OCCURRENCE AND MANAGEMENT OF PURPLE BLOTCH OF GARLIC

By

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(J-19-M-673)

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Divisionof Plant Pathology

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Certificate-I

This is to certify that the thesis entitled "**Occurrence and Management of Purple Blotch of Garlic**" submitted in partial fulfillment of the requirements for the degree of Master of Science in Agriculture (Plant Pathology) to the Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, is original work and has similarities with published work not more than minor similarities as per UGC norms of 2018 adopted by the University. Further the level of minor similarities has been declared after checking the manuscript with Urkund software provided by the University.

The work has been carried out by **Mr .Chandra Teja Gangavaram**, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. It is further certified that help and assistance received during the course of thesis investigation have been duly acknowledged.

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ABSTRACT

Title of the thesis	:	Occurrence and Management of Purple Blotch of Garlic
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ABSTRACT

The present investigation entitled "Occurrence and Management of Purple Blotch of Garlic was studied during the year of 2020-2021. Survey was conducted during research work in major garlic growing regions of Jammu district. Survey revealed that among four tehsils of Jammu district, maximum disease severity was recorded in the village of Kotli (33.82%) in R. S. Pura and minimum disease severity was recorded in the village of Garkhal (21.89%). Epidemiology studies revealed that the maximum temperature, minimum temperature, maximum relative humidity and minimum humidity showed significance correlation in disease development, whereas, rainfall showed non- significant in the development of the disease. Different fungicides and botanicals were evaluated under *in vitro* as well as field conditions. In non-systemic fungicides propineb exhibited maximum mycelial inhibition (78.66%) at 500ppm followed by copper oxychloride which showed 77.11 per cent mycelial inhibition at 500ppm under *in vitro* conditions. In case of systemic fungicides, difenoconazole showed 100 per cent of mycelial inhibition followed by tebuconazole which showed 96.66 per cent reduction of mycelial growth. In botanicals Datura showed maximum mycelial inhibition (82.66%) and minimum mycelial inhibition was observed in neem leaf extract (62.66%). Under field conditions, difenoconazole @ 01 % reduced the maximum disease severity (58.29%) with maximum yield (119.33q/ha) and provided the highest cost benefit ratio (1:7.43) Whereas, Datura leaf extract @25% (25.59%) showed maximum disease with (110.52q/ha) yield with cost benefit ratio (1:7.02)

Key words: Purple blotch, disease severity, epidemiology, *in vitro*, management yield, cost benefit ratio.

A K Singh

Signature of Major Advisor

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Signature of the student

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LIST OF ABBREVIATIONS USED IN THE MANUSCRIPT

viz.	*Videlicet (namely)*
Cm	Centimeter
G	Gram
Kg	kilogram
Q	quintal
Ha	hectare
et al.	*et alibi (and others)*
WP	wettable powder
MT	metric ton
%	Per cent
CD $_{(p= 0.05\%)}$	critical difference at 5% level of significance
@	at the rate
i.e.	*id est (it/that is)*
e.g.	*exempli gratia (for example)*
C:B	Cost benefit

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Chapter-1

Introduction

CHAPTER-1

INTRODUCTION

Garlic (*Allium sativum* L.) belongs to the family Amaryllidaceae and it is the important spice crop of the genus *Allium*. Due to its odoriferous characteristics, it is also known as the shrinking rose. It is believed to be originated from Southern Europe and Western Asia. (Etoh and Simon 2002) and thought that garlic has been grown in China and India since from 5,000 years and in Egypt from over 4000 years.

The active element in garlic is allicin, which is produced by crushing garlic cloves. Allicin gives a pungent flavour to garlic along with ample benefits. Garlic leaves are sources of protein and vitamin A and C. Garlic is reported to have antibiotic compounds that inhibit bacterial growth. It is used in folk medicine to treat whooping cough, lung ailments, stomach complaints (as a healing agent for intestine ulcers), and disorders caused by childbirth, as well as colds, sore eyes, and earaches (Neeraj *et al.,* 2014) Recently, it was scientifically proved that garlic extract can inhibit the growth of cancer cells in a syngeneic orthotopic breast cancer model. (Petrovic *et al.,* 2018)

It is a biennial plant that grows up to 60 centimetres tall. Several cloves (10-16) or individual portions consisting of thickening storage leaves and a growth tip emerge from the bulbs' flattened conical stem. The leaves are flat and solid, and the flowers are pink when they appear (Rice *et al.,* 1990). Cloves are used to cultivate garlic vegetative the small central cloves are rarely employed because they generate small plants and as a result, small bulbs will be developed.

India stands at second position in garlic production after China. In India the total garlic production was 2836 thousand metric tonnes from an area of 354 thousand hectares in 2018-19. The average production of garlic is 0.61 thousand metric tonnes in Jammu district with an area of 0.710 thousand hectares during 2017-18. Long-day garlic is exclusively grown in temperate areas, such as Jammu & Kashmir (U.T), Himachal Pradesh, and Uttarakhand. (Anonymous, 2019)

Garlic crop affected by several diseases caused by fungi, bacteria and viruses. Out of them, the fungal diseases are Purple blotch (*Alternaria porri*), White Rot (*Sclerotium cepivorum*), Downy mildew (*Peronospora destructor*), Basal rot (*Fusarium calmorium*) and Stemphilium blight are some of the important disease

caused by the fungi. Garlic contains anti-bacterial compounds that suppress bacterial growth, therefore bacterial diseases are minor concerns. However, a few viral infections, such as onion yellow dwarf virus, latent virus, and leek yellow stripe virus, can infect the crop as minor disease.

Among the fungal diseases, purple blotch (*Alternaria porri*) is one of most destructive foliar disease of genus *Allium* and it is widespread in all parts of the world where garlic crop is grown, causing significant losses in bulb of the crops. The pathogen usually associated with the purple blotch is *Alternaria porri* (Ellis) Cif.

The infection appears on the leaves as concentric rings, which subsequently turn brown with a grey centre. The patches grow oval or circular and in shape as the disease progresses. The affected leaves become dry from the tip and fall off prematurely as a result of the infection. The infection also spreads to other plant parts such as the stem, bud, and seeds, causing the entire plant to dry out. The disease increases in warm, humid environmental conditions which is most favourable for disease development. Any pathogen's host range is one criterion that revealed its pathogenicity and host preference. (Sharma and Ratnoo 2019)

Due to the purple blotch disease in garlic there is a drastic reduction in yield (in quality and quantity) up to 97% in all over the world by infecting on leaves and bulb. In India up to 2.5 to 97% yield loss was reported due to purple blotch disease (Tripathi *et al.,* 2013, Nanda *et al.,* 2016)

Hence, keeping the view the seriousness of the disease in the state, destructive nature of the pathogen and importance of the crop, the present study was envisaged with the following objectives:

1. To assess the status of purple blotch of garlic in Jammu district
2. To study the Epidemiology of the disease
3. Management of purple blotch of garlic through fungicides and botanicals

Chapter-2

Review of Literature

CHAPTER-2

REVIEW OF LITERATURE

Purple blotch of garlic caused by *Alternaria porri* is the most problematic disease throughout the world in major garlic growing region. It causes serious yield reduction of the crop. Management of the disease by using fungicides and different botanicals are being explored in many countries of the world. Relevant literature related to the present study is briefly reviewed in this chapter.

2.1 History

Purple blotch symptom was discovered in onions by Nolla (1927), who named the fungus *Alternaria alli*. Using several cultures at a specific physical and environmental condition, Docampo and Conci (1996) isolated *A. alternata* and *A. porri* from a garlic (*Allium sativum*) plants showing leaf blight. Ponnappa (1974) identified *A. cepulae* from Karnataka as the cause of onion purple blotch. Utikar and Padule (1980) found purple blotch abdudisease on onion, with *A. alternate* as the causative agent.

2.2 Intensity and Yield loss

Gupta and Pathak (1988) recorded the highest yield loss in blub crop (50.43%). Similarly, in seed yield (59.09%) in onion crop due to purple blotch disease. It was concluded that maximum disease index will leads to the reduction of blub as well as seed yield

Bisht and Agrawal (1993) conducted field experiments to find out the yield losses and relationship between garlic leaf age and susceptibility of *A. porri* on different garlic susceptibility varieties and monitored till crop harvesting. That observed that Sel-10 showed highly susceptibility followed by G-41 cultiver, IC-49382 (moderately susceptible) and IC-49373 (moderate to less susceptible). Sel-10 and IC-49373 showed high disease severity during last week before bulb maturity and also observed that more lesions were seen on young leaves

Bisht and Agarwal (1994) developed AUDPC model to determine the relationship between *A. porri* and yield loss in garlic. It was observed that significant

yield reduction by 25 per cent defoliation at 5th week, 50 per cent defoliation at 4 week and 75 per cent defoliation at 3rd week before the crop maturity

Huq *et al.* (1999) assessed the intensity of yield loss due to purple blotch of garlic under natural epiphytotic conditions. The disease severity, yield loss and yield parameter varied significantly and ranged 26.69 per cent to 38.12 per cent in unsprayed plots.

2.3 Occurrence of the disease

Deepshikha *et al.* (2013) observed the disease incidence at different stages of garlic crop. The data on the incidence of purple blotch showed that the maximum incidence was observed in bulb formation stage (76.75%) in genotype G-41 while minimum at (1.51%) leaf formation stage in genotype HG-17.

Sharma and Ratnoo (2019) studied the host range of *Alternaria porri* and found that viable symptoms on all the tested crop and recorded the disease severity by using 1-5 scale and found the highest disease index in onion (43.33 per cent) followed by garlic (36.51%) and minimum PDI was recorded in sunflower (26.44%). From the result, it was concluded that *A. porri* has a wide host range.

2.4 Symptoms

Aveling and Nudae (1992) reported purple blotch of garlic for the first time in South Africa by observing the foliar damage. Leaf symptoms varied from small, elliptic white lesions to large, sunken purple lesions with concentric dark and light zones where sporulation was heavy or sparse, respectively.

Yan *et al.* (2009) observed the violet leaf spots on garlic and identification of resistance on different leaf stages and development of the disease by influencing the different abiotic factors under *in vitro* conditions as well as *in vivo* conditions by using different susceptible cultivers *viz.*, G087 (R), G064 (MR) and G073 (S). It was observed that, the purple blotch disease can infect through wounds at seedling stage and natural opeanings at flowering stage. Under *in vitro* condition the inoculation of the disease was observed at 21ºC and the optimal survey of the disease index was up to 6th day. Using this cultivars G087 (R), G064 (MR) and G073 (S) showed the true resistance of garlic cultivars.

2.5 Survey

Padma *et al.* (2018) conducted survey to assess the disease severity of purple blotch of onion in North-Eastern Karnataka. The survey of onion purple blotch reported that the highest disease severity was noticed in Garjanal village (86.40%) whereas, the lowest disease severity was noticed in Dornahalli village (9.60%) and concluded that disease severity is more in Koppal district in North- eastern Karnataka due to mono-cropping, favourable climatic condition, presence of initial inoculums and cultivation of susceptible varieties in large scale.

