SUMMARY
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Red gram (*Cajanus cajan*, L., Millsp.), is one of the important pulse yielding crop of India and other tropical countries of the world including Africa, America, Australia and Hawaii having a prominent place in human diet being a nutritive ingredient menu of humanbeing. It improves the nutritive value of cereal based diets of majority of Indians particularly vegetarians being rich in proteins. Inspite of the presence of improved varieties and large acreage under its cultivation the total production in India is very low in comparison to that of other countries of the world, mainly due to off setting of the foliar diseases of fungal origin as well as bacterial, viral and nematodal diseases. Among these, the Alternaria blight disease of Red gram caused by *Alternaria alternata* (Fries.), Keissler and *A. tenuissima* (Kunze. ex. Pers; Wiltshire) gradually increasing on new evolved high yielding varieties of Red gram, has been recorded to be predominated in Uttar Pradesh during recent years, about which there is no information available, requiring the immediate attention of Plant Pathologists, if the production of this crop is to be boosted in the country. So far, with a view combating this serious malady effectively, the present investigation was taken to find out the prevalence and severity of disease in Uttar Pradesh to investigate the morphological and cultural characters of the fungi, to ascertain the role of enzymes in pathogenesis in *vivo* and *vitro*, effect of pathogens on certain biochemical constituents of diseased parts of host, susceptible growth period of host, influence of climatic conditions on the development of disease, effect of nitrogen, phosphorus and potash on the incidence of disease, host range relationship of the pathogens, disease perpetuation as well as source of resistance with an aim of its control managing the strategy of disease, and the results sought are discussed here in brief.

Alternaria blight disease of Red gram caused by *Alternaria alternata* (Fries.) Keissler and *A. tenuissima* (Kunze. ex. Pers; Wiltshire) were found to be moderately to heavy in severity widely prevalent under different agroclimatic conditions of Uttar Pradesh as evident from the survey.

(258)
conducted during the years, 2003-2004 and 2004-2005 in sixteen localities during Kharif and Rabi seasons. The incidence of disease at different research stations during Kharif seasons varied from 19.20 per cent to 33.14 per cent from the germplasms/cultures viz., Vijaipur-49, ICPL-151, Manak, BR-64, Pusa-33, Mukta, Pant A-3, ICPL-87, Basant, Sharda, DA-2, UPA-120 and Prabhat and 18.18 per cent to 33.15 per cent from the germplasms/cultures viz.; Vijaipur-49, Pusa-33, Pant A-3, S-11, BR-64, ICPL-151, Mukta, ICPL-87, Manak, Basant, DA-2, U.P.A.-120, Sharda, Lakshmi and Prabhat in the years 2003-2004 and 2004-2005. The maximum disease incidence 33.14 per cent and 33.15 per cent was recorded at Chandra Shekhar Azad University Crop Research Farm, Araul, Kanpur in both the years from the germplasm/culture Prabhat, followed by 31.46 per cent and 31.25 per cent at Indian Pulse Research Institute Kalyanpur, Kanpur and Chandra Shekhar Azad University Crop Research Farm Belatal, Hamirpur, in both the years from the germplasms/cultures UPA-120 and Lakshmi and rest of locations, while minimum 19.20 per cent and 18.18 per cent disease incidence, was recorded at Regional Research Centre Madhurikund, Mathura in both the years. During Rabi season maximum incidence 31.11 per cent and 31.46 per cent, was recorded at Chandra Shekhar Azad University Crop Research Farm Araul, Kanpur from the germplasms/culture Prabhat followed by 30.23 and 30.55 per cent from the germplasms/cultures UPA-120 and Sharda at Indian Pulse Research Institute Kalyanpur, Kanpur and N. D. University Farm Kumarganj, Faizabad in the years 2003-2004 and 2004-2005 respectively and at rest locations varied from 15.23 per cent to 28.26 per cent from the germplasms/cultures viz; Vijaipur-49, BR-64, KH-2, S-11, ICPL-151, ICPL-87, DA-2, Pant A-3, Sharda, Basant and Lakshmi in the year 2003-2004 and 12.17 per cent to 28.38 per cent from the germplasm viz; Pant A-3, Vijaipur-49, KH-2, BR-64, ICPL-87, S-11, ICPL-151, Mukta, D.A.-2, Basant, UPA-120 and Lakshmi in the year 2004-2005, while minimum 15.23 per cent and 12.17 per cent disease incidence was recorded at Regional Agriculture Research Station Saini, Allahabad and Regional Agriculture Testing and Demonstration Farm, Hardoi from the germplasms Vijaipur-49 and Pant A-3 respectively in both crop seasons of 2003-2004 and 2004-2005.
The average disease incidence ranged from 8.45 per cent to 30.85 per cent to 30.85 per cent and 7.19 per cent to 30.15 per cent in both the years of survey at different crop seasons.

