and pathogen were grown separately on V8 agar medium. Sterilized V8 agar medium (20 ml) was poured aseptically in 90 mm diameter sterilized Petri-plate. Mycelial disc (5 mm diameter) from seven days old actively growing culture of the bio-agents and *P. colocasiae* were cut aseptically from the periphery of the colony with the help of sterilized cork borer and placed on solidified V8 agar medium approximately 40 mm away from each other. Test pathogen and bio-agents were subjected alone for growth and comparison. Three replications of each treatment were maintained and Petri plates with 5 mm diameter discs of seven days old culture of the pathogen only on V8 served as control. All inoculated Petri-plates were incubated at 27±2°C temperature in an incubator. Observations on radial growth in each Petri-plate was measured periodically and final observations were recorded when control plate was fully covered with the growth of *P. colocasiae*.

The per cent growth inhibition of the fungus in each treatment in comparison with control was calculated by the following equation (Bliss, 1934) [1];

$$PGI = \frac{C - T}{C} \times 100$$

Where

PGI = Per cent growth inhibition

C= Colony diameter (mm) in control

T= Colony diameter (mm) in treatment

In vitro efficacy of fungicides against pathogen

The *in vitro* efficacy of different fungicides was studied by using poisoned food technique (Nene and Thapliyal, 2000) [13]. Each fungicide was evaluated at four concentrations (Table 1). The measured quantities of different fungicides were incorporated separately in conical flasks containing 100 ml of melted sterilized V8 agar medium aseptically to obtain desired concentrations of the fungicides at the time of pouring the medium. The medium was shaken well to give uniform dispersal of the fungicides and then poured into sterilized Petri-plates under aseptic conditions. The Petri-plates were inoculated in the center by placing mycelial disc of 5 mm diameter seven days old mycelia disc and then incubated at 27±2°C temperature for seven days. Simultaneously, a control was also maintained by growing the fungus on fungicide free V8 agar medium. Three Petri-plates were maintained for each treatment.

The observations on radial growth in each Petri-plate was measured periodically and final observations were recorded when control plate was fully covered with the growth of *P. colocasiae*. The per cent growth inhibition of the pathogen was calculated by using the formula as given by Bliss, 1934[1] which mentioned earlier.

Table 1: Systemic, non-systemic and compound fungicides tested against test pathogen

Sr. No.	Common name	Concentration (ppm)			
Systemic fungicides					
1	Difenconazole 25 EC	50	100	250	500
2	Propiconazole 25 EC	50	100	250	500
3	Azoxystrobin 23 SC	50	100	250	500
4	Carbendazim 50 WP	50	100	250	500
Non systemic fungicides					

7	Mancozeb 75 WP	500	1000	1500	2000
8	Chlorothalonil 75 WP	500	1000	1500	2000
9	Propineb 70 WP	500	1000	1500	2000
10	Copper oxychloride 50 WP	500	1000	1500	2000
Compound (Systemic + Nonsystemic) fungicides					
11	Carbendazim 12 + Mancozeb 63 WP	50	100	250	500
12	Metalaxyl 8 + Mancozeb 64 WP	50	100	250	500
13	Carboxin 37.5 + Thiram 37.5 DS	50	100	250	500
14	Azoxystrobin 11 + Tebuconazole 18.3 SC	50	100	250	500

In vitro efficacy of Phyto-extracts against test pathogen

The effects of extracts of different plants belonging to different families were evaluated against *P. colocasiae in vitro* by poisoned food technique. The fresh plant materials were collected and washed thoroughly with tap water and then finally repeated changes of sterilized distilled water. They were separately grinded in sterilized distilled water at the rate of one ml/g of the plant parts in a sterilized pestle and mortar. The extracts were filtered through two layers of muslin cloth and subsequently filtered through filter paper (Whatman No. 1). This formed the standard plant extract solution (100%). All the plant extracts mentioned in Table 2 were use at 10 and 20 per cent concentrations. For 10 per cent concentration 10 ml of the plant extract was added to 90 ml of the sterilized warm V8 agar medium. For 20 per cent concentration 20 ml of the plant extract was added to 80 ml of the sterilized warm V8 agar medium. Then the medium were poured into the sterilized Petri plates under aseptic conditions. A five mm disc of seven days old culture of the pathogen were cut by means of a sterilized cork borer and placed at the center of the Petri plate. The plates were incubated at 27 ± 2 °C. The medium without incorporating the plant extract was served as control. The mycelial growth of the pathogen was measured periodically and final observations were recorded when control plate was fully covered with the growth of *P. colocasiae*. Observation on sporulation was measured when control plate was fully covered with the growth of test pathogen. The per cent growth inhibition of the pathogen was calculated by using the formula as given by Bliss, 1934[1] which mentioned earlier.

The spore germination test was carried out by cavity slide method. Equal volume of spore suspension and the test phyto extract of measured concentration were put on to cavity slide and mixed thoroughly. Equal volume of spore suspension and sterilized distilled water served as control. Two cavity slides can be accommodated in one Petri-plate and was incubated at 27±2 °C temperatures. The slides were then observed at 24 and 48 hours of incubation. Per cent spore germination was calculated as per the formula given by Singh *et al*. (1986) [25].

$$\text{Per cent spore germination} = \frac{\text{Germinated spores}}{\text{Total number of spores examined}} \times 100$$

Table 2: List of Phyto-extracts of various plant species

Sr. No.	Name of Plants	Botanical name	Family	Plant part used	Concentration (%)	
1.	Garlic	*Allium sativum* L.	Liliaceae	Clove	10	20
2.	Onion	*Allium cepa* L.	Liliaceae	Bulb	10	20
3.	Datura	*Datura stramonium* L.	Solanaceae	Leaves	10	20
4.	Tulsi	*Ocimum sanctum* L.	Labialae	Leaves	10	20
5.	Barmasi	*Vinca roseae* L.	Apocynaceae	Leaves	10	20
6.	Ardusa	*Ailanthus excela* Roxb.	Acanthaceae	Leaves	10	20
7.	Neem	*Azadirachta indica* Juss.	Meliaceae	Leaves	10	20
8.	NSKE	*Azadirachta Indica* Juss.	Meliaceae	Kernel	10	20
9.	Lantana	*Lantana camera* L.	Verbenaceae	Leaves	10	20
10.	*Akdo*	*Calotropis gigentia* L.	Euphorbeaceae	Leaves	10	20