John *et al.* (2018) conducted survey in major onion growing regions *viz.*,Hadha, Thanthanwa, Ghoorpur, Chaka, Pahlukapurwa, Karchana, Jari, Kanti, Soraon and Phoolpur and from each village eight fields were selected randomly to assess the disease incidence of purple blotch disease. It was observed that the maximum disease incidence was observed in the village of Jari village (16.00%) followed by Karchana (15.37%), Pahlukapurwa (14.87%), Kanti (14.75%), in the year of 2016.

Tiwari and Singh (2020) conducted survey to study the disease index of purple blotch of onion during *rabi* season 2018-2019 in major onion growing regions of Central Bihar and collected samples. This study reported that the highest (37.17%) per cent disease index was recorded in the Nalanda district and the lowest (23.98%) per cent disease index was identified in Vaishali district of Bihar. Based on the isolation and morphological studies, the pathogen was identified as *Alternaria porri*.

2.6 Epidemiological studies

Hadisutrisno *et al.* (1995) conducted field trials to study the ecology of purple blotch disease and concluded that purple blotch disease was influenced by the temperature, relative humidity and wind velocity. Conidium dissimilation was occurred both during day and night when the air temperature was high with low humidity.

Gupta and Pathak (1986) observed the leaf age and favourable condition for the disease development. It was observed that the 60 days old plants showed highly susceptible and also observed the lowest incubation period (5.17 days) and 100 per cent disease incidence and 66 per cent relative humidity. They also concluded that maximum disease incidence and shortest incubation period was observed due to high relative humidity

Suheri and Price (2001) studied purple blotch incidence by cultivating commercial leek crops and the first symptom was observed on older leaves 54-69 days after transplanting). Lesions with typical symptoms were observed by *Alternaria porri* (6%) and *Stemphylium vesicarium* (42%).

Razdan *et al*. (2011) studied the influence of weather factors on disease development by selecting seven cultivars namely; N 53, Royal Select, Raj, Pankaj, Local, Pusa Red and IKO and conducted field trials during 2003 and 2004. The results revealed that the selected varieties showed that the maximum disease severity was observed in the 18th meteorological standard week in the year of 2003 in Royal select cultivar (74.05%) and minimum disease severity in Pankaj cultivar (44.04%). It was finally concluded that the maximum temperature and maximum relative humidity showed 95% disease progression during 2003. Whereas, maximum temperature and maximum relative humidity showed 97% disease prediction.

Kareem *et al.* (2012) observed that *A. porri* requires 15-35^{o}C for causing infection in onion crops and it was observed that the infection was maximum when it was incubated under light for 24hrs and less infection was observed when inoculated plant was kept in dark region for 24hrs. It requires 95% relative humidity for causing the infection.

Mohammad and Dabbas (2012) observed the influence of abiotic factors of the disease development due to environmental conditions such as temperature and relative humidity. It was concluded that conidial germination (71.0%) and germ tube germination (46.0µm) was observed at maximum temperature (28^{o}C) under laboratory condition. Under field condition maximum temperature (25.50-28.0^{o}C and 26.5-27.2^{o}C) and relative humidity (88-76% and 80-78%) showed significant correlation.

Jhala *et al.* (2017) observed the maximum disease severity of purple blotch disease in onion at 13-32℃ temperature and relative humidity more than 75 per cent with optimum rainfall and wind speed. It was also concluded that increasing the plant age will leads to increase the disease susceptibility

Khamari *et al.* (2017) observed the influence of development of the purple blotch disease due to weather parameters such as temperature, rainfall, relative humidity on large susceptible cultivars. It was revealed that maximum temperature,

minimum temperature, maximum RH, minimum RH and rainfall showed significance relationship and contributed 70.3 per cent development of disease incidence

Premchand *et al.* (2017) conducted field trail to observe the development of purple blotch disease during 2016 at Bagalkot district Karnataka. This studies revealed that 0 to 73.33 per cent plant disease incidence have been recorded and 2052.195 AUDPC value was recorded. It was concluded that delay sowing increases the disease severity of purple blotch in onion.

2.7 Pathogenicity test

Fernandez *et al*. (2011) conducted pathogenicity test on two cultivars namely Mercedes and Excalibur and selected these cultivars as test plants. The infected leaves were isolated from 60-70 days old plant and inoculated on these two onion cultivars at the centre part of the leaves and wound by using sterile dissecting needle. C Totally 19 Alternaria spp were isolated and inoculated on these two onion cultivars and out of five Alternaria spp were identified as the pathogenic to onion plants. Two isolates of *A. enuissima*, two isolates of *A. allii* and one isolate of Alternaria spp by observing their colony growth and conidia and it was reisolated to justify the Koch pastulate's

Mayur and Borse (2015) collected onion and garlic samples from field by observing the foliar symptoms and isolated the pathogen and observed the mycelium growth after three days. The isolated culture was inoculated on healthy plants. It was observed that similar foliar symptoms were seen on the inoculated plants and conforms the pathogenicity of *A. porri* and *S. Vasicarium* grow rapidly on green leaves under favourable conditions.

Osman *et al.* (2021) isolated eight Alternaria spp by seeing the symptoms on garlic leaves from field. For the pathogenicity test these isolates were cultured on potato dextrose agar media and observed the colony growth. Later conidial suspension was adjusted up to 1×10^6 in distilled water and sprayed the inoculum suspension on garlic leaves after 50 days planting and covered with polythene bag for the development of humidity. It was observed that the same symptoms were developed which was observed in the field and IS4 isolate showed maximum disease severity as compare with among eight isolates.

2.8 Physiological test

Khare and Neema (1981) observed the maximum sporulation of *A. porri* occurs immediately after rainfall. Whereas, in the lab, it requires 22ºC temperature and 90 per cent relative humidity. Most conidia were trapped at 8.00 PM at a mean temperature >18ºC.

Tahira *et al* (2019) studied the effect of nutrient media, temperature, hydrogen ion concentration and photoperiod to record the growth of mycelium of *Alternaria porri* under *in vitro* conditions and they recorded that the maximum mycelium growth of *Alternaria porri* at 28ºc and on PDA media having pH 6.5 with 16/8 light and dark period.

2.9 Management

2.9.1 Germplasm

Bishat and Thomas (1992) evaluated garlic germplasm lines against *A. porri* and *S. vesicarium* under natural and artificial epiphytotic conditions during 1986-88.No lines were completely resistant to both pathogens with most lines being moderately or highly susceptible of the remaining lines, 39 and 18 were resistant to *S. vesicarium* and *A. porri*, respectively, while, 9 lines were resistant against both pathogens (IC-32320, IC-35286, IC 43398, IC 48157, IC 48875, IC 49415, EC-158250, T84/13 and C 1525).

Alam *et al.* (2007) evaluated six local garlic varieties like Agliobianco, Alladher local, Chinese, Hazro, Peshawar local and S4 varieties against rust and purple blotch disease. Results revealed that Hazro cultivar variety (0.8%) with minimum disease severity showed moderate to highly resistance to rust and purple blotch in garlic and recommended this cultivar for wider cultivation.

2.9.2 Chemical method

Sastrahidayat (1995) controlled the purple blotch of garlic (*A. porri*) under *in vitro* and green house conditions by using chemical method with the combination of other species. Garlic leaves have been isolated which were infected by *Fusarium spp, Curvulariaspp, Penicillium*, and *Trichoderma viride*and showed high antagonistic ability. Whereas, in the chemical method difenoconazole 0.8ml/litre the antagonist *T.*

viride (10,000 spores /ml) covering the crops with transparent sheets and a combination of these treatments has been inhibited the growth of the pathogen in the field.

Domingues *et al.* (2004) evaluated fungicides under field conditions against purple blotch in garlic crop. The results showed that maximum disease reduction was controlled in the treatment of kresoxim (77.1%) followed by azoxystrobin (74.4%) and minimum disease control was observed in the treatment of pyremythanil (58.3%) promoted good control.

Chaurasia *et al.* (2007) concluded that two sprays of fungicides is effective for the management of purple blotch disease. It was observed that by spraying the carbendazim can reduce the disease intensity (52.42%) with maximum yield (1745 kg/ha) followed by Mancozeb (43.68%) with (1254 kg/ha) yield.

Black *et al.* (1985) surveyed fungicides use in Chiangamai-Lamphun valley, Northern Thailand. This study revealed in a survey that the use of fungicides against purple blotch in garlic is always not related to the need for control. Few farmers used fungicides effectively where needed, because they were hardly aware of the factors affecting the efficiency of applications such as time of applications, dosage and weather conditions.

El-Shehaby *et al.* (2009) observed the highest disease reductions like downy mildew, purple blotch, and rust disease and increased the garlic yield by the foliar spray of microelements such as zinc, manganese, iron and boron once sprayed at the rate of 100 g 60 days after planting.

Deshmukh *et al.* (2007) applied the different combination of fungicides against purple blotch of onion on different susceptible varieties under greenhouse condition. The results showed that maximum disease inhibition (79.58%) was observed by the foliar application of different fungicide combinations such as hexaconazole (0.5%) + mancozeb (0.3%) followed by difenoconazole (0.25%) + mancozeb (0.3%).

Mishra and Gupta (2012) evaluated fungicides and plant extract under *in vitro* conditions against purple blotch and Stemphylium blight caused by *A. porri* and *S. vesicarium*. Among the plant extract, Aloe vera at (10%) and *Azadirachta indica* (10%) resulted in the maximum inhibition growth of *A. porri* (53.5%) and *S. vesicarium* of (47.15%), respectively. Whereas, in fungicides maximum mean percent inhibition of mycelial growth was recorded (98.94 and 100%) in mancozeb at 0.2 per cent, followed

by a companion at 0.2 per cent (98.40 and 97.13%) and azoxystrobin at 0.15 per cent (95.40 and 94.23%) as compared to other treatments.

Chethana *et al.* (2012) evaluated botanicals, fungicides and biological agents against purple blotch in onion. They observed that garlic extract (20%) is more effective against purple blotch in botanicals and *T. hazaridium* showed the 79.5 per cent mycelium inhibition of *A. porri* in biological agents. Whereas, fungicides propineb and mancozeb (0.3%) showed 100 per cent mycelium inhibition under *in vitro* conditions.

Gupta *et al.* (2014) conducted field trials for the management of purple blotch of garlic with different fungicides and recorded maximum yield with the spray of contact fungicide mancozeb and systemic fungicides i.e. tebuconazole (55.63%) and azoxystrobin (54.78%) disease reduction observed after 30 DAP and subsequent sprays at fortnightly intervals.

Agale *et al.* (2014) evaluated fungicides and plant extractsunder *in vitro* conditions against *A. porri* and were found the most effective in inhibiting mycelial growth. Propiconazole 25% EC (0.1%) and combi product of iprodione 25% + Carbendazim 25% WP (0.1 and 0.05%) completely inhibited the mycelial growth of *A. porri*. Among the different plant extract, tested against *A. porri* maximum per cent inhibition of mycelial growth was achieved with 10 per cent Cinnamon extract (72.22%), followed by Soapnut (64.77%) and Jatropha (64.44%).