Disease intensity during Kharif season varied from 23.40 per cent to 38.20 per cent from the germplasms / cultures viz; Vijaipur-49, ICPL-151, BR-64, D.A-2, Mukta, Pusa-33, S-11, Pant A-3, UPA-120, ICPL-87, Manak, Sharda, Basant and Prabhat and 19.60 per cent to 40.40 per cent from the germplasms / cultures viz; Lakshmi, Vijaipur-49, BR-64, ICPL-151, DA-2, Pusa-33, S-11, Mukta, ICPL-87, Pant A-3, U.A.-120, Manak, Basant, Sharda and Prabhat in the year 2003-2004 and 2004-2005 showing wide spread prevalence in nature. Maximum 38.20 per cent and 40.40 per cent disease intensity was recorded from the germplasm / culture Prabhat at Chandra Shekhar Azad University Crop Research Farm Araul, Kanpur followed by 37.40 per cent and 38.50 per cent from Chandra Shekhar Azad University Crop Research Farm Deegh, Kanpur and Regional Research Centre Madhurikund, Mathura from germplasms/cultures Basant and Sharda and rest of locations in both the years while minimum 23.40 and 19.60 per cent disease intensity was recorded from Regional Agriculture Research Station Saini, Allahabad and Regional Agriculture Testing and Demonstration Farm, Hardoi from the germplasm cultures Vijaipur-49 and Lakshmi in both the years respectively. During Rabi season maximum disease intensity 25.20 per cent and 35.40 per cent was recorded from the germplasm culture Prabhat at Chandra Shekhar Azad University Crop Research Farm Araul, Kanpur followed by 23.40 per cent and 29.60 per cent from the germplasm / cultures ICPL-87 and Mukta at Regional Agriculture Research Station Saini, Allahabad and Regional Agriculture Research Station Bharari, Jhansi and at the rest of locations varying from 12.30 per cent to 19.20 per cent from the germplasm/cultures viz; DA-2, KH-2, Vijaipur-49, UPA-120, S-11, ICPL-151, BR-64, Basant, Lakshmi, Pant A-3 and Sharda in the year 2003-2004 and 6.40 per cent to 28.70 per cent from the germplasms/cultures viz; S-11, Vijaipur-49, UPA-120, BR-64, KH-2, DA-2, Lakshmi, ICPL-151, Pant A-3, ICPL-87, Basant and Sharda in the year 2004-2005, while minimum 12.30 per cent and 6.40 per cent was recorded at N.D. University Farm Kumarganj,
Faizabad and Regional Agriculture Testing and Demonstration Farm, Hardoi from the germplasms/cultures DA-2 and KH-2 in both the crop seasons of 2003-2004 and 2004-2005. The average disease intensity varied from 8.50 per cent to 27.93 per cent and 7.10 per cent to 32.40 per cent in both the years of survey conducted.

The disease incidence as well as disease intensity could not be recorded in the years 2003-2004 and 2004-2005 at Farmer Field Saraimira, Kannauj and Regional Research Station Kotwa, Azamgarh and Chandra Shekhar Azad University Crop Research Farm, Belatal, Hamirpur, Regional Agricultural and Demonstration Farm, Hardoi and Gorakhpur University Farm Gorakhpur.

The investigations on the symptomology of the disease caused by *Alternaria alternata* and *A. tenuissima* revealed that under natural conditions, the disease appeared in the month of August and September in Kharif and Rabi seasons crop and symptoms were confined on the upper surface of leaves only. The spots caused by *Alternaria alternata*, observed as small, brown to black, circular to oval with paler margins and Yellow halo measuring 0.20-1.0 cm. in size with characteristic concentric rings and cracked centre. The lesions at first were recorded as smaller in size, while in later stage the spots were found numerous extending over the whole leaf surface due to coalescence of adjacent spots, which later became perforated due to falling away of dead tissue. The spots caused by *Alternaria tenuissima* became visible as small, isolated, scattered pale, brown spots on the leaves. Lowest leaves were attacked first and upper leaves later. The lesions, were surrounded by a narrow chlorotic zone, which fades into normal green tissues of leaves and increases with the increase in size of spots up to 3.0 to 4.50 mm.

According to Koch’s postulates the pathogens, were isolated on two per cent Potato dextrose agar medium by transferring surface sterilized portions of diseased leaf and subsequently, it was purified by Single Spore Culture technique. In order to test pathogenicity reisolations of the fungi, were done and the results indicated that all the isolates of fungi proved pathogenic on
Red gram plants. The fungi was able to cause Alternaria blight disease even inoculation was done without injury, thereby indicating that it was pathogenic. The infection percentage 92.50 per cent and 86.70 per cent was recorded on injured leaves in comparison to un-injured leaves, which showed 3.50 and 2.80 infection percentage of *Alternaria alternata* and *A. tenuissima* respectively.

Different methods of inoculation proved that the disease was always more in case of pin pick inoculation than without injury indicating the fact that injured leaves provided avenues for the pathogenic attack.

The pathogens viz; *Alternaria alternata* (Fries), Keissler and *A. tenuissima* (Kunze. ex. Pers; Wiltshire) revealed that colonies were fast growing; cottony smoky black; mycelium septate; branched; hyaline at first; later olive buff 2.80 - 8.30 µ in width, sometimes swollen (13.0 - 20.14 µ) to form chains of Chlamydospores; conidiophores long; more or less cylindrical simple or rarely branched; septate (2-11 cross septa), light to dark brown; 16.90 - 74.0 µ in length and 2.85 - 4.70 µ in width; conidia produced in short chains of 2-6; conical or oval; smooth; tapering gradually in beaks, generally with 2-80 cross and 0-6 longitudinal septa; slightly or unconstricted at septa; 12.0-58.13 × 11.25 - 18.0 µ in size, beaks almost equal to length of conidium, light in colour; 11.35 - 55.25 µ in length and 3.25 - 5.12 µ in width with 0-8 µ cross septa.

The morphological characters of the pathogen, *Alternaria alternata* was studied on Potato dextrose agar medium, revealed that colonies were moderately fast growing, which in the beginning dull; white; fluffy; circular and later turned into dark; greenish olive with abundant sporulation. Mycelium was found as septate; branched; hyaline; later turning into black and olive buff in colour measuring 3.20-4.80 µ in width. Conidiophores arise singly or in groups usually simple; septate; straight or bent; sometimes branched; swollen terminally; geniculate and dark olive buff measuring 24.50 - 69.30 × 3.20 - 6.40 µ. Conidia were formed in chains of 3-21; muriform; ovoid to obclavate; obpyriform; catenate (3 - 7); dark olive buff in colour; smooth sometimes verrucose with age; with 1-6 transverse septa and
0-6 longitudinal septa measuring 15.40 - 41.20 x 8.20 - 13.50 µ. Beaks were found usually short; light olive buff in colour and conical or cylindrical measuring 3.60 - 17.90 x 3.40 - 5.80 µ in size with 0 - 2 transversa septa. Chlamydospores were recorded sometimes terminal and intercalary and dark olive buff in colour, measuring 12.70 - 22.80 µ in diameter, while A. tenuissima, revealed that colonies were fast growing cottony; smoky black; mycelium septate; branched; hyaline at first; later olive buff; 2.80 - 8.30 µ in width; sometimes swollen (15.0 - 20.14 µ) to form chains of chlamydospores; conidiophores long; more or less cylindrical; simple or rarely branched, septate (2 - 11 cross septa); light to dark brown; 16.90 - 74.0 µ in length and 2.85 - 4.70 µ in width; conidia produced in short chains of 2 - 6; conical or oval; smooth tapering gradually in beaks; generally 2 - 80 cross and 0 - 6, longitudinal septa; slightly or unconstricted at septa, 12.80 - 58.1 x 11.25 - 18.0 µ in size; beaks almost equal to length of conidium; light in colour 11.35 - 55.25 in length and 3.25 - 5.12 µ in width with 0 - 8 cross septa. On the basis of morphological characters the fungi, under study have been identified as Alternaria alternata (Fries.) Keissler and A. tenuissima (Kunze. ex. Pers; Wiltshire) causing Alternaria blight disease of Red gram.