In vitro efficacy of de-oiled cakes against test pathogen

To study the effect of different de-oiled cakes on the growth of colocasia leaf blight pathogen, the poisoned food technique was employed. The four de-oiled cakes *viz.*, groundnut, castor, cotton and neem cakes were determined at 5, 10, 20 and 30 per cent concentrations. All the cakes were crushed to make fine powder. Fifty grams powder of each cake was taken into 250 ml flask and then added for decomposing the cake for 15 days. After 15 days, the material was strained with muslin cloth to obtain the extract. The strained liquid will be autoclaved at 1.045 kg/cm2 pressure for 20 minutes and considered as cent per cent concentration (standard solution). The measured quantity of standard solution of the cakes was incorporated separately in melted V8 agar medium in conical flasks aseptically at the time pouring the medium to obtain desired concentration. The medium was shaken well to give uniform dispersal and then poured about 20 ml in each sterilized Petri-plates. Three replications of each treatment were maintained. After solidification of the medium, the Petri-plates were inoculated in the center by placing seven days old mycelial discs and then incubated at 27±2°C temperature. A control was also maintained by growing the pathogen on cake free medium. The mycelial growth of the pathogen was measured periodically and final observations were recorded when control plate was fully covered with the growth of *P. colocasiae*. Observation on sporulation was measured when control plate was fully covered with the growth of test pathogen. The per cent growth inhibition of the pathogen was calculated by using the formula as given by Bliss, 1934 [1] which mentioned earlier and Per cent spore germination was calculated as per the formula given by Singh *et al*. (1986) [25].

Results and Discussion

In vitro efficacy of bio agents against test pathogen

The results presented in Figure No.1, revealed that all the bio-

agents significantly inhibited the mycelial growth of the *P. colocasiae*. Among the seven bio-agents tested, the highest per cent radial growth inhibition of 69.99 per cent was recorded by the *T. harzianum* (Sardarkrushinagar) which was closely followed by *T. harzianum* (Junagadh) (69.25%), *T. harzianum* (Navsari) (67.03%), *T. harzianum* (Jagudan) (65.55%), *T. viride* (Sardarkrushinagar) (63.71%) and *T. viride* (Junagadh) (61.47%). All these bio-agents were at par with each other in inhibiting the mycelial growth of *P. colocasiae*. Although, *P. fluorescens* (Sardarkrushinagar) was comparatively inferior to all other bio-agents, as it recorded only 60.36 per cent growth inhibition.

Jagtap *et al*. (2012a) [4] studied of root rot, collar rot, fruit (brown) rot and gummosis caused *P. nicotianae*, *P. citrophthora* and *P. palmivora in vitro* and reported that *T. harzianum* most effective in suppressing the growth (87.85%) of pathogen. Shashidhara *et al*. (2008) [23] studied *in vitro* evaluation of the antagonists against foot rot of black pepper caused by *P. capsica*. They reported that *T. harzianum* reduced the growth of the pathogen. Singh and Islam (2010) [24] studied antagonist effect of *Trichoderma* spp. isolates against *P. nicotianae* and reported that *T. harzianum* was found highly inhibitory effect against *P. nicotianae*. Thus, the present findings are in accordance with the findings of earlier research workers.

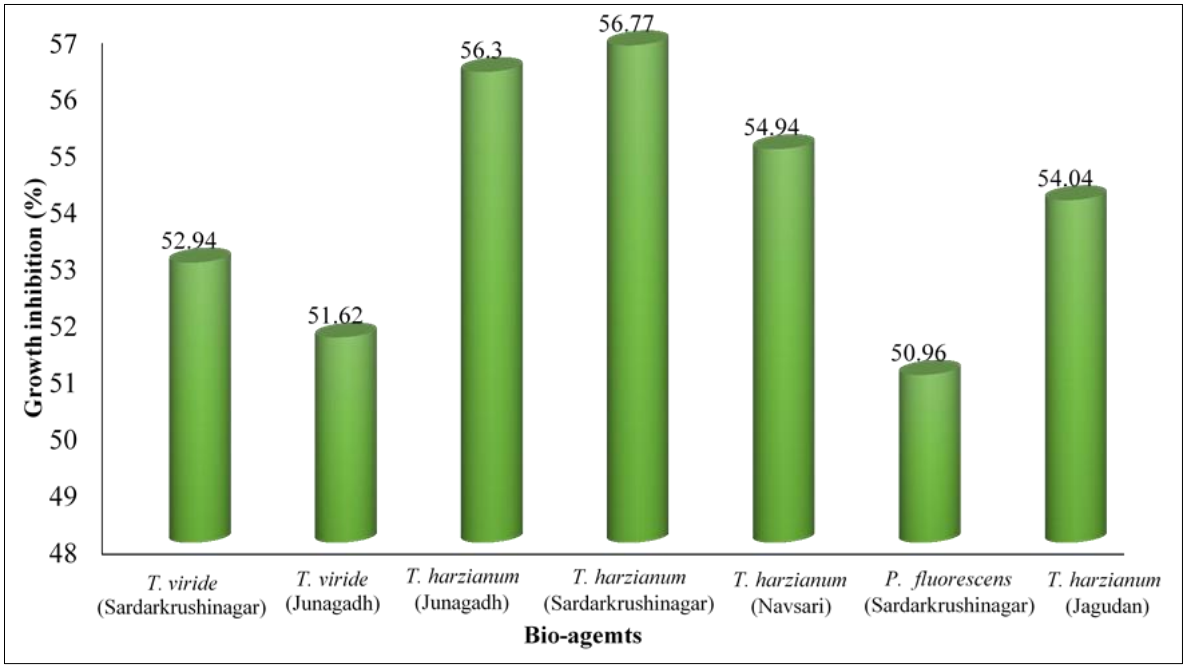

Fig 1: Effect of bio-agents on growth inhibition of *P. colocasiae in vitro*

In vitro efficacy of fungicides against test pathogen

The systemic, non-systemic and compound fungicides (four each) at different concentrations were tested *in vitro* for their comparative efficacy against *P. colocasiae* through poisoned food technique. The results on the inhibition of mycelial growth are presented in Table 3, 4 and 5.

All the four systemic fungicides were found inhibitory to the radial growth of *P. colocasiae*. The mean growth inhibition was ranged 65.55 per cent in carbendazim to 92.03 per cent in Azoxystrobin. The highest per cent growth inhibition (92.03%) recorded in azoxystrobin which was at par with difenconazole in which 86.84 per cent mean growth inhibition was recorded and it was closely followed by propiconazole (82.77%). While carbendazim recorded least mean growth inhibition and thereby proved less effective (Table 3).