Gupta *et al.* (2012) evaluated 3 fungicides namely mancozeb (0.25%), tebuconazole (0.1%) and Propiconazole (0.1%) against purple blotch disease and observed that the maximum disease reduction (21.11%) was observed by the spraying of mancozeb (0.25%) with maximum yield (86.49q/ha) yield

El-shehKader *et al.* (2015) suggested chemical treatments such as $CuSo_4$ (0.5 %) + Zn So4 (0.2%) + Urea (0.5 %) + Borax (0.1 %) or $CuSo_4$ (0.1 %) + Zn So_4 (0.1 %) + Urea (1 %) + Borax (0.1 %) in addition to Radomil plus treatment. The findings revealed that maximum inhibition of disease severity (86.17%) and maximum disease incidence reduction was observed in the treatment of CuSo4 0.2% (55.21%) during first season whereas, in season two the minimum disease severity was observed in the treatment of Radomil plus treatment (83.05%) and the maximum disease incidence was observed in the treatment of CuSo4 0.2% (64.26%) purple blotch in garlic.

Mohsin *et al.* (2016) isolated infected leaf samples in different growing regions from Bangladesh regions for studying the cultural, and morphological and pathogenic variabilities. The pathogen showed high variability in cultural, morphological and pathogenic variables in which it has accumulated to Bangladesh environment.

Maharana *et al*. (2016) evaluated the fungicides, biocontrols, and some plant extract under *in vitro* conditions for managing the purple blotch disease. The extracts of neem (*Azadirachta indica*), tulsi (*Ocimum sanctum*), eucalyptus (*Eucalyptus globulus*), and ginger (*Zingiber officinale*) were found to be the most effective in inhibiting the mycelial growth. Maximum inhibition was found in neem i.e. 90.4 per cent and 82.6 per cent followed by tulsi 86.8 per cent and 78.4 per cent at 20 per cent and 10 per cent concentration respectively. *Trichoderma harzianum* (88%) and *Trichoderma viride* (83%) were found the most effective biocontrol agent against *Alternaria porri*. All the fungitoxicants inhibited the mycelial growth of *Alternaria porri*. Carbendazim + mancozeb and difenoconazole showed complete inhibition (100%) followed by hexaconazole (94.2%), fluconazole (92.5%), and propiconazole (90.1%).

Savitha and Ajithkumar (2016) evaluated six fungicides against *Alternaria porri* under laboratory conditions and field conditions. Results showed that the maximum mycelial inhibition (100%) was observed with azoxystrobin and tebuconazole combination as well as under field condition which showed 34 per cent disease severity as compared with maximum yield (21.31 t/ha).

Yadav *et al.* (2017) evaluated six fungicides under *in vitro* and *in vivo* conditions against purple blotch disease in onion. The results showed that the maximum mycelial inhibition was observed in the treatment of tebuconazole (88.94%) followed by difenoconazole (84.68%) as well as under *in vivo* conditions the minimum disease severity (21.53%) in the treatment of tebuconazole followed by difenoconazole with 34.01% disease severity was observed under epiphytotic conditions.

Arunakumara and Satyanarayana (2018) evaluated 10 fungicides, 10 botanicals and 8 bioagents under *in vitro* and *in vivo* conditions against *Alternaria porri* 0.1% Azoxystrobin-23 EC, Tebuconazole-25 EC, Mancozeb-75 WP, *Allium sativum* (15%) and *Trichoderma harzianum* recorded the maximum inhibition of mycelial growth of *Alternaria porri*. The field evaluation of different fungicides and botanicals during Rabi

2013-2014 showed that 0.1% Tebuconazole-25 EC was significantly effective in reducing the disease intensity by recording a Percent Disease Index of 20.00 and yield of 86.00 q/ha. 0.1% Azoxystrobin 23 EC, 0.2% Mancozeb-75 WP, 0.2% Propineb-50 WP, 0.1 % Hexaconazole-5 EC and *Allium sativum* cloves extract were next best treatments in reducing the disease intensity.

Ruth (2017) conducted field experiments and evaluated different fungicides under *in vivo* conditions such as , Pyraclostrobin 20% WG @ 0.5 g./L, Chlorothalonil @ 2.0 g/L, Tebuconazole @ 1.25 ml/L, Propineb 70 WP @ 3.0 g/L, Copper Hydroxide @ 2.5 g/L, Iprodione 25% + Carbendazim 25% @ 1.0 g /L, Tebuconazole 50% + Trifloxystrobin 25% WG @0.5 g/L. They concluded that Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.5 g/L decreased 50.98% disease severity and more effective against purple blotch disease in onion.

Islam *et al.* (2020) was carried an experiment on the management of purple blotch disease of onion (*Alternaria porri*) during 2015-2016 at BARI, Joydebpur, Gazipur, Bangladesh to see the effectiveness of fungicides in controlling the disease and evaluate the performance of some plant extracts in controlling purple blotch disease of onion seed crop. In *in vitro*, conditions the effectiveness of 10 fungicides (Antracol, Folicur, Iindofil M-45, Metaril, Rovral, Score, Sulcox, Sun copper oxychloride, Unilax and Vonot 306 were screen against the disease. Out of these Rovral (32.0%) inhibited minimum mycelial inhibition and maximum mycelial inhibition was observed in the treatment of vandozeb (58.66%)

Khalil *et al.* (2018) evaluated fungicides and biocides under *in vitro* and *in vivo* conditions against the purple blotch of garlic. The maximum inhibition in mycelial growth was found in the treatment of Bio Arc 6% WP which lies in the third group. Galben Copper 69.8% WP gave inhibition in the mycelial growth reached to 84.42 per cent. Whereas, under greenhouse conditions galben copper 69.8% WP was more effective than the other tested biocides. Bio Arc 6% WP was superior among biocides against purple blotch disease in garlic, while plant guard liquid was the inferior one.

Prajapati *et al*. (2019) suggested that poultry manure (12.5t/ha) and neem cake (500 kg/ha) as the best treatments to minimize the purple blotch disease of garlic. Whereas, effects on the environment as well as the person who handles it, while the

application in the field and consumers using the product, use of organic manures in field condition could be considered as better, as it is beneficial and eco-friendly.

Kolte and Patalae (2019) evaluated plant extracts against purple blotch and stemphylium blight of garlic. Extracts of *Azadirachta indica* extract showed maximum inhibition against *A. porri* (71.2%) and *S. vesicarium* followed by (70.06%) followed by *Ocimum sanctum* inhibited *A. porri* (68.23%) and *S. vesicarium* followed by (56.12%).

Chapter-3

Materials and Methods

CHAPTER-3

MATERIALS AND METHODS

The investigation were carried out in laboratory and research farm of division of Plant Pathology, Sher-e-Kashmir University of Agriculture Science and Technology, Chatha, Jammu, during 2020-21 to determine the incidence, epidemiology, and performance of selective fungicides as well as botanicals for disease management under field and laboratory conditions. Summary of the experimental methodologies and materials employed during the course of the research are as follows.

3.1 Survey

Survey was done to determine the status of purple blotch in important garlic growing regions in Jammu district during February and March 2021. Starting with the appearance of first symptom and continuing until before crop maturity. To record the disease severity, three fields from each location (villages) will be chosen at random and disease severity was calculated by using the formula given below (McKinney 1923)

$$\text{Per cent Disease Severity} = \frac{\text{Sum of individual rating}}{\text{Total no. of rating} \times \text{Maximum disease grade}} \times 100$$

Table: 3.1 Locations selected for survey

Location	Village
Akhnoor	Garkhal
	Mattu
	Pindi
	Tanda
	Pangiari
Bishnah	Deola
	Salehar
	Pandori
	Pasgal

	Barmal
R. S. Pura	Samka
	Kotli
	Kullian
	Nari
	Korukanta
Jammu	Chatha
	Hakal
	Badgah
	Bansultan
	Mandal

Disease Scoring

The disease severity was calculated during survey as per the following scale (Bhangale and Joi 1985).

Rating Scale	Per cent disease severity	Reaction
0	No disease symptom	Highly Resistance
1	1-10% plant area covered with disease spots	Resistance
2	11-20% plant area covered with disease spots	Mild resistance
3	21-50% plant area covered with disease spots	Susceptible
4	51-75% plant area covered with disease spots	Susceptible
5	76-100% plant area covered with disease spots	Highly susceptible

3.2 Location of the experiment:

The field trial was conducted at the Research farm, Division of Plant Pathology, SKUAST-J, Chatha, Jammu. This is located at 32.69º N latitude, 74.65º E longitude and at an altitude of 336 m above the mean sea level. (Plate-1

Plate – 1

Lay out of trial

Plate -2

Field trial of garlic laid out at Plant Pathology, divisional research farm, SKUAST-J

.3 Field preparation

Field selected for experiment was ploughed twice after incorporating the 20 tonnes of farmyard manure. Plot size was 1.5m × 1.5m dimensions were prepared and cloves were sown with the spacing of 15×10 cm. Each treatment were replicated thricein randomised block design (RBD). (Plate- 1)

3.4 Epidemiological studies

The effect of certain abiotic factors such as atmospheric temperature, rainfall and relative humidity on the development of disease was studied under field conditions. Five plants were selected randomly from each replication plot and observations were taken at weekly intervals. The data of different environmental factors like relative humidity, temperature and rainfall was collected from the Agro-meteorological Unit, Division of Agronomy, FOA, SKUAST Jammu. The data of disease severity was recorded from 2^{nd} meteorological standard week to 16^{th} standard week and disease severity data was recorded at weekly intervals along with different weather factors represented in Table- 4.2

3.4.1 Simple correlation

For simple correlation the disease severity was taken as dependent variable (Y). Whereas, weather parameters like maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall were taken as X_1, X_2, X_3, X_4, and X_5. The data was analysed by using statistical package (Opstat)

3.4.2 Linear regression

The effect of different weather factors under study on disease progress was estimated by using linear regression analysis

3.5 Sterilization of glass wares

For all the laboratory experiments, glass wares were cleaned with washing power and were dried before use. After drying the glass wares was sterilized in the hot air oven at 160^{o}C for two hours

3.5.1 Sterilization of inoculated needles and blades

The inoculated needles and blades are dipped in methyl alcohol and heated to red hot over spirit lamp flame 2 to 3 times for proper sterilization.

3.5.2 Preparation of cultural media

The Potato Dextrose Agar (PDA) media was used for isolation. For the preparation of the PDA, the following ingredients were used for the isolation of the pathogen

Potato (Peeled) : 200g

Dextrose : 20g

Agar-agar : 20g

Distilled water : 1000ml

Peeled potatoes 200g were cut into slice and boiled in 500ml distilled water and sieved with two layered fined muslin cloth. Take remaining 500ml of water and heat it and added 20g of agar –agar bit by bit by stirring until it dissolved. Thereafter, 20g of dextrose was added into it and mixed well by stirring. The volume of the extract was made up of 1000ml and then poured in the flask. The flask was plugged with non-absorbant cotton covered with butter paper and sterilized with autoclave at 15lb psi for 20 minutes. After cooling it to approximately 40ºC, streptomycin was added to the medium to avoid the bacterial growth. The pH of the medium was examined by using litmus paper and adjusted up to 5.3± 0.2.