The effect of media on the growth and sporulation of the fungi on Natural (Non-Synthetic), Semi-synthetic and Synthetic media, were studied and recorded the best growth on Potato Dextrose agar medium measuring 91.70 mm. and 84.50 followed by Richard's agar, Czapek's agar, Coon's agar, Leaf decoction agar, Malt salt agar, Sabouraud's agar, Corn meal agar and Asthana and Hawker's agar media and Czapek's agar, Coon's agar; Asthana and Hawker's agar, Richard's agar, Leaf decoction agar, Malt salt agar, Sabouraud's agar and Carnal meal agar media of Alternaria alternata and A. tenuissima respectively. The least minimum growth measuring 19.50 mm. and 16.30 mm. was obtained on Brown's agar medium of both the pathogens.

Apart from studying the radial growth and sporulation of the pathogens various other cultural characters viz; growth; shape; zonation and colour of colony; substratum colour; pigmentation; colour of hyphae; colour of conidiophores; number and septation of conidia; variation in shape; size and colour existence and size of chlamydospores are quite different on the
different types of solid media belonging to Natural (non-synthetic), Semi-synthetic and Synthetic media are given below -

(A) *Alternaria alternata* (Fries), Keissler :

The results revealed that colony growth was found good; compact good; compact and raised; good compact with downy appearance; good sparse, thick and cottony; good sparse with entire margin; average sparse with entire margin; average sparse with suppressed hairy margin; average compact; good and semi-suppressed, compact; thin and cottony; average sparse with entire margin and poor sparse with entire margin on Potato dextrose agar, Czapek’s agar, Richard’s agar; Leaf decoction agar; Coon’s agar; Corn-meal agar; Malt salt agar; Sabouraud’s agar; Asthana and Hawker’s agar and Brown’s agar media respectively. The colony shape was recorded almost circular on all the media except Czapek’s agar medium, which exhibited lobe shaped colony. The colour of colony was almost recorded as dark grey; green with greenish tinge at the marginal ends; smoky grey; olivaceous black; dark black; dark greenish with darker centre; dark greenish with whitish margin; light green and creamy white on Asthana and Hawker’s agar; Brown’s agar; Sabouraud’s agar; Malt salt agar, Richard’s agar; Potato dextrose agar; Leaf decoction agar and Corn meal agar and Czapek’s agar and Coon’s agar media, respectively.

Substratum colour, was also found as irony grey; olive grey; light green, blackish green grey; olivaceous black; light vinaceous cinnamon; dark quaker drab and white smoky grey on Potato dextrose agar; Brown’s agar; Asthana and Hawker’s agar; Corn-meal agar; Czapek’s agar; Leaf decoction agar, Malt extract agar, Richard’s agar, Sabouraud’s agar and Coon’s agar media respectively. Zonation was found as distinct on Potato dextrose agar and Richard’s agar media; not clear on Asthana and Hawker’s agar medium; clear from upper side on Coon’s agar and Czapek’s agar media; clear from underside on Corn meal, Leaf decoction and Malt salt agar media, less clear from bottom side and absent from upper side on Brown’s agar medium and dark quaker drab on Sabouraud’s agar medium. Pigmentation was found absent on different types of media.
Colour of hyphae was recorded as olive buff; mid olive; olive buff to greyish; pale olive buff; pale olive grey; light olive grey and colourless to greyish on Czapek’s agar, Richard’s agar and Sabouraud’s agar media; Brown’s agar, Malt salt agar, Asthana and Hawker’s agar, Coon’s agar, Corn meal agar and Leaf decoction agar media and Potato dextrose agar medium respectively. Hyphae were found septate varying in size from 2.0 - 8.0 μ in width on different types of media under study.

Colour of conidiophores, was recorded as olive buff to brown; midolive to brown; olivaceous brown; dark olive buff; pale to olive brown; dark olive brown and olive grey on Brown’s agar and Richard’s agar media, Czapek’s agar and Sabouraud’s agar media; Coon’s agar and Malt salt agar media; Asthana and Hawker’s agar medium, Potato dextrose agar medium, leaf decoction agar and Corn meal agar media respectively. The conidiophores varied in size from 24.20 - 68.0 x 10 - 7.80 μ on different types of media under study.

Conidia, were also found as olivaceous to dark brown; dark olive brown; olive buff to brown; light brown; dark olive grey and deep olive brown on Czapek’s agar; Malt salt agar; Richard’s agar and Sabouraud’s agar media; Potato dextrose agar; Asthana and Hawker’s agar; Brown’s agar; Coon’s agar Corn meal agar and Leaf decoction agar media. Conidia were found borne in chains of 2-4 on Asthana and Hawker’s agar, Brown’s agar and Coon’s agar media; 2-5 on Corn meal agar, Czapek’s agar and -Malt salt agar media; 3-7 on Potato dextrose agar medium and 2-7 on Richard’s agar medium. Septation in conidia was also observed variable on different types of media. Transverse septa varied from 1-5 to 2-8 viz; 1-4; 1-5; 2-6 and 2-8 on Corn Meal agar medium; Asthana and Hawker’s and Brown’s agar media; Coon’s agar; Czapek’s agar; Leaf decoction agar; Malt salt agar and Sabouraud’s agar media and Potato dextrose and Richard’s agar media respectively, while longitudinal septa varied from 0-3 to 0-6 viz.; 0-3 on Asthana and Hawker’s agar; Brown’s agar, Coon’s agar and Corn meal agar media; 0-4 on Czapek’s agar; Leaf decoction; Malt salt and Sabouraud’s agar media; 0-5 on Richard’s agar medium and 0-6 on Potato dextrose agar medium. Conidia, were also
found varied in size from 7.0 - 35.0 x 3.0 - 13.80 µ in size on different types of media.