Four different systemic fungicides were determined at four different concentration *viz*., 50, 100, 250 and 500 ppm. Irrespective of the fungicides, the inhibitory effect due to concentrations was increased positively with increasing concentration. The inhibition in radial growth was ranged 68.42 to 93.78 per cent at different concentrations. High per cent growth inhibition (93.78%) was observed at the higher concentration of 500 ppm and it was significantly superior to rest of the concentrations. Further, it was also noted that increase in growth inhibition was noticeable between 50 and 100 ppm as well as 250 and 500 ppm concentrations. It was evident from the data that the growth inhibition was increased from 68.42 to 77.31 per cent when concentration was increased from 50 to 100 ppm. Similarly, it was also observed that mean growth inhibition was increased from 87.77 to 93.78 per cent when concentration was increased from 250 to 500 ppm. The difference of increase in growth inhibition was not so notable between 100 and 250 ppm concentration.

The interaction effect of systemic fungicide and concentration was also found significant. More than 90 per cent growth inhibition was recorded in azoxystrobin, difenconazole and propiconazole (99.25, 98.14 and 97.77%, respectively) at 500 ppm concentration. The next best in order of merit was Azoxystrobin at 250 ppm concentration with 97.77 per cent growth inhibition. At lowest concentration of 50 ppm, azoxystrobin, difenconazole and propiconazole recorded more than 70 per cent growth inhibition (81.11, 72.96 and 70.73 respectively). Carbandazim was less effective as it recorded only 79.99 per cent growth inhibition even at highest concentration of 500 ppm. Azoxystrobin, difenoconazole and propiconazole recorded more than 80 per cent growth inhibition at 100 and 250 ppm where it recorded growth inhibition of 87.22 per cent. Thus, it is evident from the data that propiconazole at 500 ppm was significantly superior to rest of the combinations and it was closely followed by

difenconazole at the same concentration; however it was at par the closely followed by difenconazole at the same concentration; however it was at par the the Azoxystrobin at 250 ppm concentration.

All the four non-systemic fungicides were found inhibitory to the radial growth of *P. colocasiae* (Table 4). The mean growth inhibition was ranged 73.78 per cent in Propineb to 89.25 per cent in Mancozeb. The highest per cent growth inhibition (89.25%) recorded in Mancozeb which was at par with copper oxychloride in which80.17 per cent mean growth inhibition was recorded and it was closely followed by chlorothalonil (78.42%). While propineb recorded least mean growth inhibition and thereby proved less effective.

Four different non fungicides were determined at four different concentration *viz*., 500, 1000, 1500 and 2000 ppm. Irrespective of the fungicides, the inhibitory effect due to concentrations was increased positively with the increasing concentration. The inhibition in radial growth was ranged 68.69 to 91.47 per cent at different concentrations. High per cent growth inhibition (91.47%) was observed at the higher concentration of 2000 ppm and it was significantly superior to rest of the concentrations. Further, it was also noted that increase in growth inhibition was noticeable as the concentration increased. It was evident from the data that the growth inhibition was increased from 68.69 to 77.49 per cent when concentration was increased from 500 to 1000 ppm. Similarly, it was also observed that mean growth inhibition was increased from 83.97 to 91.47 per cent when concentration was increased from1500 to 2000 ppm.

The interaction effect of non-fungicide × concentration was also found significant. More than 90% growth inhibition was recorded incopper oxychloride, chlorothalonil and mancozeb (90.73, 90.73 and 96.66%, respectively) at 2000 ppm concentration. The next best in order of merit was mancozeb at 1500 ppm concentration with 92.22% growth inhibition. At lowest concentration of 500 ppm, copper oxychloride, chlorothalonil and mancozeb recorded more than 60% growth inhibition (67.03, 68.51 and 80.36% respectively). Propinebwas less effective as it recorded only 87.77% growth inhibition even at highest concentration of 2000 ppm. Copper oxychloride, chlorothalonil and mancozeb recorded more than 80% growth inhibition at 1500 ppm and chlorothalonil recorded more than 50% growth inhibition at 500 and 1000 ppm concentration. While, captan was found effective only at higher concentration of 2000 ppm where it recorded growth inhibition of 72.78 per cent. Thus, it is evident from the data that mancozeb at 2000 ppm was significantly superior to rest of the combinations.

All the four compound fungicides were found inhibitory to the radial growth of *P. colocasiae* (Table 5). The mean growth inhibition was ranged 81.66to 97.95%. The highest per cent growth inhibition (97.95%) was recorded in metalaxyl 8% + mancozeb 64% WP which was significantly superior to rest of the compound fungicides. The next best in order of merit was with mean growth inhibition of carbendazim 12% + mancozeb 63% WP (90.55%)followed by azoxystrobin 11% + tebuconazole 18.3% SC with 86.47% growth inhibition, while recorded least mean growth inhibitioncarboxin 37.5% + thiram 37.5% DS (81.66%) and thereby proved less effective.

Four different compound fungicides were determined at four different concentration *viz*., 50, 100, 250 and 500 ppm. Irrespective of the fungicides, the inhibitory effect due to concentrations was increased positively with the increasing concentration. The inhibition in radial growth was ranged 81.84 to 96.20 per cent at different concentrations. High per cent growth inhibition (96.20%) was observed at the higher concentration of 500 ppm and it was significantly superior to rest of the concentrations. Further, it was also noted that increase in growth inhibition was noticeable between various concentrations. It was evident from the data that the growth inhibition was increased from 81.84 and 86.47% when concentration was increased from 50 to 100 ppm and so onto 96.20% when concentration was increased to 500 ppm.