3.5.2 Isolation, purification and mass multiplication of *Alternaria porri*

During field survey, infected leaves of garlic were collected, bagged separately in paper bag by observing their symptoms and brought to the laboratory for the isolation of the pathogen from the infected plant. Small bits of the infected plant were taken from the junction of infected and healthy portion. The bits was dipped in the sodium hypo chloride (1.0%) for the 30 seconds for the surface sterilization and washed it three times in the distilled water. The bits were dried on sterilized filter paper and transferred in to PDA under aseptic conditions in laminar air flow. This inoculated plates are incubated in BOD at 25 ± 1ºC temperature for 7 days to allow to grow the pathogen. Morphology of *A. porri* has been studied by using the microscope for the conformation and identify of the fungus. The isolated pathogen was sub-cultured on PDA at regular intervals and preserved for further use in various experimental investigations. (Plate-5)

Plate – 5

Sub culture of *Alternaria porri*

3.6 Pathogenicity test

To prove the pathogenicity test, the infected garlic samples were collected from field and isolated under *in vitro* conditions for the development of pure culture. The isolation was done by taking 2/3rd healthy and 1/3rd infected leaf and after surface sterilization placed in PDA medium and incubated in BOD at 25^{o}c for 7 days. The culture was examined under microscope and it was found that the pathogen was *Alternaria porri* and this pure culture was inoculated in to healthy plant by spraying spore suspension. To prove the Koch's postulates, after the development of the disease, pathogen was re-isolated and examined their characters for similarity with earlier isolated cultures and symptom, developed after artificially inoculation.

3.7 *In vitro* evaluation of fungicides against *Alternaria porri*

Two non-systemic fungicides like propineb (70%) and copper oxychloride (50%) WP were used at 50, 100, 250 and 500ppm doses and four systemic fungicides namely difenoconazole (35%) EC, propiconazole (25%) EC, azoxystrobin (23%) SC and tebuconazole (25.9%) EC, were used at 10, 25, 50, and 100ppm. Whereas, three botanicals namely Neem extract (*Azadirachta indica*), Datura extract (*Datura stramonium*) and Bhang extract (*Cannabis sativus*) on 10, 15 and 20 per cent concentration to assess their efficiency against *Alternaria porri* under *in vitro* condition by using poisoned food technique (Nene and Thapliyal, 1993) were evaluated under *in vitro* conditions. The trials were conducted in completely randomized design (CRD) with three replications, except non-systemic fungicides trial who was replicated five times. The desired concentrations were obtained by adding appropriate stock solution of fungicides to PDA medium in Petri plates replicated thrice for each treatment. PDA without fungicide is served as control. Each plate was inoculated with a 5mm mycelia disc of the pathogen taken from seven days old culture with the help of crok borer. The inoculated plates are incubated at 25± 1ºC till the fungus growth. The per cent inhibition of mycelium growth over control was calculated in each treatment by using the formula given by Vincent (1947)

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

Where, I = per cent Inhibition of mycelial growth

C = growth of the fungus in control (mm)

T = radial growth of the fungus in treatment (mm)

3.8 Evaluation of fungicides and botanicals in field conditions against purple blotch of garlic

For trial purpose, the garlic variety Yamuna Safed (G-I) was grown. The efficiency of fungicides and botanicals were evaluated under field conditions on garlic crop under Randomized block design with 10 treatments and 3 replications including untreated control and treatments as follows

3.2 List of fungicides and botanicals

S. No.	Common Name	Chemical Name	Trade name	Dose (%)
1	Propineb 70% WP	polymeric zinc 1,2-propylenebis (dithiocarbamate)	Antracol 75WP	0.25%
2	Copper oxychloride 50%WP	Dicopper(II) chloride tri hydrogen	Blitox 50W	0.3%
3	Azoxystrobin 23% SC	Methyl (2E)-2-{2-{(6-(2-cyanophenoxy) pyrimidin-4-y}oxy}phenyl)-3-methoxy	Amister 50WP	0.1%
4	Tebuconazole 25.9 EC	(RS)-1-p-chlorophenyl-4,4-dimethyl-3-(1H-1,2,4-triazol-1-ylmethyl)pentan-3-ol	Folicur 25.9 EC	0.1%
5	Propiconazole 25% EC	1-(2,4-dichlorophenyl)4-propyl-1-3-dioxalan-2-methyl) H-1, 4-triazole	Tilt 75WP	0.1%
6	Difenoconazole 35% EC	1-(2,4-dichlorophenyl)4-propyl-1-3-dioxalan-2-methyl) H-1, 4-triazole)	Score 35EC	0.1%
	Name of the plant	**Botanical Name**	**Plant Part Used**	
7	Neem	*Azadirachta indica*	Leaf extract	25
8	Datura	*Datura stramonium*	Leaf extract	25
9	Bhang	*Cannabis sativa*	Leaf extract	25
10	Control	-	-	-

DAS Days after sowing

1st spray = 90DAS

3.9 Preparation of plant extract

Leaf of neem (*Azadirachta indica*), datura (*Datura stramonium)* and bhang (*Cannabis sativa*) plants were collected, thoroughly washed in the distilled water and dried. The hard veins of the dried leaves were removed with the help of scissors and then macerated with water in an electric blender for 10 minutes in the ratio of 1:1 (W/V). The macerate was first filtered through double layered muslin cloth and then centrifuged for 30 minutes. The supernatant was filtered through muslin cloth and the filtrate served as the pure extract.

Chapter-4

Results

CHAPTER-4

RESULTS

In recent years, purple blotch disease was more severe and causing yield loss in garlic. So, keeping in view, the losses caused by disease the following investigations were carried out on various aspects viz., survey, impact of weather factors on disease development, evaluation of fungicides and botanicals under *in vitro* conditions as well as field conditions for the management of the disease and results mentioned as follows

4.1 Survey

Survey was conducted in major garlic growing areas of Jammu district to ascertain the status of purple blotch of garlic during *rabi* season 2020. The prevailed data in Table -4.1 revealed that the disease was observed in all locations and overall purple blotch disease severity ranged from 21.89 to 33.82 per cent, with maximum disease severity at kotli of R.S. Pura tehsil (33.82%) and minimum (29.89%) at Garkhal village of Akhnoor tehsil. In Akhnoor block, the maximum disease severity was observed in Mattu village (32.68%) and minimum was observed in Garkhal village (21.89%). Whereas in Bishnah block the maximum disease severity was observed in Barmal village (31.74%) and the minimum was recorded in Salehar village (22.71%) while, in R. S. Pura block the maximum disease severity was observed in Kotli village (33.82%) and minimum was observed in Samka village (24.62%). Finally in Jammu block the maximum disease severity was observed in Chatha village (31.26%) and the minimum disease severity was observed in the Bansulthan village (24.32%)

4.2 Symptomology

The symptoms caused by *Alternaria porri* appeared as whitish chlorotic patches on the leaf surface and these patches immediately turned brown and in centre of this spots turned into purple colour. Later, a circular dark concentric ring was observed in the chlorotic area and finally it spreads all over the leaf and leads to the hang down from the diseased point and as severity increased the plant dried up and bulb became dry and papery. (Plate- 3)

4.3 Pathogen

Conidia of *A. porri* were found septate with 8-12 transverse and zero to several longitudinal or oblique septa with brown colour. Conidiophore arise singly or in group and the shape of the conidia were straight or curved. Mycelium was coloured, septate and branched. (Plate- 6)

4.4 Epidemiological studies

Data revealed from Table 4.2 showed during 2nd meteorological standard week there was no disease but from 3rd meteorological standard week the disease appeared with 2.77% severity and gradually increased up to 47.22% at 16th meteorological week and it was highest during whole cropping season.

4.4.2 Correlation and regression

The relationship between weather factors and the development of the disease was established by using correlation and regression analysis to find out the effect of different weather factors on the disease development.

The weather factors such as maximum temperature (X_1), minimum temperature (X_2), maximum relative humidity (X_3), minimum relative humidity (X_4) and rainfall (X_5) were taken as independent variable Whereas, disease severity (Y) was taken as dependent variable.

Maximum temperature and minimum temperature showed positive correlation with development of the disease and maximum and minimum relative humidity showed negative correlation in development of the disease. Whereas, rainfall showed non-significant relationship in development of the disease. (Table 4.3)

The regression equation $Y= 6.979 + 0.420 X_1 + 2.147 X_2 - 0.074 X_3 -0.287 X_4 + 1.654 X_5$ with coefficient of multiple regression, R^2 value was found 0.96 which implied that 96 per cent variation in development of the purple blotch disease severity was due to weather parameters. (Table- 4.4)

4.5 Pathogenicity test

In pathogenicity test isolation was done from samples collected from farmer's field and it was observed that the pathogen was characterized as *Alternaria porri*. The same culture when inoculated on healthy plants in pots the symptoms like whitish chlorotic patches appeared again after 8th day of inoculation and later on dark brown concentric rings also developed. (Plate- 3)

4.6. *In vitro* evaluation of non- systemic fungicides against *Alternaria porri*

Non-systemic fungicides like propineb 70%WP, copper oxychloride 35%EC were evaluated against *A. porri* by using different concentrations viz., 50ppm, 100ppm, 250ppm and

Table: 4.1 Status of Purple blotch (*Alternaria porri*) of garlic disease in Jammu district

Tehsil/Block	Village	Purple Blotch
		Disease severity (%)
Akhnoor	Garkhal	21.89
	Mattu	32.68
	Pindi	29.83
	Tanda	24.23
	Pangiari	26.12
	Mean ± SE	26.95± 1.72
	Range	21.89 - 32.68
Bishnah	Deola	28.32
	Salehar	22.71
	Pandori	33.65
	Pasgal	29.45
	Barmal	31.74
	Mean ± SE	29.17±1.66
	Range	22.32 - 31.74
R. S. Pura	Samka	24.62
	Kotli	33.82
	Kullian	31.74
	Nari	29.25
	Korukanta	32.12
	Mean ± SE	30.31± 1.4
	Range	24.62 ± 33.82
Jammu	Chatha	31.26
	Hakal	29.52
	Badgah	28.62
	Bansultan	24.32
	Mandal	29.82
	Mean ± SE	28.70 ± 1.05
	Range	28.62 ± 31.26
Over all Range		**21.82 – 33.82**
Overall Mean		29.49