The beaks were found septate, and varied in size from 10.0 - 78.40 x 1.20 - 6.40 µ. The transverse septa varied from 0-1 on Asthana and Hawker's agar, Czapek's agar, Leaf decoction agar, Malt extract agar and Sabouraud's agar media and 0-2 on Brown's agar, Coon's agar, Corn meal agar, Potato dextrose agar and Richard's agar media.

The beaks were also recorded as olive green; olive buff to brown; light brown; olive grey; dark olive brown; olive to dark brown and light olive buff on Asthana and Hawker's agar medium; Brown's agar medium; Coon's agar and Richard's agar media; Corn meal agar medium; Czapek's and Sabouraud's agar medium; Leaf decoction agar medium; Malt salt agar medium and Potato dextrose agar medium respectively. The beaks were reported as cylindrical on corn meal, Czapek's, Leaf decoction; Richard's and Sabouraud's agar media and conical on Asthana and Hawker's; Brown's Agar; Coon's, Malt salt agar and Potato dextrose agar media.

Chlamydospores were found terminal as well as intercalary varying in size from 4.70 - 22.80 µ in diameter on all the different types of media but varying in size as dark brown; dark olive green; dark olive brown; olivaceous to dark brown; olive buff to brown; olive buff, light brown and olive grey on Czapek's and Sabouraud's agar medium, Asthana and Hawker's agar, Leaf decoction agar, Malt salt agar; Brown's agar, Potato dextrose agar; Coon's agar and Richard's agar media and Corn meal agar medium respectively.

(B) *Alternaria tenuissima* (Kunze. ex. Pers; Wiltshire)

The results revealed that colony growth was found average; sparse with suppression hairy margin; good sparse with entire margin; good and semi-suppressed; average sparse with suppressed hairy margin; good, compact and raised; poor sparse with entire margins; good; compact and downy appearance; good and compact and good and semi-suppressed on Asthana and Hawker's agar, Brown's agar, Coon's agar, Corn meal agar, Czapek's agar, Leaf decoction agar, Malt salt agar, Potato dextrose agar, Richard's agar and Sabouraud's agar media. The colony shape was almost circular on all the
media except Asthana and Hawker's agar, Brown's agar, Leaf decoction agar and Richard's agar media. The colour of colony was almost recorded as green with greenish tinge at the marginal ends; creamy white; dark green with whitish margin; green with greenish tinge at the marginal ends; concentric rings of allomate light green and green colour; dark brown; dark green with whitish margin; light green; dark green darker at the centre and creamy white on Asthana and Hawker's agar, Brown's agar, Coon's agar, Corn meal agar, Czapek's agar, Leaf decoction agar, Malt salt agar, Potato dextrose agar, Richard's agar and Sabouraud's agar media respectively.

Substratum colour was also found as white smoky grey; grey; light vinnaceous cinnamon; dark quaker drab; light green; olivaceous black; blackish green grey; light green; olivacious black and light green on Asthana and Hawker's agar; Brown's agar; Coon's agar; Corn meal agar; Czapek's agar; Leaf decoction agar; Malt salt agar; Potato dextrose agar; Richard's agar and Sabouraud's agar media respectively. Zonation was found as distinct on Coon's agar, Corn meal agar and Richard's agar media; clear from upper side on Brown's agar and Potato dextrose agar media; not clear on Asthana and Hawker's agar, Leaf decoction agar and Sabouraud's agar media and less clear from bottom side and not clear from upperside on Malt salt agar media. Pigment was found absent on different kinds of media.

Colour of hyphae was recorded as pale olive grey; olive buff; pale olive grey; olive buff; light olive grey; olive buff; colourless to greyish; light olive grey; olive buff and pale olive grey on Asthana and Hawkers, Brown's agar, Coon's agar, Corn meal agar, Czapek's agar, Leaf decoction agar, Malt salt agar, Potato dextrose agar, Richard's agar and Sabouraud's agar media. Hyphae were found septate varying in size from 2.30 - 8.10 \( \mu \) in width on different types of media under study.

Colour of conidiophores was recorded as olive grey; olive brown; olive buff to brown; dark brown; midolive to brown; pale to olive brown; olive buff to brown; dark brown and mid olive brown on Asthana and Hawker's agar, Brown's agar, Coon's agar, Corn meal agar, Czapek's agar, Leaf decoction agar, Malt salt agar, Potato dextrose agar, Richard's agar and Sabouraud's

(267)
agar media respectively. The conidiophores varied in size from 22.20 - 68.60 \times 3.20 - 7.80 \mu on different kinds of media under study.

Conidia were also found as olivaceous to dark brown; light brown; olivaceous dark brown; deep olive brown; dark olive grey; olivaceous dark brown; dark olive grey; dark brown, dark olive grey and olivaceous dark brown on Asthana and Hawker's agar, Brown's agar, Coon's agar, Corn meal agar, Czapek's agar, Leaf decoction agar, Malt salt agar, Potato dextrose agar, Richard's agar and Sabouraud's agar media respectively. Conidia were formed borne in chains of 2 - 4 on Asthana and Hawker's agar, Brown's agar, Leaf decoction agar and Malt salt agar media, 1 - 5 on Corn meal agar and Sabouraud's agar media, 2 - 5 on Coon's agar media and 2 - 6 on Potato dextrose agar and Richard's agar media. Septation in conidia was also observed variable on different kinds of media. Transverse septa varied from 1 - 5 to 2 - 6 viz. 1 - 5 on Asthana and Hawker's agar, Brown's agar, Corn meal agar and Leaf decoction agar and 2 - 6 on Coon's agar, Czapek's agar, Malt salt agar, Potato dextrose agar, Richard's agar and Sabouraud's agar media respectively, while longitudinal septa varied from 0 - 3 to 0 - 4 on Asthana and Hawkers agar, Corn meal agar and Potato dextrose agar and Brown's agar, Coon's agar, Czapek's agar, Richard's agar and Sabouraud's agar media respectively. Conidia were also found varied in size from 7.0 - 30.0 \times 3.10 - 8.20 \mu in size on different kinds of media.