The interaction effect of compound fungicide and concentration was also found significant. More than 95% growth inhibition was recorded in metalaxyl 8% + mancozeb 64% WP and carbendazim 12% + mancozeb 63% WP (100 and 98.51%, respectively) at 500 ppm concentration. The next best in order of merit was metalaxyl 8% + mancozeb 64% WP at 250 ppm concentration with 99.25% growth inhibition and they all were at par with each other at lowest concentration of 50 ppm, was metalaxyl 8% + mancozeb 64% WPrecorded 95.18% growth inhibition. Carboxin 37.5% + thiram 37.5% DSwas less effective as it recorded only 91.48% growth inhibition even at highest concentration of 500 ppm. Carbendazim 12% + mancozeb 63% WP and azoxystrobin 11% + tebuconazole 18.3% SCrecorded 93.70 and 89.25% growth inhibition at 250 ppm. azoxystrobin 11% + tebuconazole 18.3% SC at higher concentration of500 ppm recorded growth inhibition of 94.81%. Thus, it is evident from the data that metalaxyl 8% + mancozeb 64% WPat 500 ppm, carbendazim 12% + mancozeb 63% WPat 500 ppm concentration and metalaxyl 8% + mancozeb 64% WP at250 ppm concentration were highly efficacious combinations as they recorded significantly highest inhibition of the growth of *P. colocasiae***.**

Maheshwari *et al.* (1999) [8] studied the efficacy of nine fungicides against *P. colocasiae* and reported that metalaxyl + mancozeb, mancozeb, copper oxychloride completely inhibited the growth of the pathogen. Shakywar *et al.* (2012) [22] tested systemic and non-systemic fungicides and reported that maximum mean per cent inhibition (92.17%) of mycelial growth was obtained in Ridomil MZ 72 WP. Jayalakshmi *et al.* (2017) [6] tested different fungicides out of these metalaxyl + mancozeb was found effective in inhibiting the growth of black shank pathogen. Sari *et al.* (2020) [20] reported mancozeb was more effective in suppressing the growth of Phytophthora sp. associated with leaf soft rot of nutmung. Peerzada *et al.* (2020) [17] tested eleven fungicides and recored that mancozeb exhibited highest inhibition percent with minimum mycelial growth of 46.77 mm followed by propineb yielding the mycelial growth of 50.13 mm tested against Phytophthora infestans causing late blight of potato. The present findings are in conformity with the findings made by earlier research workers. More or less they reported metalaxyl + mancozeb as an effective fungicide. In the present study also, azoxystrobin among systemic fungicides, mancozeb among non-systemic fungicides and metalaxyl + mancozeb were proved to be highly effective in inhibiting the growth of *P. colocasiae*.

Table 3: Per cent growth inhibition of *P. colocasiae* by systemic fungicides at different concentration *in vitro*

Sr. No.	Fungicides	Growth inhibition (%) Concentration (ppm) 50	100	250	500	Mean
1	Difenconazole 25% EC	58.65^{e} (72.96)*	66.46^{d} (84.07)	73.88^{c} (92.22)	82.40^{b} (98.14)	70.35^{b} (86.84)
2	Propiconazole 25% EC	57.23^{e} (70.73)	58.41^{e} (72.59)	71.60^{c} (89.99)	81.56^{b} (97.77)	67.20^{c} (82.77)
3	Azoxystrobin 23% SC	64.21^{d} (81.11)	71.55^{c} (89.99)	81.56^{b} (97.77)	85.72^{a} (99.25)	75.76^{a} (92.03)
4	Carbendazim 50% WP	44.34^{g} (48.88)	52.27^{f} (62.59)	57.46^{e} (71.11)	63.42^{d} (79.99)	54.37^{d} (65.55)
Mean		56.11^{d} (68.42)	61.17^{c} (77.31)	71.13^{b} (87.77)	78.28^{a} (93.78)	-
		Fungicide		Concentration		Fungicide × Concentration
S.Em. ±		0.52		0.52		1.05
C.D.(P=0.05)		1.50		1.50		3.02
C.V.%		2.71				

*Figures in parentheses are retransformed values of arc sine transformation.
Treatment means with the letter(s) are not significant by Duncan's New Multiple Range Test at 5% level of significance

Table 4: Per cent growth inhibition of *P. colocasiae* by non-systemic fungicides at different concentration *in vitro*

Sr. No.	Fungicides	Growth inhibition (%) Concentration (ppm) 500	1000	1500	2000	Mean
1	Mancozeb 75% WP	63.70^{def} (80.36)*	69.51^{c} (87.77)	73.88^{b} (92.22)	79.53^{a} (96.66)	71.66^{a} (89.25)
2	Chlorothalonil 75% WP	55.85^{gh} (68.51)	58.41^{g} (72.59)	64.77^{de} (81.85)	72.34^{bc} (90.73)	62.84^{c} (78.42)
3	Propineb 70% WP	50.10^{i} (58.88)	57.24^{gh} (70.73)	61.84^{f} (77.77)	69.51^{c} (87.77)	59.67^{d} (73.78)
4	Copper oxychloride 50% WP	54.94^{h} (67.03)	62.62^{ef} (78.88)	66.46^{d} (84.07)	72.29^{bc} (90.73)	64.08^{b} (80.17)
Mean		56.15^{d} (68.69)	61.95^{c} (77.49)	66.74^{b} (83.97)	73.42^{a} (91.47)	-
		Fungicide		Concentration		Fungicide × Concentration
S.Em. ±		0.45		0.45		0.45
C.D. (P=0.05)		1.32		1.32		NS
C.V.%		2.46				

*Figures in parentheses are retransformed values of arc sine transformation.
Treatment means with the letter(s) are not significant by Duncan's New Multiple Range Test at 5% level of significance

Table 5: Per cent growth inhibition of *P. colocasiae* by compound fungicides at different concentration *in vitro*

Sr. No.	Fungicides	Growth inhibition (%) Concentration (ppm) 50	100	250	500	Mean
1	Carbendazim 12% + Mancozeb 63% WP	65.06^{i} (82.22)*	69.51^{gh} (87.77)	75.44^{de} (93.70)	83.05^{c} (98.51)	73.26^{b} (90.55)
2	Metalaxyl 8% + Mancozeb 64% WP	77.41^{d} (95.18)	80.73^{c} (97.40)	85.91^{b} (99.25)	89.96^{a} (100)	83.50^{a} (97.95)
3	Carboxin 37.5% + Thiram 37.5% DS	58.89^{j} (73.33)	60.35^{j} (75.55)	68.26^{gh} (86.29)	73.00^{ef} (91.48)	65.12^{d} (81.66)
4	Azoxystrobin 11% + Tebuconazole 18.3% SC	61.09^{j} (76.66)	67.33^{hi} (85.18)	70.86^{fg} (89.25)	76.86^{d} (94.81)	69.0.3^{c} (86.47)
Mean		65.61^{d} (81.84)	69.48^{c} (86.47)	75.12^{b} (92.12)	80.72^{a} (96.20)	-
		Fungicide		Concentration		Fungicide × Concentration
S.Em. ±		0.43		0.43		0.87
C.D.(P=0.05)		1.25		1.25		2.51
C.V.%		2.08				

*Figures in parentheses are retransformed values of arc sine transformation.
Treatment means with the letter(s) are not significant by Duncan's New Multiple Range Test at 5% level of significance