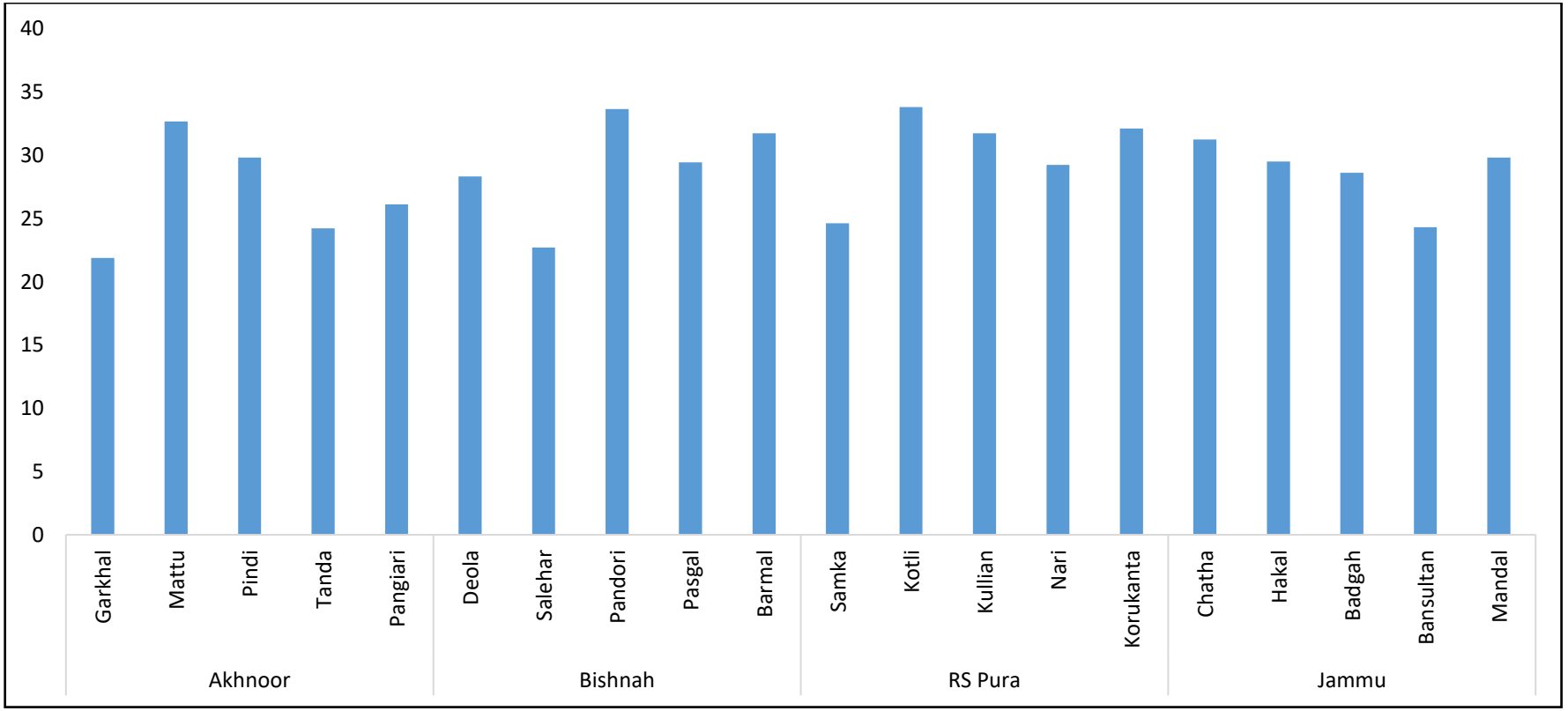


Fig 1: Graphical representation of purple blotch of garlic disease severity in Jammu district

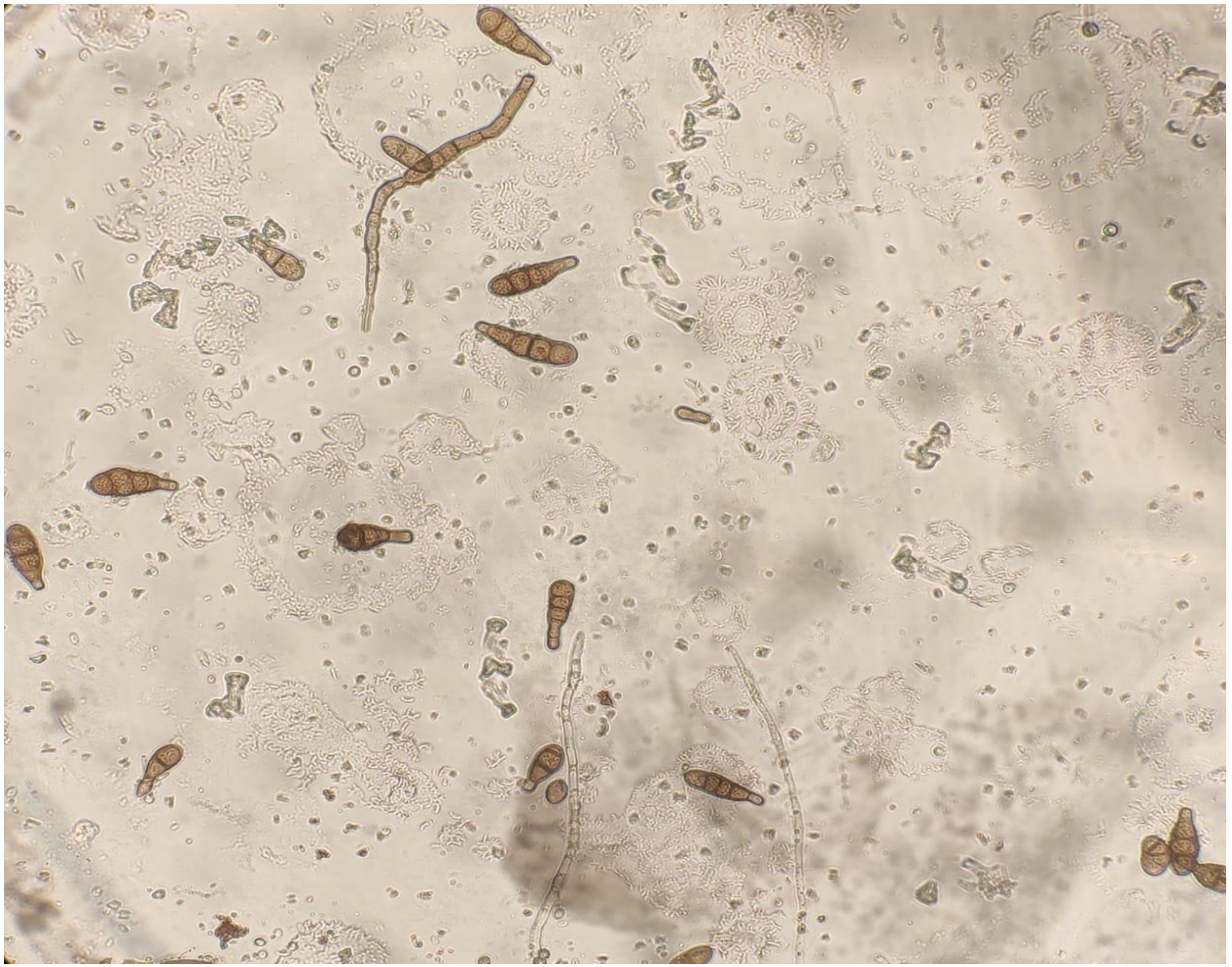
Plate- 3

Symptoms of Purple Blotch of Garlic

Plate- 4

Severe Purple blotch disease symptoms in Garlic

Plate - 6



Mycelium and conidia of *Alternaria porri*

Table: 4.2 Effect of meteorological parameters on the development of Purple blotch (*Alternaria porri*) of garlic

MSW	Date of Observation	Disease severity (%)	Disease Progression	Rate of infection (r)	Temperature(°C)		Relative humidity (%)		Rainfall (mm)
					Max	Min	Max	Min	
2	10-01-2021	-	-	-	14.94	7.44	93.71	80.43	0.0
3	17-01-2021	2.77	0	-	17.60	6.09	92.71	73.71	0.0
4	24-01-2021	3.88	1.11	0.05	18.83	3.76	94.86	53.00	3.81
5	31-01-2021	6.94	5.83	0.09	20.06	6.83	87.43	48.43	0.0
6	07-02-2021	9.44	3.61	0.05	21.14	8.50	93.71	62.43	0.0
7	14-02-2021	11.66	8.05	0.03	22.54	9.76	95.57	63.39	0.0
8	21-02-2021	17.5	9.45	0.07	26.80	11.96	87.43	49.00	0.0
9	28-02-2021	20.27	10.82	0.03	26.71	8.70	84.86	46.00	0.0
10	07-03-2021	25.55	14.73	0.04	27.73	12.80	80.29	45.71	1.63
11	14-03-2021	30.55	15.82	0.04	28.96	12.23	85.57	41.57	0.0
12	21-03-2021	31.11	15.29	0.00	26.50	13.34	80.86	49.29	2.1
13	28-03-2021	33.88	18.59	0.02	31.01	12.54	63.29	28.71	0.0
14	04-04-2021	36.11	17.52	0.01	31.97	12.73	65.86	26.71	0.2
15	11-04-2021	41.66	24.14	0.03	33.37	16.69	52.43	32.57	1.67
16	18-04-2021	47.22	23.08	0.03	29.13	13.67	69.57	33.57	2.72

Table: 4.3 Correlation coefficients between the weather parameters and purple blotch of garlic

S. No	Weather parameter	Purple blotch
1	Maximum Temperature	**0.930
2	Minimum Temperature	*0.895
3	Maximum Relative humidity (%)	-0.862
4	Minimum Relative humidity (%)	-0.860
5	Rainfall (mm)	0.261^{NS}

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Table: 4.3 linear regression of epidemiological factors with the disease intensity of purple blotch of garlic

Variety	Linear regression	Correlation coefficient (R)	Coefficient of determination (R^2)
Yamuna Safed (G-1)	$Y=6.979 +0.420X_1+2.147X_2-0.074X_3-0.287X_4+1.654X_5$	0.93	0.96

Where, X_1 = Maximum temperature (℃)

X_2 = Minimum temperature (℃)

X_3 = Maximum relative humidity (%)

X_4 = Minimum relative humidity (%)

X_5 = Rainfall (mm)