The beaks were found septate and varied in size from 1.20 - 48.6 \times 1.30 - 5.30. The transverse septa varied 0 - 1 on Brown's agar, Leaf decoction agar, Malt salt agar and Potato dextrose agar media and 0 - 2 on Asthana and Hawker's agar, Coon's agar, Corn meal agar, Czapek's agar, Richard's agar and Sabouraud's agar media.

The beaks were also recorded as olive buff to brown; olive green; olive buff to brown; dark green; dark olive brown; light brown; olive grey; olive buff to brown; dark brown and olive grey on Asthana and Hawker's agar, Brown's agar, Coon's agar, Corn meal agar, Czapek's agar, Leaf decoction agar, Malt salt agar, Potato dextrose agar, Richard's agar and Sabouraud's agar media respectively. The beaks were recorded as cylindrical on corn.
meal, Czapek's agar, Leaf decoction agar, Richard's and Sabouraud's agar media and conical on Asthana and Hawker's agar, Brown's agar, Coon's agar, Malt salt agar and Potato dextrose agar media.

Chlamydoospore were found terminal as well as intercalary varying in size from 4.80 - 19.20 µ in diameter on all different kinds of media but varying in colour as dark brown; olive buff to brown; dark brown; olivaceous brown; dark olive brown; light brown; olive buff; light brown; dark brown and light brown on Asthana and Hawker’s agar, Brown’s agar, Coon’s agar, Corn meal agar, Czapek’s agar, Leaf decoction agar, Malt salt agar, Potato dextrose agar, Richard’s agar and Sabouraud’s agar media respectively.

The pathogens were also grown on different Natural (non-synthetic), Semi-synthetic and Synthetic media to select the ideal medium form, carrying out further physiological activities of the pathogens. Out of ten liquid media studied Potato dextrose medium was found to boost the fungal growth of Alternaria alternata and A. tenuissima, weighing 472.50 mg. and 463.80 mg. mycelial growth as well as excellent sporulation followed by Richard’s medium. Brown’s medium yielded poorest growth and poor sporulation.

In solid states of the media findings showed a trend almost similar to that found with their liquid forms, of course there are some variations in the order of their superiority. In present investigation Potato dextrose agar medium took first place instead of Richard’s medium in terms of mycelial growth. Almost close correlation, was observed between growth and sporulation in dry weight and linear growth of pathogens. Potato dextrose agar medium was selected as a basal medium for physiological and enzymatic studies due to uniform best growth and sporulation. Some variations in cultural and morphological characters were recorded on different culture media but significant differences on morphological characters were not observed.

The test organisms viz., Alternaria alternata and A. tenuissima, could grow on a wide range of temperatures of 5°C to 50°C viz; 5°C (T-1), 10°C (T-2), 15°C (T-3), 20°C (T-4), 25°C (T-5), 30°C (T-6), 35°C (T-7), 40°C (T-8), 45°C (T-9) and 50°C (T-10). The optimum range being 30°C (T-6) and 35°C

(269)
(T-7). The best growth and sporulation was recorded at 30°C (T-6), followed by 35°C (T-7) and 25°C and 30°C of *Alternaria alternata* and *A. tenuissima* respectively. Sporulation, was also recorded as excellent at 25°C (T-5), 30°C (T-6), and 35°C (T-7), good at 20°C (T-4) and 40°C (T-8), fair at 15°C (T-3) and poor at 5°C (T-1) and 45°C (T-9). The pathogens failed to sporulate at 5°C (T-1) and 50°C (T-10).

The pathogens viz., *Alternaria alternata* and *A. tenuissima*, were able to grow on pH ranged from 2.50 to 12.0 viz; P-1 (2.50), P-2 (3.0), P-3 (3.50), P-4 (4.0), P-5 (4.50), P-6 (5.0), P-7 (5.50), P-8 (6.0), P-9 (6.50), P-10 (7.0), P-11 (7.50), P-12 (8.0), P-13 (8.50), P-14 (9.0), P-15 (9.5), P-16 (10.0), P-17 (10.50), P-18 (11.0), P-19 (11.50), P-20 (12), but sporulated between the range of pH 3.50 (P-3) to pH 10.50 (P-17).

The maximum growth weighing 496.0 mg. and 488.70 mg. of *Alternaria alternata* and *A. tenuissima*, were observed at pH 6.50 (P-9), which was referred to as optimum pH. Excellent sporulation, was observed as P-9 (pH 6.50); followed by P-10 (pH 7.0); good at P-11 (pH 7.50) and P-12 (pH 8.0); fair at P-5 (pH 4.50), P-6 (pH 5.0), P-7 (pH 5.50) P-8 (pH 6.0), P-13 (pH 8.50), P-14 (pH 9.0) and P-15 (pH 9.50) and poor at P-3 (pH 3.50), P-4 (pH 4.0), P-16 (pH 10.0) and P-17 (pH 10.50). The pathogens failed to sporulate on P-1 (pH 2.50), P-2 (pH 3.0), P-18 (pH 11.0), P-19 (pH 11.50) and P-20 (pH 12.0). The pH, altered the pH of medium towards neutrality side. It was also observed that reaction of medium tended towards alkaline in cases, where the pH was on acidic side and vice-versa in the cases, where the media, was adjusted at P-14 (pH 9.0) to P-16 (PH 10.0) initially.

The studies on production of enzymes by the fungi in *vitro*, revealed that it produced Cellulase (CX), Polygalacturonase (PG) and Polymethylgalacturonase (PMG) enzymes. It was found that the activity of the enzymes was comparatively more in the medium supplemented with Carboxymethylcellulose (CMC), Sodium polypectate and Citrus pectin respectively; which play an important role in pathogenesis. In *vivo* studies, it was found that activity of Cellulase (CX), Polygalacturonase (PG) and Polymethylgalacturonase (PMG) enzymes took place in the diseased leaves

(270)
inoculated with pathogens, *Alternaria alternata* (Fries.), Keissler and *A. tenuissima* (Kunze. ex. Pers; Wiltshire) and no enzymatic activity was produced in healthy leaves.