In vitro efficacy of Phyto-extracts against pathogen

The clove, bulb, kernel and leaf extracts of various plants were evaluated and found inhibitory to the radial growth of *P. colocasiae*. The highest radial growth inhibition (51.84%) was recorded with neem leaf (*Azadirachta indica* Juss) extract which was significantly superior to rest of the phyto-extract. This was closely followed by lantana (*Lantana camera* L.) leaf extract (47.77%). The next best phyto-extracts in order of merit were NSKE (*Azadirachta indica* Juss.), ardusa (*Ailanthus excela* Roxb.) and barmasi (*Vinca roseae* L.) with 43.69, 43.14 and 43.14 per cent radial growth inhibition, respectively and were statistically at par with each other. Akdo (*Calotropis gigentia* L.), tulsi (*Ocimum sanctum* L.), datura (*Datura stramonium* L.) and onion (*Allium cepa* L.) were also effective with respective growth inhibition of 40.92, 38.33, 36.10 and 31.66 per cent, respectively. The remaining phyto-extracts were comparatively less effective as recorded less than 30 per cent growth inhibition. The garlic (*Allium sativum* L.) clove extract revealed the lowest (27.03%) growth inhibition of *P. colocasiae*.

Irrespective of the clove, bulb, kernel and leaf extracts, the inhibitory effect was recorded significantly higher (44.43%) at 20 per cent concentration. The 10 per cent concentration recorded 36.29 per cent growth inhibition of *P. colocasiae*.

The results presented in Figure 2 revealed that all clove, bulb, kernel and leaf extracts at 10 and 20 per cent concentration inhibited the growth of the pathogen non-significantly as compared to control. Neem leaf extract recorded 57.03 and46.66 per cent growth inhibition of P. colocasiae at 20 and 10 per cent concentrations, respectively. The next effective extract was lantana which recorded 52.59 and 42.96 per cent radial growth inhibition at 20 and 10 per cent concentration,

respectively. Extract of neem leaf at 10 per cent concentration and leaf extract of lantana at 20 per cent were at par with each other. Garlic clove extract was observed least effective in inhibiting the mycelial growth of *P. colocasiae* at 10 and 20 per cent concentrations (22.59% and 31.48%, respectively). Among phytoextracts highest growth inhibition was revealed by NSKE extract with 47.40 and 39.99 per cent radial growth inhibition at 20 and 10 per cent concentrations, respectively. This was followed by barmasi leaf extract which recorded 46.29 and 39.99 per cent growth inhibition and was at par with ardusa leaf extract at 20 and 10 per cent concentration. The next effective phyto- extracts at 10 and 20 per cent concentration in order of inhibition were akdo leaf extract (44.07 and 37.77%), tulsi leaf extract (41.11 and 35.55%), datura leaf extract (39.99 and 32.22%), and onion bulb extract (37.03 and 26.29%). Garlic clove extract recorded least growth inhibition of 31.48 and 22.59 per cent at 20 and 10 per cent concentrations, respectively.