Y = Disease seve

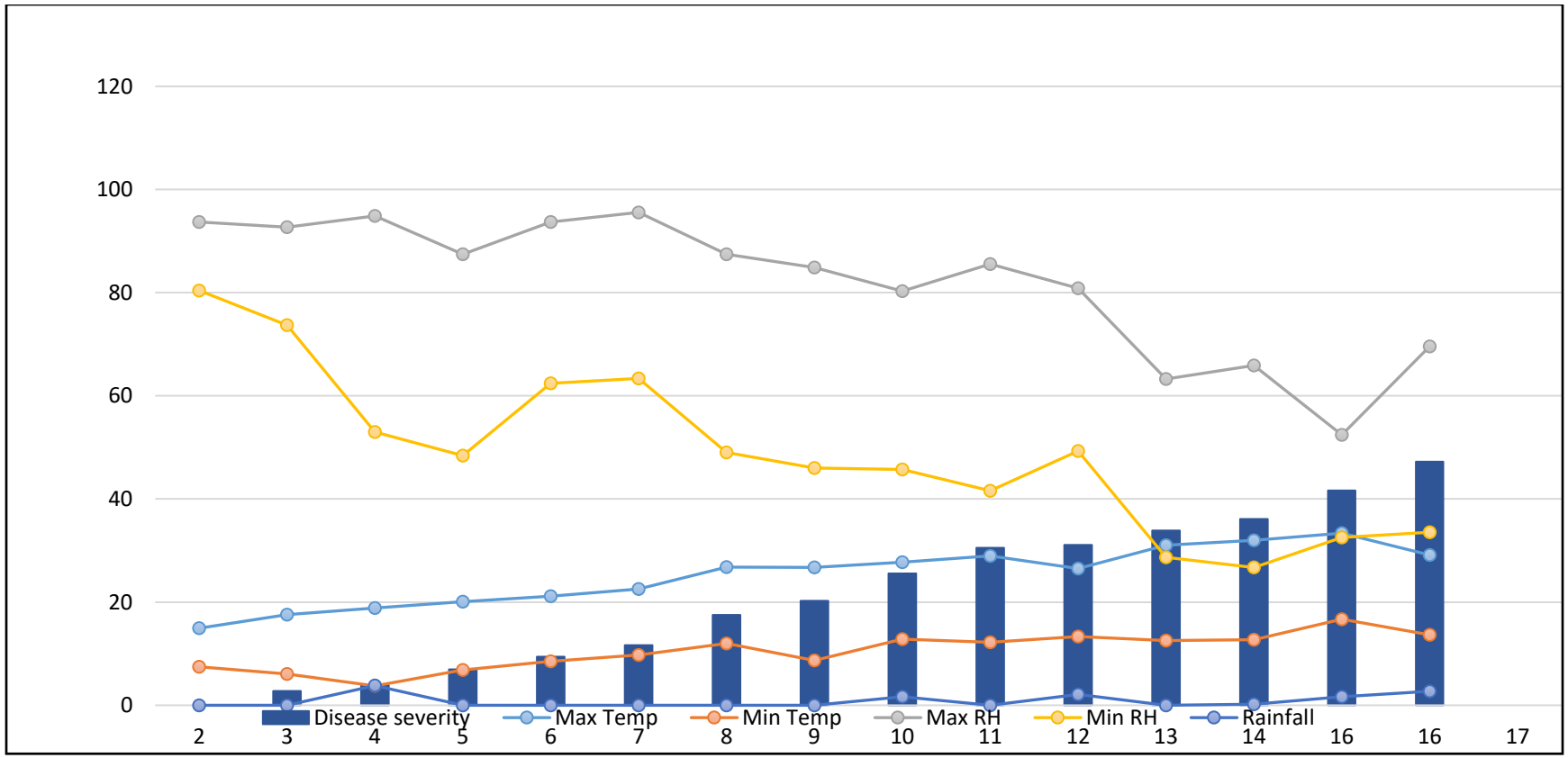


Fig. 2: Effect of weather factors on disease development

500ppm by using food poison technique. Each treatment was compared with control. Diameter of the mycelial growth was measured after seven days of incubation. (Table-4.5) (Plate-7) and it was observed that both fungicides inhibited the mycelial growth at all concentrations. propineb 70%WP observed 22.6, 16.20, 15.0 and 10.20mm mycelial growth at 50, 100, 250 and 500ppm concentrations respectively. While, copper oxychloride 21.6, 17.60, 15.8 and 11.60 mm observed at different concentrations.

4.7 *In vitro* evaluation of systemic fungicides against *Alternaria porri*

Systemic fungicides such azoxystrobin 23% SC, tebuconazole 25.9% EC, propiconazole 25% EC, difenoconazole 35% EC were evaluated against *A. porri* with different concentrations of 10ppm, 25ppm, 50ppm and 100ppm. Data revealed (Table- 4.6) (Plate- 8) that minimum mycelial growth was observed in difenoconazole 35% EC (26.4, 11.6, 6.20 and 0.00) at 10, 25, 50 and 100ppm concentration respectively. This treatment gave 100 per cent mycelial inhibition at 100ppm concentration as compared with the control, followed by tebuconazole 25.9% EC 19.4, 13.6, 12.40, 3.00 mm, propiconazole 25%EC 38.40, 37.80, 30.60, 10.20 mm Whereas, azoxystrobin 23% SC was found least effective with mycelial growth 60.40, 46.60, 44.00 and 39.40 mm mycelial inhibition was maximum at 100ppm concentration.

4.8 *In vitro* evaluation of botanicals against *Alternaria porri*

Three botanicals like neem leaf extract (*Azadirachta indica*) 25 per cent, Datura leaf extract (*Datura stramonium*) 25 per cent, and bhang extract (*Cannabis sativa*) 25 per cent were evaluated under *in vitro* conditions against *A. porri* at different concentrations (10, 15 and 20%) by using poison food technique. The data showed that the minimum mycelial growth was observed in the Datura leaf extract (22.2, 11.20 and 6.6%) followed by bhang leaf extract (24.2, 21.40 and 16.4%) and least effective was observed in neem (35.0, 28.0 and 24.6%) respectively. All treatment showed significant disease control. It was also observed that maximum inhibition of mycelial growth (82.66 mm) was observed with datura leaf extract at 20 per cent concentration. While, minimum inhibition from neem leaf extract (62.66%) at 20 per cent concentration. (Table: 4.7) (Plate-9)

4.9 Management of purple blotch of garlic under field conditions

Six chemicals namely propineb 70%WP, copper oxychloride 35%EC, azoxystrobin 23% SC, tebuconazole 25.9% EC, propiconazole 25% EC, difenoconazole 35% EC and three botanicals neem leaf extract (*Azadirachta indica*) 25%, datura extract (*Datura stramonium*) 25%,bhang extract (*Cannabis sativa*) 25% were evaluated under field conditions. All the fungicides were found significantly effective against purple blotch disease as compare with control. At 90 DAS the disease severity in control was 51.02%. Whereas, in treated plot difenoconazole showed 21.28 per cent disease severity followed by tebuconazole (23.66%), Propineb (26.35%), copper oxychloride (33.65%), propiconazole (29.89%) and azoxystrobin (36.96%) disease severity. In botanicals datura leaf extract showed the minimum disease severity of 40.59 per cent followed by bhang leaf extract (42.36%) and neem leaf extract (45.59%). (Table 4.8)

4.10 Yield

The data in the Table -4.9 revealed that the minimum yield was observed in control (95q/ha). Whereas, maximum was observed in difenoconazole (119.3 q/ha) followed by tebuconazole (117.3 q/ha), propineb (116.00 q/ha), copper oxychloride (114.33 q/ha), propiconazole (112.66 q/ha) and azoxystrobin (111.67 q/ha). In botanicals the maximum yield was observed in the treatment of Datura leaf extract (110.52 q/ha), followed by bhang leaf extract (109.52 q /ha) and neem leaf extract (107.66 q/ha).

4.11 Cost benefit ratio

The maximum cost benefit ratio was occurred in the treatment of difenoconazole (1:7.43), followed by tebuconazole (1:7.38), propineb (1:7.32), copper oxychloride (1:7.18), propiconazole (1:7.13) and minimum cost benefit ratio was observed in the treatment of azoxystrobin (1:6.90). In botanicals the maximum cost benefit ratio was occurred in the treatment of datura leaf extract (1:7.02), followed by neem leaf extract (1:6.83) while, minimum ratio was observed with neem leaf extract (1:6.95). However, minimum cost benefit ratio was occurred in control (1:6.06) plots.

Table: 4.5 *In vitro* evaluation of non-systemic fungicides against *Alternaria porri* causing purple blotch of garlic

Treatment No	Fungicide	Mycelial growth (mm)				Mycelial inhibition (%)			
		50ppm	100ppm	250ppm	500ppm	50ppm	100ppm	250ppm	500ppm
T_1	Propineb 70%WP	22.60	16.20	15.00	10.20	64.8	72.00	73.33	78.66
T_2	Copper oxychloride 35%EC	21.60	17.60	15.80	11.60	66.0	70.44	72.44	77.11
T_3	Control	90.00	90.00	90.00	90.00	-	-	-	-
SE(m)±		0.41	0.36	0.33	0.44	-	-	-	-
CD (p=0.05%)		1.297	1.138	1.049	1.39	-	-	-	-

Plate- 7

Control

T_1 Propineb

T_2 Copper oxycoride

50ppm **100ppm** **250ppm** **500ppm**

In vitro* evaluation of non- systemic fungicides against *A. porri

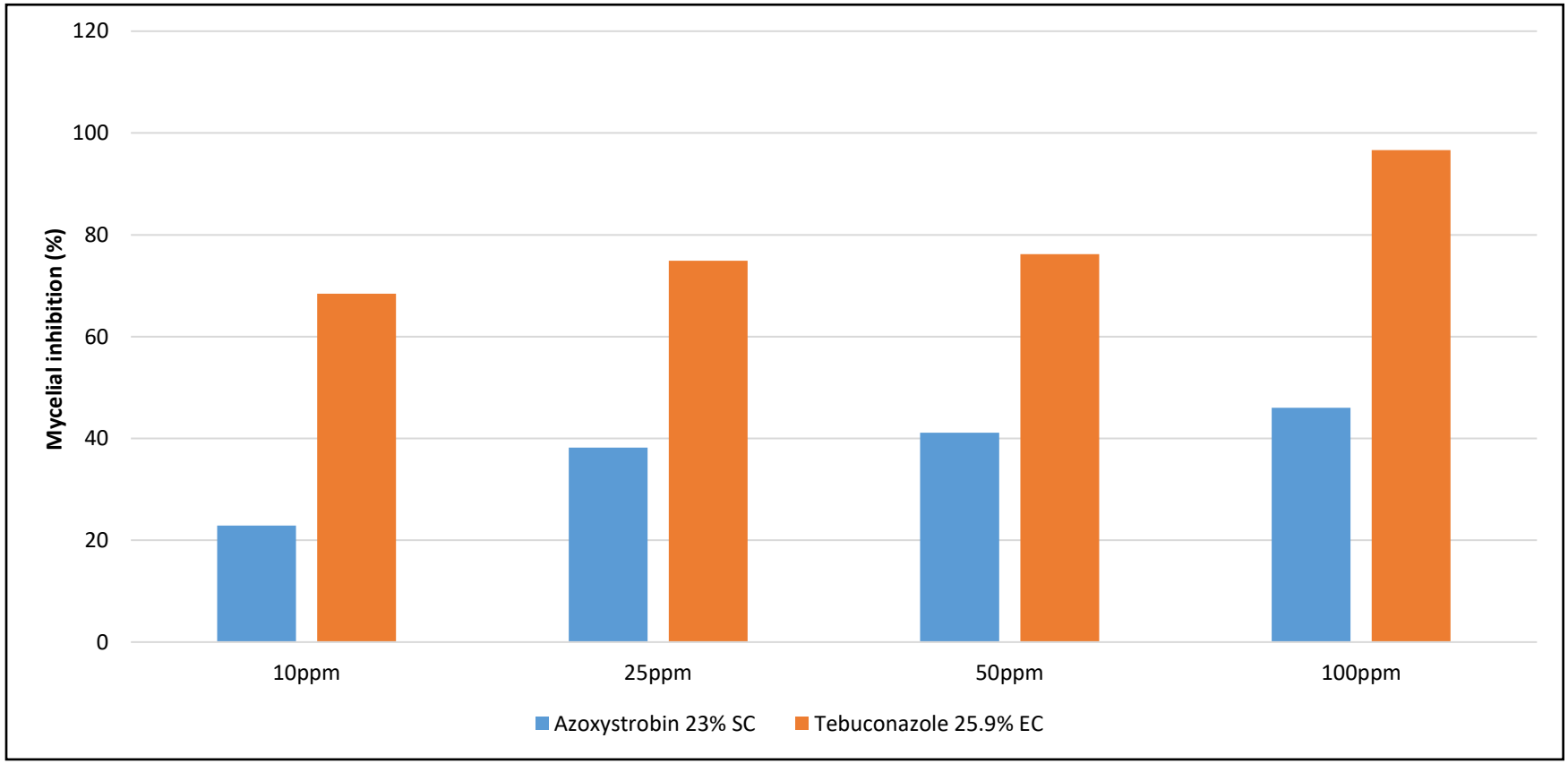


Fig: 3 *In vitro* evaluation of non- systemic fungicides against purple blotch disease