In studies on biochemical parameters relating to disease resistance it was observed that the contents of surface wax, chlorophyll a and b, polyphenol, nitrogen, phosphorus, potassium, sugar and sulphur, were higher in healthy leaves than those of diseased ones after 40 and 70 days after inoculation in the order narrated. Only small quantity of these components was present in necrotic tissue.

As regards the susceptible age of the host, it was observed that the pathogens may cause the disease at any stage of plant growth but the maximum susceptibility was observed in the plants, which attained the age of 50 days, followed by 60, 40 and 70 days old plants. The minimum disease intensity was recorded from 10 days old plants. It was also concluded that plants were susceptible to disease at the age of 40-60 and 50-70 days particularly at 50 days. The susceptibility of plants towards disease decreased with the increasing age of plants and found almost as traces at the age of 90 days and onward. In general the susceptibility of plants to the disease gradually was found decreased below or above 50 days old plants.

The environmental factors like atmospheric temperature, relative humidity and rainfall, were proved to have profound influences on the disease incidence. The disease exhibited firstly its appearance in second week of July in both the years 2003-2004 and 2004-2005 and increased gradually. The maximum disease development 35.81 per cent and 38.15 per cent and 33.74 per cent and 36.27 per cent respectively of the pathogens viz., *Alternaria alternata* and *A. tenuissima* was recorded in the second week of August during both the years 2003-2004 and 2004-2005 respectively, when the average temperature was 29.67°C and 28.70°C and relative humidity was 88.70 per cent and 54.30 and 81.25 and 76.80 per cent respectively. A trend of decline of disease severity was also recorded with lowering down the temperature and relative humidity and finally by the fourth week of October, when both the atmospheric temperature and relative humidity were

(271)
unfavourable. In general the disease intensity decreased with the increase in temperature, whereas increased with the increase in relative humidity in both the years 2003-2004 and 2004-2005. The effect of rain fall, however was relatively more important in epidemiology of the disease as compared to distribution of rainfall 5-6 days a week accompanied by a cloudy weather.

The effect of NPK on host nutrition expressed that the disease intensity and susceptibility increased with the increase in level of nitrogen, whereas negative correlation was recorded between the levels of phosphorus and potash with the severity of disease. It was observed that 60 Kg. P$_2$O$_5$ + 10 Kg. K$_2$O were most effective in reducing the disease incidence as compared to 60.0 Kg. + N-60.0 Kg., P$_2$O$_5$ + 40 Kg. K$_2$O / Ha. The effect of phosphorus and potash was less significant in combination with 120 Kg. nitrogen per hectare.

The investigation on mode of survival of the fungi revealed that the pathogens remained viable in soil, seeds and plant debris from November to June till the next sowing season. In tested seeds soil and diseased plant debris, were observed as virulent to serve as a source of primary inoculum for the pathogens. Secondary spread of disease was observed to be caused by conidia produced on the diseased spots of infected leaves and transmitted through air.

For screening the source of resistance against Alternaria blight disease of Red gram 32 germplasm / cultures, were examined under natural and artificial conditions in order to examine their reactions to pathogens viz. Alternaria alternata and A. tenuissima. In natural conditions four germplasms / cultures viz; Pusa-33, Manak, ICPL-151 and DA-2 were found Tolerant being disease free (F), six germplasms / cultures viz; Pusa-84, Type-21, Pant A-10, Sharda, Mukta and Pusa Ageti, were recorded as Resistant (R), five germplasms / cultures viz. Pusa-84, N.P.(WR)-15, Type-7, Pusa-64 and Pusa-74, were recorded as moderately Resistant (MR); five germplasms / cultures viz; Basant, Gwalior-3, UPA-120, Type-17 and BR-183 were found moderately susceptible (MS); eight germplasms / cultures viz; Bahar, Pant A-3, ICPL-87, C-21, KH-2, Lakshmi, M.A.-128-1 and M.A.-128-2,
were found susceptible (S) and four germplasms / cultures in viz; Prabhat, SA-1, ICPL-317 and B-7, were found Highly Susceptible (H.S.).

Further in artificial epiphytotic conditions of seeds and plant inoculation for their reactions to pathogens during Kharif season in the year 2005 the seeds of fifteen germplasms / cultures which were found Disease Free (F), Resistant (R) and Moderately Resistant (MR) were further examined in seed inoculation test. Out of fifteen three germplams/cultures viz; DA-2, Pusa-33 and I.C.P.L.-151 were found as Resistant (R); five germplasms / cultures viz; Pusa-84, Type-21, Sharda, Mukta and Pant-A-10 were found as Moderately Resistant (MR) four germplasms / cultures viz; Pusa-84, Type-7, Pusa-64 and Pusa-74 were found as Moderately Susceptible (MS) and three germplasms / cultures viz; Manak, NP (WR)-15 and Pusa Ageti were found susceptible (S).