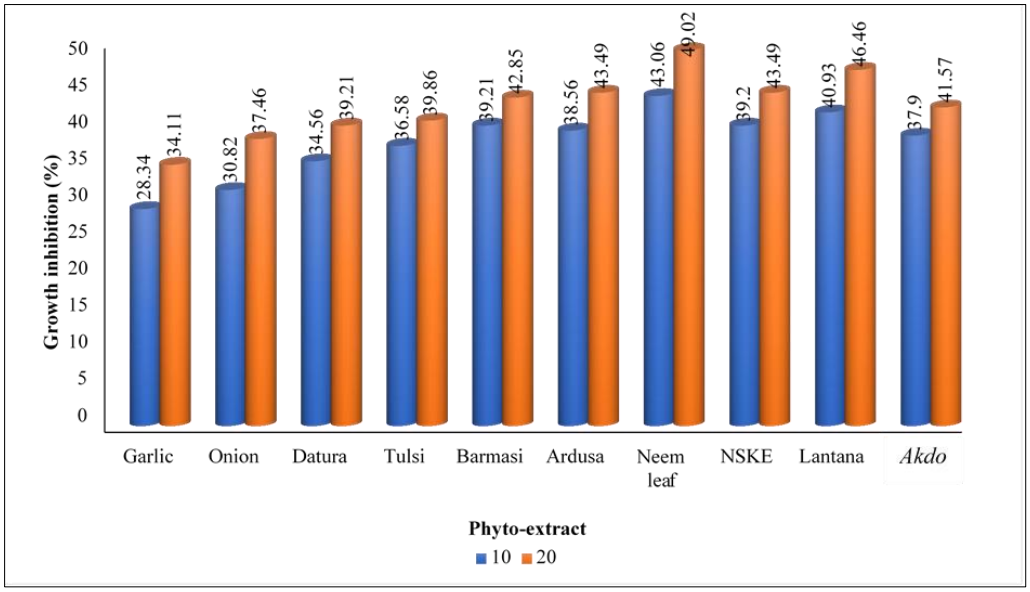

Fig 2: Effect of phyto-extract on growth inhibition of *P. colocasiae in vitro*

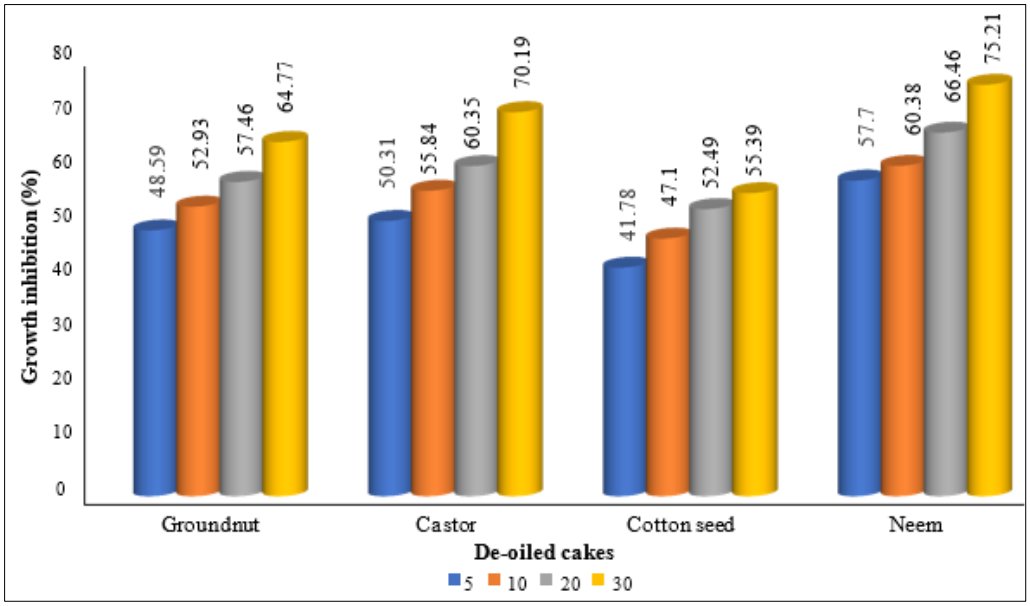

Fig 3: Effect of de-oiled cakes on growth inhibition of *P. colocasiae in vitro*

Spore germination

Germination per cent of the spores observed after 24 and 48 hours were presented in Table 6. Effect of phyto-extracts Irrespective of concentration, significant effect was exhibited by phyto-extracts on the spore germination inhibition of *P. colocasiae*. Significantly the lowest mean germination of 23.90 and 26.80 per cent in neem leaf and lantana extracts, respectively without a notable difference after 24 hours.

This result was followed by 27.53 per cent germination in ardusa extracts. Subsequent germination follows the order as, at par germination per cent of 28.98 and 32.60 in barmasi and NSKE extracts, 37.68 per cent in akdo, 39.84 per cent in tulsi, 45.64 per cent in datura and the highest germination of more than 50.00 per cent in onion and garlic extract. Increase in the germination percentage after 48 hours altered the order of supremacy of treatments with respect to spore germination inhibition. Significantly the lowest spore germination of 27.53 per cent was recorded in neem leaf extracts after an incubation of 48 hours. This was followed by lantana and ardusa extracts with 31.15 and 31.15 per cent mean

germination. Effective reduction of 34.05 per cent in barmasi was succeeded by significantly at par values of 36.23 per cent in NSKE and 39.85 per cent in akdo, 42.74 per cent in tulsi, 48.54 per cent in datura, 53.62 per cent in onion and the highest germination per cent of 58.68 was observed in garlic extracts.

Irrespective of phyto-extracts, concentration displayed a significant effect. Notable decrease in the germination percentage was observed with an increase in the level of concentration of treatments. Highest concentration of 20 per cent displayed the lowest germination per cent of 35.64 and 39.12 after 24 and 48 hours followed by 38.25 and 41.58 per cent germination in 10 per cent concentration in the respective time intervals. Comparatively higher germination observed in 10 per cent concentration was recorded 24 and 48 hours, respectively.

Interaction of phyto-extract and concentration exhibited a non-significant effect on the spore germination of *P. colocasiae*. Neem leaf, lantana and ardusa indicated superior inhibition potential from 10 and 20 per cent concentrations after 24 hours incubation. The spore germination of less than 30 per cent was recorded in neem leaf, lantana and ardusa at all the concentration while at 20 per cent concentration in case of barmasi followed by percentages of 30.43 and 34.78 by NSKE at 10 and 20 per cent concentrations at par with 36.23 and 39.13 per cent germination in akdo at 39.12 and 40.57 per cent germination in tulsi in the same concentration levels. Datura, onion and garlic recorded more than 50 per cent spore germination.

Incubation after 48 hours recorded increase in the number of germinated spores in comparison to 24 hours incubation. However, neem leaf exhibited superior inhibition potential with 28.98 and 26.08 percentage germination at 10 and 20 per cent concentrations, respectively. Subsequently, lantana extracts with 31.88 and 30.43 per cent same as 26.08 and 28.98 per cent germination in ardusa extracts at10 and 20 per cent concentrations, respectively. Spore germination percentage ofbarmasi 34.78 and 33.33 which was at par with NSKE extract with 37.68 and 34.78 per cent germination in 10 and 20 per cent concentrations, respectively followed by akdo and tulsi. Highest germination percentages of 60.86 and 56.52 in garlic extract was followed by 47.89 and 46.22 per cent germination by onion in the same concentration levels. This indicated the least efficacy of datura, onion and garlic extract to inhibit the spore germination of *P. colocasiae*.

Similar results were reported by earlier research workers. Shakywar *et al.* (2012) [22] tested antifungal activity of six plant extracts (botanical) on growth of *P. colocasiae* causing leaf blight of taro and results indicated that the *Azadirachta indica* leaf extract 10 per cent concentration caused significantly maximum inhibition of growth (50.13%). Jagtap *et al.* (2012) [5] tested total of six different plants extracts of Neem (*Azadirachta indica*), Mehendi (*Lowsonia inermis*), Eucalyptus (*Eucalyptus cinarium*), Acacia (*Acacia catechu*), Glyricidia (*Glyricidia sepium*), Dhatura (*Dhatura stramonium*) and Lantana (*Lantana camera*) against *Phytophthora spp*. under *in vitro* conditions using poisoned food technique. *L. camera* was significantly more effective in inhibiting the mycelial growth (44.54%) of *Phytophthora citrophthora* and *D. stramonium* against *Phytophthora nicotianae*, inhibiting mycelial growth (57.78%), both at 5 per cent concentration. Khan *et al.* (2019) [7] evaluated five plant extracts at three different concentrations (5, 10 and 15%) through food poisoned technique to test antifungal activity against, *Phytophthora infestans* causal agent of potato late blight. Among tested plant extracts, *Azadirachta indica* was the most effective in decreasing the linear mycelial growth and increasing the inhibition percentage (33.24 mm and 59.77%) against *Phytophthora infestans* causal agent of potato late blight. Thus, the results obtained in present investigation collaborate with the findings of earlier research workers.

***In vitro* efficacy of de-oiled cakes against pathogen**

The various cakes were evaluated and found inhibitory to the radial growth of *P. colocasiae*. The mean growth inhibition was ranged from 57.21 to 81.10 per cent. The highest per cent growth inhibition (81.10%) was recorded in neem which was significantly superior to rest of the de-oiled cakes. The next best de-oiled cakes in order of merit were castor cake with mean growth inhibition of 72.95 per cent followed by ground nut cake with 68.23 per cent growth inhibition, while recorded least mean growth inhibition recorded with cotton cake (57.21%) and thereby proved less effective.