Table: 4.6 *In vitro* evaluation of systemtic fungicides against *Alternaria porri* causing purple blotch of garlic

Treatment No	Fungicide	Mycelial growth (mm)				Mycelial inhibition (%)			
		10ppm	25ppm	50ppm	100ppm	10ppm	25ppm	50ppm	100ppm
T_1	Azoxystrobin 23% SC	60.40	46.60	44.00	39.60	22.88	38.22	41.11	46.00
T_2	Tebuconazole 25.9% EC	19.40	13.60	12.40	3.00	68.44	74.88	76.22	96.66
T_3	Propiconazole 25% EC	38.40	37.80	30.60	10.20	47.33	48.00	56.00	78.66
T_4	Difenaconazole 35% EC	26.40	11.60	6.20	0.00	60.66	77.11	83.11	100
T_5	Control	90.00	90.00	90.00	90.00	-	-	-	-
SE(m)±		0.60	0.60	0.52	0.41	-	-	-	-
CD (p=0.05%)		1.80	1.79	1.54	1.26	-	-	-	-

Plate: 8

Control

T_1 Azoxystrobin

T_2 Tebuconazole

T_3 Propiconazole

T_4 Difenoconazole

10ppm **25ppm** **50ppm** **100ppm**

In vitro* evaluation of systemic fungicides against *A. porri

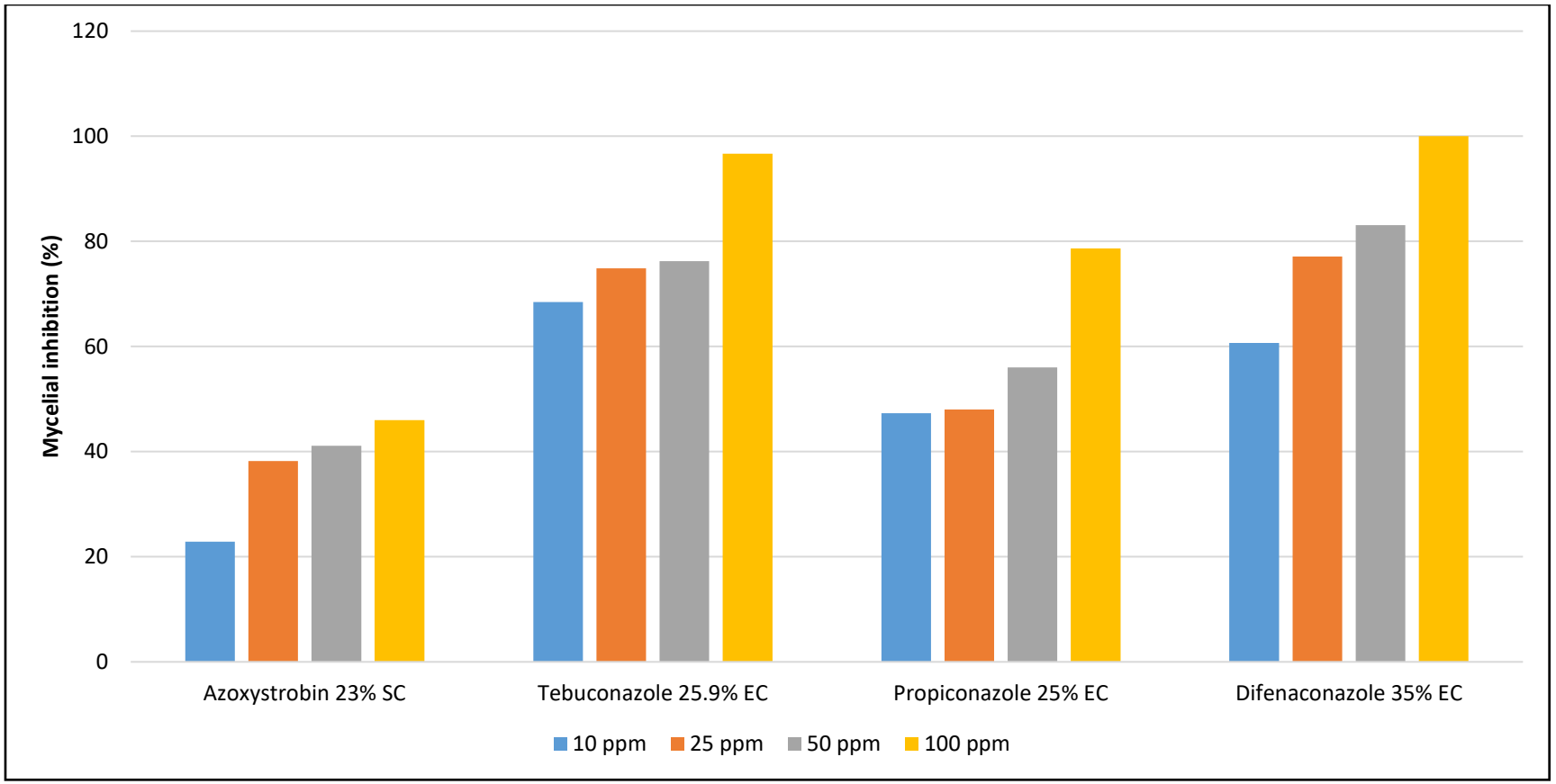


Fig: 4 *in vitro* evaluation of systemic fungicides against purple blotch disease

Table: 4.7 *In vitro* evaluation of botanicals against *Alternaria porri* causing purple blotch of garlic

Treatment No	Botanical name	Mycelial growth (mm)			Mycelial inhibition (%)		
		10%	**15%**	**20%**	**10%**	**15%**	**20%**
T_1	Neem (*Azadirachta indica*) 25%	35.00	28.00	24.60	54.11	58.88	62.66
T_2	Datura extract (*Datura stramonium*) 25%	22.20	11.20	6.60	65.33	77.55	82.66
T_3	Bhang extract (*Cannabis sativus*) 25%	24.20	21.40	16.40	63.11	66.22	71.77
T_5	Control	90.00	90.00	90.00	-	-	-
SE(m)±		0.41	0.41	0.44	-	-	-
CD (p= 0.05%)		1.24	1.26	1.33	-	-	-

Plate: 9

Control

T_1

Neem leaf extract

T2
Datura leaf extract

T3
Bhang leaf extract

20% **15%** **10%**

In vitro* evaluation of botanicals against *A. porri

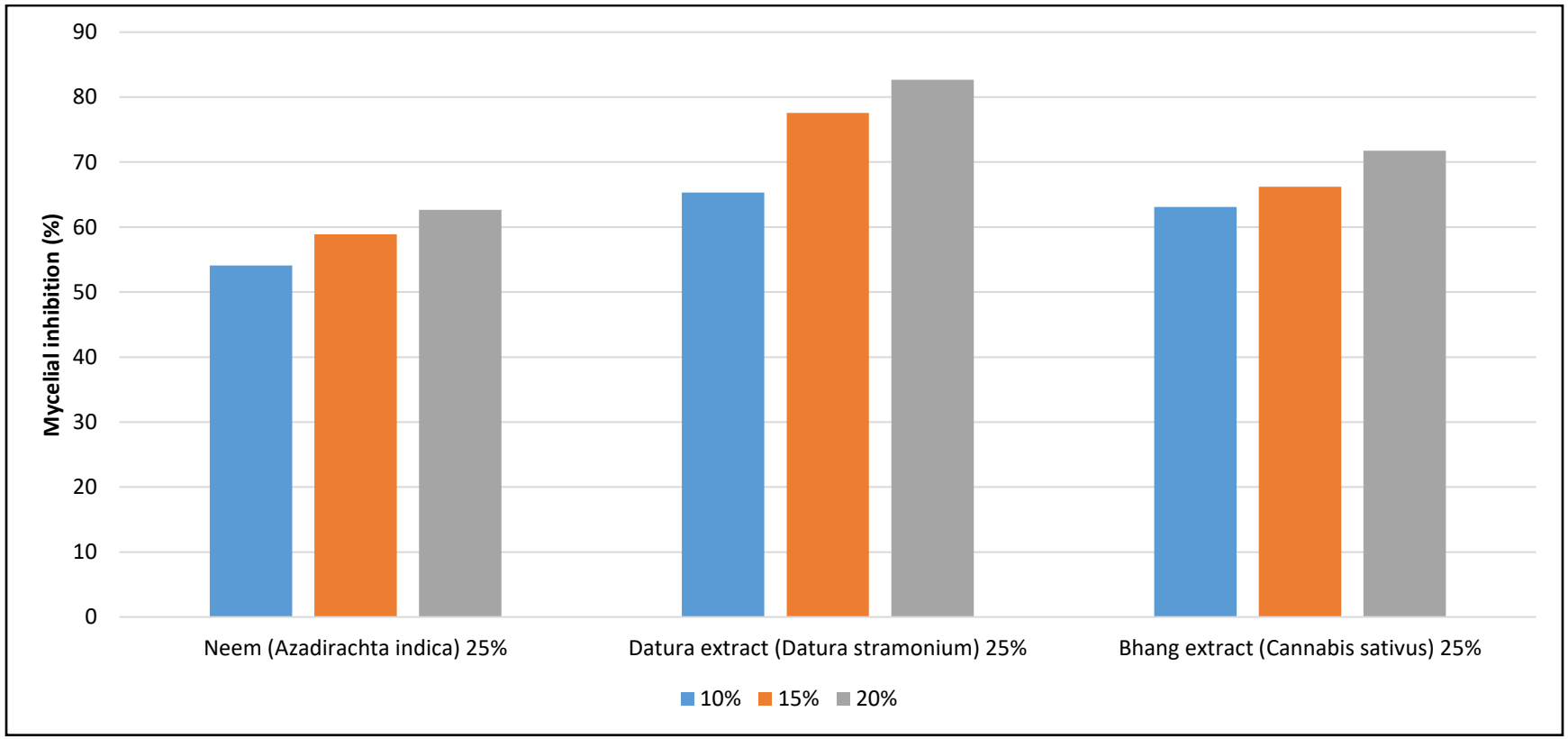


Fig: 5 *In vitro* evaluation of botanicals against purple blotch disease

Table: 4.8 Evaluation of different fungicides and botanicals under field conditions against Purple blotch disease in garlic

Treatment name	Disease severity (%)	Disease reduction over control (%)
Propineb	26.35 (30.39)	48.35
Copper oxychloride	33.65 (37.46)	34.04
Azoxystrobin	36.96 (37.46)	27.55
Tebuconazole	23.66 (29.11)	53.62
Propiconazole	29.89 (33.14)	41.41
Difenoconazole	21.28 (27.47)	58.29
Neem extract	45.59 (40.60)	10.64
Datura extract	40.59 (39.42)	25.69
Bhang extract	42.36 (40.60)	16.97
Control	51.02 (45.58)	0.00
SE(m)	1.88	
CD P = (0.05%)	1.72	