Host range study revealed that the pathogens Alternaria alternata and A. tenuissima, were able to infect the wide range of 66 host plants, both cultivated and wild belonging to 19 different families viz; Apocynaceae, Aracaceae, Chenopodiaceae, Asteraceae, Brassicaceae, Cucurbitaceae, Euphorbiaceae, Poaceae, Fabaceae, Labiatae, Liliaceae, Linaceae, Malvaceae, Myrtaceae, Papaveraceae, Pedaliaceae, Rosaceae, Solanaceae, and Umbelliferae. Out of these 48 plants Abelmoschus esculentus, Abutilon indicum, Althaea rosea, Allium cepa, Argemone mexicana, Avena savita, Arachis hypogea, Brassica campestris, B. Campestris var. dichotoma, B. juncea, B. oleracea var. botrytis, B. oleracea var. capitata, B. oleracea var. gongylodes, Carissa carandus, Carthamus tinctorius, Capsicum annum, Chenopodium album, Chrysanthemum indicum, Colocasia antiquorum, Coriandrum sativum, Crotalaria juncea, Cucurbita maxima, Cynodon dactylon, Dahlia sp, Datura alba, Dolichos lablab, Gossypium sp., Glycine max, Hibiscus rosa-sinensis, Hordeum vulgare, Linum usitatissimum, Lagenaria vulgaris, Lycopersicum esculentum, Luffa cylindrica, Ocimum sanctum, Pismum sativum, Pennisetum typhoides, Raphanus sativus, Ricinus communis, Saccharum officinarum, Sesamum indicum, Sorghum vulgare, Solanum nigrum, S. melongena, S. xanthocarpum, S.tuberosum. Tagetes erecta and Triticum aestivum, belonging to fifteen different families were found infected under artificial conditions of inoculation with
spore-cum-mycelial suspension of the pathogens. It was found that the pathogens could infect the monocotyledonous and dicotyledonous plants having wide host range.

To select the suitable fungitoxicant for the control of the disease caused by *Alternaria alternata* and *A. tenuissima*, under field conditions the efficacy of twenty five fungitoxicants, Benzene (Halogenated organic compound), Inorganic Copper compound, Dithiocarbamate, Hetrocyclic nitrogenous compound, Organomercury, Quinone, Systemic inorganic Sulphur compound and an Antibiotic viz; Agrosan G.N.; Bavistin, Benlate, Blitox-50, Brassicol, Calixin, Captafol. Captan, Cersan (Dry), Dichlone, Dithane M-45, Dithane Z-78, Duter, Emisan-6, Ferbam, Karathane, Hexaferb, Pancotine, Ridomil, Spergon, Suflex, Thiram, Vitavax and Ziram as well as an antibiotic (Aureofungin), were tested in the laboratory on the effect of growth of fungus. Dry weight of fungal mycelium in different concentrations of 0.005 per cent, 0.10 per cent, 0.15 per cent, 0.20 per cent, 0.40 per cent and 0.60 per cent were significantly better in performance in comparison to control. A dosage response indifferent concentrations viz; 0.05 per cent, 0.10 per cent, 0.15 per cent, 0.20 per cent, 0.40 per cent and 0.60 per cent of fungitoxicants with reference to the pathogenic effect viz., light yellow lesion (LY), Yellowish brown lesion (YB), Light yellow brown lesion (LB), Extensive brown lesion (EB) and Phytotoxic effect (PE) on the plants were also studied. Out of the 24 fungitoxicants tested Agrosan G. N., Ceresan (Dry) and Emisan-6, belonging to Organomercury, Duter, Karathane and Thiram belonging to Dithiocarbamate, Aureofungin (Antibiotic), Captan and Foltal 80-W (Captafol) belonging to Hetrocyclic nitrogenous compound and Panacotine belonging to Systemic group were most effective as they inhibited the growth of fungi and did not produce any pathogenic effects. Other fungicides viz.; Dithane M-45 and Vitavax, were also found effective in checking the growth of fungus and superior to the remaining fungicides tested. These fungitoxicants were found to be most effective as they inhibited the growth of fungi, when tested the different concentrations of 0.05 per cent, 0.10 per cent, 0.15 per cent, 0.20 per cent, 0.40 per cent, and 0.60 per cent, in respect of dry weight of mycelium. The other fungicides viz; Calixin
(Systemic) and Suflex (Inorganic sulphur), were found also effective in arresting the growth of fungi upto 85.24 per cent at 0.05 per cent, 88.30 per cent at 0.10 per cent, 89.52 per cent at 0.15 per cent, 90.38 per cent at 0.20 per cent, 92.72 per cent at 0.40 per cent and 95.62 at 0.60 per cent and 87.92 per cent at 0.05 per cent, 91.61 per cent at 0.10 per cent. 92.06 per cent in 0.15 per cent. 93.25 per cent in 0.20 per cent, 94.50 per cent in 0.40 per cent and 95.09 per cent in 0.60 per cent respectively. The significant variations in inhibition in hyphal dry weight with respect to treatment of different fungitoxicants as well as different concentrations were recorded. Apart from this these fungitoxicants were also found effective as did not produce any pathogenic effects but Brassicol (Benzene), Calixin (Systemic) and Suflex (Inorganic sulphur) were also found effective in producing Light yellow lesions (LY) only in different concentrations of fungitoxicants and established better in comparison to the remaining fungitoxicants tested except Brassicol (Benzene) in 0.30 per cent, where no pathogenic effect were shown. The number of germ tubes in A. alternata and A. tenuissima varied from 6-39, 5-32 and 2-29 in 0.002 per cent, 0.0004 per cent and 0.0006 per cent concentrations of fungitoxicants, Minimum 6, 5, and 7 germs tubes were produced in treatment with Vitavax (Systemic) in 0.0002, 0.0004 and 0.0006 per cent concentrations respectively, while maximum 39 germs tubes in the treatment of Calixin (Systemic) and in treatment with other fungicides 7, 8, 10, 11, 13, 16, 18, 22, 26, 28, 30 and 32 germs tubes were found. They were also effective as fungal spores failed go germinate, when fungitoxicants were applied in 0.0002 per cent, 0.0004 per cent and 0.0006 per cent concentrations but Dithane M-45 (Dithiocarbamate) and Vitavax (Systemic) were less effective as produced minimum spore germination and proved better in comparison to other fungitoxicants. As for as the length of germ tube is concerned, varied from 0.006 to 0.017; 0.005 to 0.015 per cent and 0.004 to 0.013 per cent in 0.002 per cent, 0.0004 per cent and 0.0006 per cent concentrations of different fungitoxicants respectively. The minimum germ tube length measuring 0.006 mm., 0.005 mm. and 0.004 mm., were recorded in treatment with Vitavax (Systemic) in 0.0002 per cent, 0.0004 per cent and 0.0006 per cent concentrations of fungitoxicants respectively,
whereas maximum number of germ tubes length 0.017 mm., 0.015 mm. and 0.013 mm. with the treatment of Calixin (Systemic) in 0.0003 per cent, 0.0004 per cent and 0.0006 per cent concentrations respectively. The inhibition percentage over control varied from 22.72 per cent to 72.72 per cent, 36.36 per cent to 72.27 per cent and 40.90 per cent to 81.81 per cent in 0.0002 per cent, 0.0004 per cent and 0.0006 per cent concentrations of fungitoxicants respectively in Alternaria alternata, while in A. tenuissima varied from 24.92 per cent to 68.92 per cent, 34.84 per cent to 75.28 per cent and 45.45 per cent to 78.18 per cent in 0.0002, 0.0004 and 0.0006 per cent concentrations of different fungitoxicants respectively. The inhibition in all the three parameters in spore germination, germ tube length and number of germtubes, produced by spores were pronounced in higher concentrations of fungitoxicants with significant differences, Dithane M-45 (Dithiocarbamate) and Vitavax (Systemic) caused appreciable degree of inhibition in respect of germination of spore, germ tube number and germ tube length. The germ tube length was inhibited up to 81.81 per cent at higher concentrations. At lower concentration Blitox-50 (Inorganic Copper) and Calixin (Systemic) were not proved effective but effective at higher concentration in inhibiting spore germination.