Four different de-oiled cakes were determined at four different concentration *viz*., 5, 10, 20 and 30 percent. Irrespective of the de-oiled cakes, the inhibitory effect due to concentrations was increased positively with the increasing concentration. The inhibition in radial growth was ranged 57.86 to 82.86 per cent at different concentrations. High per cent growth inhibition (82.86%) was observed at the higher concentration of 30 per cent and it was significantly superior to rest of the concentrations. Further, it was also noted that increase in growth inhibition was noticeable between various concentrations. It was evident from the data that the growth inhibition was increased from 57.86 and 65.36 per cent when concentration was increased from 5 to 10 per cent and so on to 82.86 per cent when concentration was increased to 30 per cent. 4.6.1.3 Interaction effect of de-oiled cake and concentration. The interaction effect of de-oiled cake and concentration was also found significant. More than 85 per cent growth inhibition was recorded in neem cake and castor cake (93.33 and 88.51%, respectively) at 30 per cent concentration. The next best in order of merit was neem cake at 20 per cent concentration with 84.07 per cent growth inhibition and they all were at par with each other at lowest concentration of 5 per cent, was neem cake recorded 71.47 per cent growth inhibition. Cotton cake was less effective as it recorded only 67.77 per cent growth inhibition even at highest concentration of 30 per cent. Castor cake and ground nut cake recorded 75.55 and 71.11 per cent growth inhibition at 20 per cent. Ground nut cake at higher concentration of 30 per cent recorded growth inhibition of 81.85 per cent. Thus, it is evident from the data that neem cake at 30 per cent, castor cake at 30 per cent concentration and neem cake at 20 per cent concentration were highly efficacious as they recorded significantly highest inhibition of the growth of *P. colocasiae*.

Spore germination

Irrespective of concentration, de-oiled cakes exerted a significant effect on the spore germination of *P. colocasiae*. Observation after 24 hours recorded significantly the lowest mean germination of 20.28 and 27.16 per cent in neem cake and castor cake, respectively. This result was followed by 35.86 per centgermination in ground nut cake. Highest mean germination of 37.81 percent in cotton cake.Increase in the

germination percentage with time altered the order of supremacy of treatments with respect to spore germination inhibition. After 48 hours, neem cake extract indicated the superior inhibition potential with only 23.90 per cent as the lowest mean germination followed by castor cake and ground nut cake with statistically results of 30.06 and 40.57 per cent.

Irrespective of de-oiled cakes, concentration had a significant effect on the spore germination of *P. colocasiae*. Increase in the concentration of treatments recorded corresponding significant decrease in the germination of spores at both time intervals. Lowest mean germination of 26.08 and 30.43 per cent were observed in 30 per cent concentration after 24 and 48 hours followed by 28.61 and 32.60 per cent germination in 20 per cent concentration. 10 per cent concentration recorded 31.51 and 35.13 per cent germination after 24 and 48 hours followed by 34.41 and37.31 per cent germination in 5 per cent concentration. Each concentration level indicated a significant difference in the germination percentage at each time interval.

Non-significant interaction effect of de-oiled cake and concentration was observed in the spore germination percentage of the fungus. As represented in the Table 7, de-oiled cake extracts at 5, 10, 20 and 30 per cent concentration expressed an effective reduction in the germination of *P. colocasiae* spores at both time intervals (24 and 48 hours). Observation after 24 hours recorded lowest germination per cent of 17.39 in neem cake and castor cake with 24.63 germination percent at 30 per cent concentration. This result was followed by 30.43 and 31.88 per cent germination by ground nut and cotton cake extracts at 30 per cent concentration, respectively. Relatively lower germination per cent of 23.18 was recorded in the 5 per cent concentration of neem cake. Germination percentages of 21.73, 27.53, 37.68 and 39.13 by neem, castor, ground nut and cotton cake extracts at 10 per cent was insignificant to germination percentage exhibited by castor cake extract at 30 per cent and neem cake extract at 5 per cent concentrations. This indicated the higher efficacy of neem cake even at 10 per cent in spore germination inhibition of P. colocasiae. Highest germination per cent of 43.47,39.13, 34.78 and 31.88 at respective concentration levels of 5, 10, 20 and 30 per cent indicated the least efficacy of cotton cake in the spore germination inhibition of *P. colocasiae*.

Incubation after 48 hours recorded increase in the number of germinated spores in comparison to 24 hours incubation. Neem cake and castor cake recorded the least germination percentages of 21.73 and 27.53 at 30 per cent concentration. Succeeding lower germination per cent of 36.23 was recorded in 30 per cent concentration of ground nut and cotton cake, respectively. Relatively higher germination percentages recorded in cotton cake and ground nut cake at 30 percent concentration. Thus, it is evident from the data that neem cake at 30 per cent, castor cake at 30 per cent concentration and neem cake at 20 per cent concentration were highly efficacious as they recorded significantly superior inhibition potential against spore germination percentage of *P. colocasiae*.

Mirza *et al*. (2000) [9] tested four neem (*Azadrchta indica* A. Juss) products namely crude neem oil, nimbokil, crude neem seed oil terpenoid extract and neem leaf decoction for their *in vitro* activity against mycelia growth, sporangial germination and sporangial production of *Phytophthora infestans*. They concluded that all the products were highly effective against the different life stages of fungus. Rashid *et al*. (2004) [18] evaluated the efficacy of different neem (*Azadirachta indica* A. Juss) products against *Phytophthora infestans* using two isolates *viz*., NR- 971 and BN-971 differing in aggressiveness. Three products from neem *viz*., neem leaf diffusate, neem leaf powder and neem seed cake were evaluated for their effect on mycelial growth, sporangial production and sporangial germination of the 2 isolates. while neem seed cake showed 100 per cent mycelial growth inhibition in NR-971 isolate at 1.0% and that of BN-971 isolate at 0.8% w/v concentration Both neem leaf powder and neem seed cake completely inhibited sporangial production sporangial germination of NR-971 and BN-971 isolate at 0.6% and 0.4% w/v concentrations, respectively. Patra *et al*. (2017) [15] and Pandey *et al*. (2014)[14] observed that de-oiled neem cake mixture was best effective in controlling wilt disease up to 46.70 percent. Duong *et al*. (2014) [3] tested neem cake extracted solutions against *Phytophthora capsici*. Undiluted neem cake extraction effectively inhibited the growth of *Phytophthora capsici.*

Table 6: Spore germination of *P. colocasiae* in Phyto-extracts at different concentrations *in vitro*

Sr. No.	Name of plants	Spore germination (%) after 24 hrs.		Mean	Spore germination (%) after 48 hrs.		Mean
		Concentration (%)			Concentration (%)		
		10	20		10	20	
1	Garlic	48.72^{l} (56.52)*	47.89^{kl} (55.07)	48.30^{h} (55.79)	51.25^{m} (60.86)*	48.72^{l} (56.52)	49.98^{i} (58.68)
2	Onion	46.22^{jk} (52.17)	44.56^{ij} (49.27)	45.39^{g} (50.72)	47.89^{kl} (55.07)	46.22^{jk} (52.17)	47.05^{h} (53.62)
3	Datura	43.73^{i} (47.82)	41.23^{h} (43.47)	42.48^{fg} (45.64)	45.39^{j} (50.72)	42.89^{i} (46.37)	44.16^{h} (48.54)
4	Tulsi	39.54^{gh} (40.57)	38.68^{fg} (39.12)	39.11^{f} (39.84)	41.23^{hi} (43.47)	40.38^{gh} (42.02)	40.81^{g} (42.74)
5	Barmasi	33.46^{d} (30.43)	31.62^{bcd} (27.53)	32.54^{d} (28.98)	36.12^{de} (34.78)	35.23^{cd} (33.33)	35.68^{d} (34.05)
6	Ardusa	32.54^{cd} (28.98)	30.69^{abc} (26.08)	31.62^{c} (27.53)	34.35^{bcd} (31.88)	33.46^{bc} (30.43)	33.90^{b} (31.15)
7	Neem leaf	29.72^{ab} (24.63)	28.74^{a} (23.18)	29.23^{a} (23.90)	32.54^{b} (28.98)	30.69^{a} (26.08)	31.62^{a} (27.53)
8	NSKE	36.12^{e} (34.78)	33.46^{d} (30.43)	34.82^{d} (32.60)	37.84^{ef} (37.68)	36.12^{de} (34.78)	36.98^{e} (36.23)
9	Lantana	31.62b^{cd} (27.53)	30.69^{abc} (26.08)	31.15^{b} (26.80)	34.35^{bcd} (31.88)	33.46^{bc} (30.43)	33.90^{c} (31.15)
10	Akdo	38.70^{fg} (39.13)	36.98^{ef} (36.23)	37.84^{e} (37.68)	39.54^{fgh} (40.57)	38.70^{fg} (39.13)	39.12^{f} (39.85)
	Mean	38.04^{a} (38.25)	36.45^{b} (35.64)	-	40.05^{a} (41.58)	38.59^{b} (39.12)	
		Phyto-extract	Concentration	Phyto-extract × concentration	Phyto-extract	concentration	Phyto-extract × concentration
S.Em. ±		0.48	0.21	0.68	0.43	0.19	0.61
C.D. (P=0.05)		1.39	0.62	NS	1.23	0.55	NS
C.V.%		3.20			2.69		

*Figures in parentheses are retransformed values ofarc sine transformation.

Treatment means with the letter(s) are not significant by Duncan's New Multiple Range Test at 5% level of significance

Table 7: Spore germination of *P. colocasiae* in de-oiled cakes at different concentration *in vitro*

Sr. No.	Treatments	Spore germination (%) after 24 hrs. Concentration (%) 5	10	20	30	Mean	Spore germination (%) after 48 hrs. Concentration (%) 5	10	20	30	Mean
1	Groundnut	39.54^{jk} (40.57)*	37.84^{i} (37.68)	36.12^{hi} (34.78)	33.46^{fg} (30.43)	36.74c (35.86)	42.06^{j} (44.92)*	40.38^{ij} (42.02)	38.70^{hi} (39.13)	36.98^{gh} (36.23)	39.53^{c} (40.57)
2	Castor	33.46^{fg} (30.43)	31.62^{ef} (27.53)	30.69^{de} (26.08)	29.72^{cd} (24.63)	31.37b (27.16)	35.23^{fg} (33.33)	33.46^{ef} (30.43)	32.54^{de} (28.98)	31.62^{cde} (27.53)	33.21^{b} (30.06)
3	Cotton seed	41.23^{k} (43.47)	38.70^{j} (39.13)	36.12^{hi} (34.78)	34.35^{gh} (31.88)	37.60d (37.31)	42.06^{j} (44.92)	41.23^{j} (43.47)	38.70^{hi} (39.13)	36.98^{gh} (36.23)	39.74^{c} (40.93)
4	Neem	28.74^{bc} (23.18)	27.77^{b} (21.73)	25.68^{a} (18.83)	24.63^{a} (17.39)	26.71a (20.28)	30.69^{bcd} (26.08)	29.72^{abc} (24.63)	28.74^{ab} (23.18)	27.77^{a} (21.73)	29.23^{a} (23.90)
	Mean	35.74^{a} (34.41)	33.98^{b} (31.51)	32.15^{c} (28.61)	30.54^{d} (26.08)	-	37.51^{a} (37.31)	36.20^{b} (35.13)	34.67^{c} (32.60)	33.34^{d} (30.43)	-
		De-oiled cake	Concentration		De-oiled cake × Concentration		De-oiled cake	Concentration		De-oiled cake × Concentration	
S.Em. ±		0.30	0.30		0.61		0.35	0.35		0.70	
C.D. (P=0.05)		0.88	0.88		NS		1.01	1.01		NS	
C.V.%		3.22					3.45				

*Figures in parentheses are retransformed values of arc sine transformation.
Treatment means with the letter(s) are not significant by Duncan's New Multiple Range Test at 5% level of significance

Conclusion

Leaf blight (*Phytophthora colocasiae*) is one of the most important disease inflicting considerable quantitative losses in colocasia. All the seven bioagents tested significantly inhibited the mycelial growth of *P. colocasiae*). However, *T. harzianum* (Sardarkrushinagar) gave significantly maximum growth inhibition followed by *T. harzianum* (Junagadh), *T. harzianum* (Navsari), *T. harzianum* (Jagudan), *T. viride* (Sardarkrushinagar) and *T. viride (*Junagadh). The least growth inhibition was recorded by *P. fluorescens.* Systemic fungicides *viz.*, Azoxystrobin 23% SC and Difenconazole 25% EC proved superior against the radial growth of *P. colocasiae*. Rests of the fungicides were also found effective to inhibit the growth of the fungus. Among non-systemic fungicides, highest mean growth inhibition in Mancozeb 75% WP and among compound fungicides, highest growth inhibition was recorded in Metalaxyl 8% + Mancozeb 64% WP followed by Carbendazim 12% + Mancozeb 63% WP and Azoxystrobin 11% + Tebuconazole 18.3% SC. Aqueous extracts of neem leaf and lantana recorded effective mean radial growth inhibition and comparitively lower mean germination percentages. The least radial growth inhibition and higher mean germination percentage in garlic clove extract. De oil cake extracts of neem and castor exhibited an effective mean radial growth inhibition percentages and spore germination percentages of *P. colocasiae*.

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