The efficacy of selected seed dressing fungitoxicants viz., Agrosan G. N., Aureofungin (Antibiotic), Captan, Ceresan (Dry), Duter, Emisan-6, Foltaf-80 W (Captafol) Karathane, Pancotine and Thiram as seed dressers proved effective in laboratory, were evaluated on seed treatments for studying their effects on seed germination and seed borne infection in vitro and it was found that all of them improved germination. The highest germination was recorded in seeds treated with Ceresan (Dry) (Organomercury) followed by Thiram (Dithiocarbamate), Captan (Heterocyclic nitrogenous compound) Agrosan G. N. (Organomercury). The seed treatment with Ceresan (Dry) resulted in elimination of the fungi but the treatment with Thiram (Dithiocarbamate), Captan (Heterocyclic nitrogenous compound) and Agroson G.N. (Organomercury), expressed their broad spectrum in nature in order mentioned and these were par in efficacy. It was also recorded that lowest infection 1.97 per cent was found in treatment with Karathane. The
maximum 14.42 percent infection was recorded in treatment with Pancotine (systemic), followed by Thiram (Dithiocarbamate), Emisan-6 (Organomercury), Duter (Dithiocarbamate), Aureofungin (Antibiotic), Agrosan G.N. (Organomercury), Foltaf 80W and Captan (Heterocyclic Nitrogenous compound). Ceresan (Dry and Agrosan), G.N. (Organomercury), was found to be best one as it completely eliminated the infection. In general all the fungicides examined were found significant over control in reducing seed borne infection.

The same seed dressing fungicides were tested in pot experiments also for ascertaining the effects of Alternaria alternata and A. tenuissima on seed germination and seedling infection. The highest seed germination 96.47 per cent was recorded in treatment with Ceresan (Dry Organomercury), followed by 92.08 per cent with Thiram (Dithiocarbamate), 92.15 per cent in Captan Heterocyclic nitrogenous compound in A. alternata while 96.47 per cent in Ceresan (dry), followed by 92.45 per cent in Thiram, 91.38 per cent in Captan, and 91.80 per cent in Agrosan G.N. respectively (Heterocyclic nitrogenous compound) and 91.38 per cent in Agrosan G. N. (Organomercury) while comparatively poor germination was noticed in treatment with Aureofungin (Antibiotic), Pancotine (Systemic), Karathane (Dithiocarbamate) and Foltaf - 80 W (Heterocyclic nitrogenous compound). The complete control of seedling infection in treatment with Ceresan (Dry, Organomercury) and Thiram (Dithiocarbamate) had no infection. Captan (Heterocyclic nitrogenous compound) and Agrosan G. N., were found superior in elimination of seedling infection, whereas other seed dressing fungitoxicants belonging to Heterocyclic nitrogenous compound (Captan), Organomercurials (Agrosan G. N. and Ceresan) compound groups were most efficaceous than fungitoxicants belonging to Dithiocarbamate, Copper, Sulphur and Quinone compounds of Systemic nature controlling seeds borne infection.

In studies regarding the control of disease in the field, ten different fungitoxicants viz., Agrosan G. N., Captan, Ceresan (Dry), Duter, Emisan-6, Foltaf-80 W, Karathane, Pancotine and Thiram as well as an antibiotic (Aureofungin), which were found completely or partially effective in bioassay test, were evaluated under pot and field in the years 1996 and 1997 in order
to select out a suitable fungitoxicant reducing the incidence of disease and boosting seed yield. The best control of disease was obtained by application of Captan (Heterocyclic nitrogenous compound) followed by Thiram (Dithiocarbamate), Ceresan (Dry) and Agrosan G. N. (Organomercury), Aureofungin (Antibiotic), Duter and Karathane (Dithiocarbamate), Pancotine (Systemic) and Emisan-6, (Organomercury) in pot and field in both the years 2004 and 2005. Further, it was observed that plants sprayed with Captan (Heterocyclic nitrogenous compound), exhibited significantly better yield per plant as 20.91 gms., 18.34 gms. and 19.25 gms. and 17.22 gms. in A. alternata and A. tenuissima respectively in pot experiments, while Thiram (Dithiocarbamate), Ceresan (Dry), and Agrosan G. N. (Organomercurials), Duter (Dithiocarbamate), Pancotine (Systemic), Emisan-6 (Organomercury), Karathane (Dithiocarbamate) and Aureofungin (Antibiotic) in field experiments differed significantly in the years 2004 and 2005 and were significantly superior over control. Lowest yield 21.19 gms. and 20.94 gms. and 16.45 gms. and 14.08 gms. and 16.04 gms. and 13.52 gms. respectively in A. alternata and A. tenuissima per plant in treatment with Captafol (Foltaf-80 W, Heterocyclic nitrogenous compound) in both the years. Complete control of the disease was not achieved by any of the fungitoxicants tested but significantly increased in the yield establishing a good correlation between leaf infection and yield, which were lowered according to the severity.