Values in the parenthesis are angular transformed valu

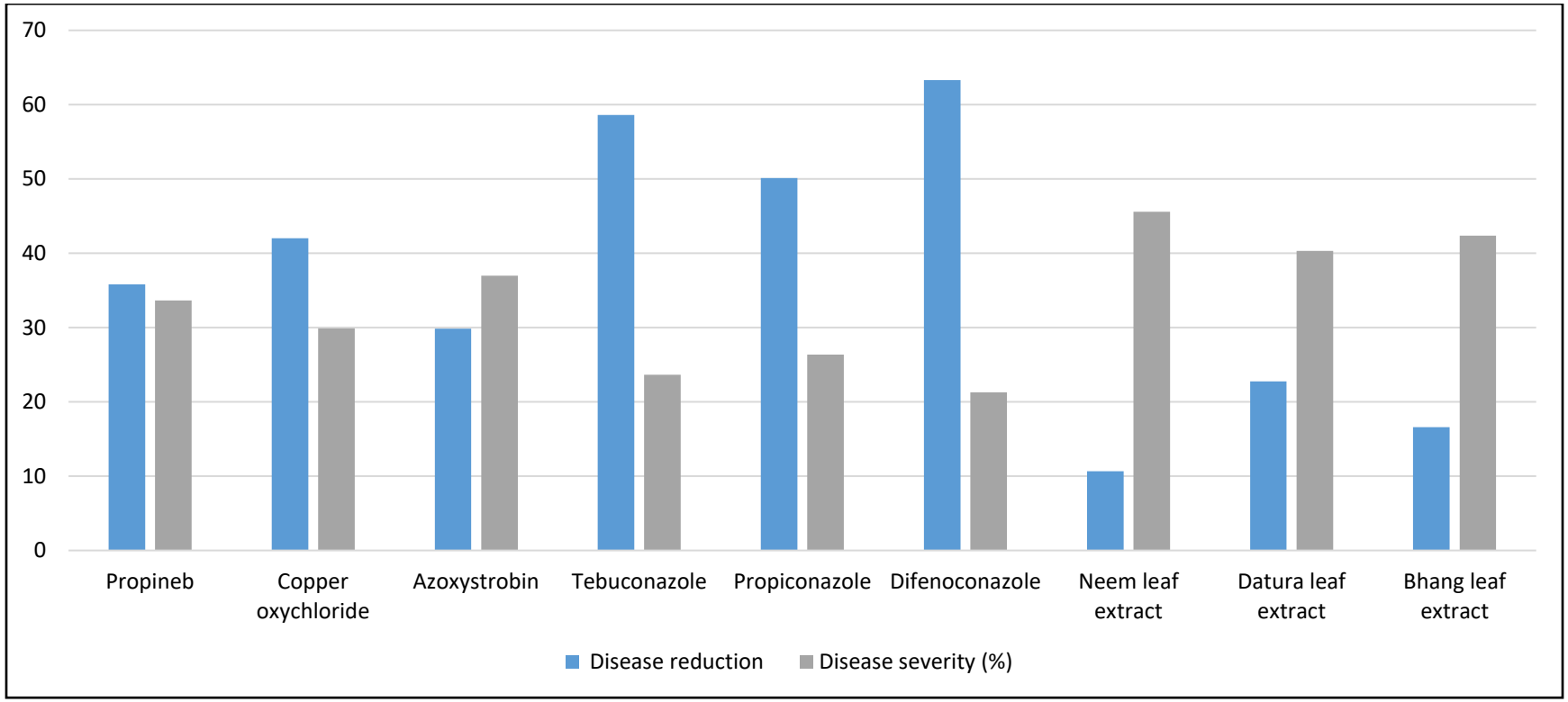


Fig: 6 Performance of fungicides and botanicals for the management of Purple blotch of garlic

Table: 4.9 Yield and Cost benefit ratio

Treatments	Yield q/ha	Disease severity (%)	Increased over control (%)	Cost of protection (Rs)	Cost of cultivation (Rs/ ha)	C:B ratio
Propineb 70% WP	116.00	26.35 (30.39)	18.10	1,200	110,900.00	1:7.32
Copper oxychloride 50%WP	114.33	33.65 (37.46)	20.34	1,710	111,410.00	1:7.18
Azoxystrobin 23% SC	111.67	36.96 (37.46)	14.92	3,448	113,148.00	1:6.90
Tebuconazole 25.9 EC	117.00	23.66 (29.11)	23.15	1,400	111,100.00	1:7.37
Propiconazole 25% EC	112.66	29.89 (33.14)	18.58	900	110,600.00	1:7.13
Difenoconazole 35% EC	119.33	21.28 (27.47)	25.16	2,640	112,340.00	1:7.43
Neem leaf extract	107.66	45.59 (40.60)	13.32	500	110,200.00	1:6.83
Datura leaf extract	110.52	40.59 (39.42)	16.33	500	110,200.00	1:7.02
Bhang leaf extract	109.52	42.36 (40.60)	15.28	500	110,200.00	1:6.95
Control	95.00	51.02 (45.58)	-	-	109,700.00	1:6.06
CD (P = 0.05%)	3.14					
SE (m) ±	1.05					

* Selling price = Rs 7,000 per quintal

** Labour charges @ Rs 350 per day

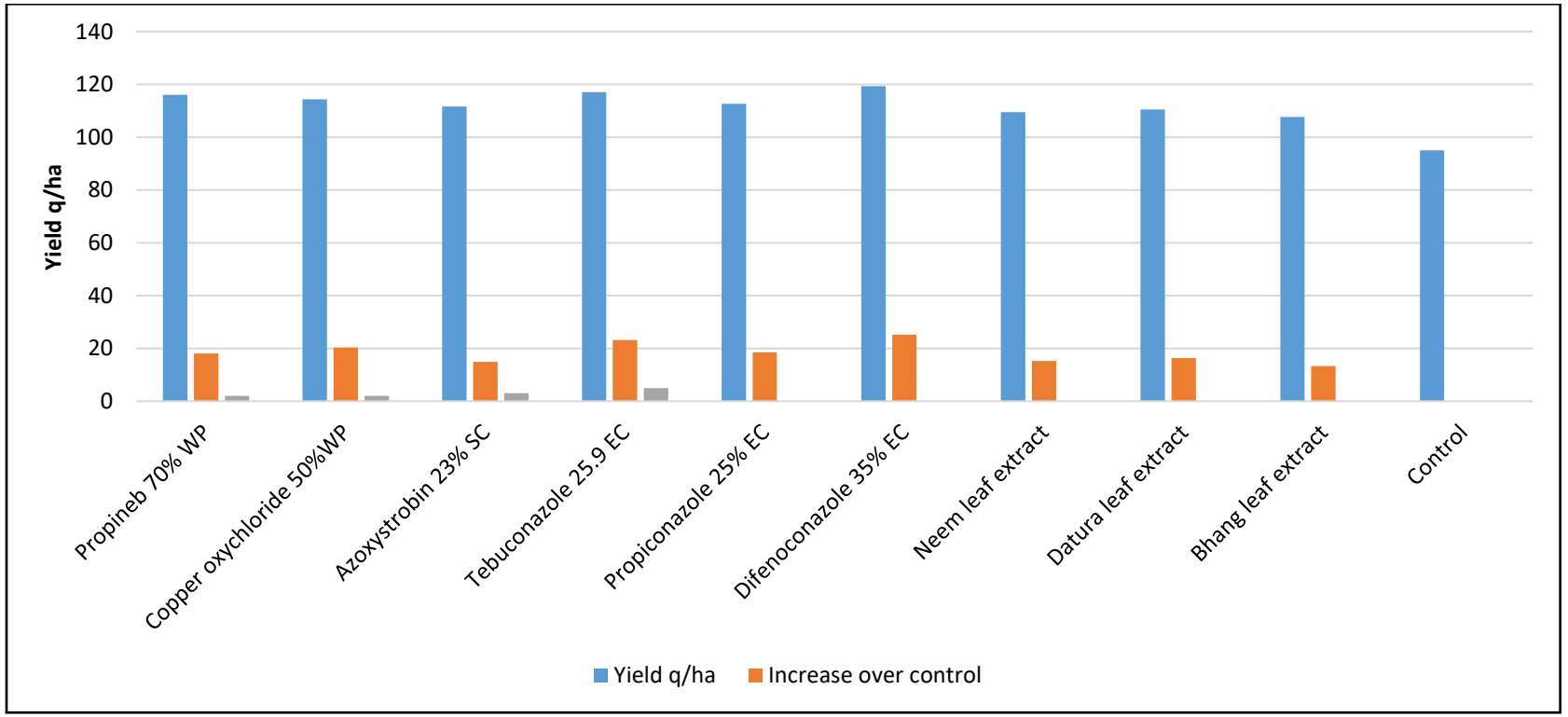


Fig: 7 Graphical representation of Yield (q/ha)

Chapter-5

Discussion

CHAPTER-5

DISCUSSION

Garlic (*Allium sativum* L.) is the high value spice crop and great source of minerals such as phosphorus, calcium, potassium, iron, copper and also rich in vitamin B6 and vitamin C. It has many medicinal properties that makes it as a high demand product. The main constraints in production of this crop losses caused by fungi, virus and bacteria. Among those purple blotch is the most important disease causing severe yield losses under field conditions.

5.1 Survey

Survey was conducted in major garlic growing areas of Jammu district in which four tehsils were selected to assess the status of purple blotch of garlic *viz.*, Akhnoor, Bishnah, R. S. Pura and Jammu tehsil. In Akhnoor tehsil maximum disease severity was observed in Mattu village (32.68%) and minimum disease severity was observed in Garkhal village (21.89%). In Bishnah tehsil, maximum disease severity was observed in Pandori village (33.65%) and minimum was observed in Salehar village (22.17%). Whereas, the maximum disease severity was observed in the village of Kotli (33.82%) and the minimum disease severity was observed in the village of Samka (24.62%) in R. S. Pura tehsil. In Jammu the maximum disease severity was observed in Chatha village (31.26%) and minimum was observed in Ban sultan village (24.32%). Whereas, among four tehsils maximum disease severity was observed in Kotli village (33.82%) of R. S. Pura tehsil and the minimum disease severity was observed in Garkhal village (21.89%) in Akhnoor tehsil. Among all surveyed locations the overall range was 21.89-33.82 per cent. Similar findings were reported by Tiwari and Singh (2020) who observed the maximum disease index in Nalanda (37.17%) and lowest disease index in Vaishali district (23.98%).

5.2 Epidemiology

Epidemiological studies recorded that maximum and minimum temperature, maximum and minimum relative humidity showed significant relationship with disease development, whereas, rainfall showed non – significant relationship with disease development. Same findings were reported by Razdan *et al*. (2011) who reported that the maximum and minimum temperature and maximum and minimum relative

humidity showed 97 per cent disease progression and concluded that these weather factors showed significant relationship with disease development. These findings were also supported by other co-workers (Jhala *et al*., 2017, Khamari *et al*., 2017)

It was observed that during present investigation that the disease appeared during 3rd standard week (2.77%) and gradually progressed till 16th standard week (47.22%). Further, the regression equation $Y=6.979 + 0.420X_1 + 2.147X_2 - 0.074X_3 - 0.287X_4 + 1.654X_5$with coefficient of determination (R^2) 0.96 showed that weather factors influences 96 per cent disease development.

5.3 Pathogenicity test

Pathogenicity test was done by inoculating the *A. porri* spores on the healthy plants and similar symptoms were developed by comparing with the infected plants. Similar results were conducted by Fernandez *et al*. (2011), Mayur and Borsae (2015) and Osman *et al.* (2021) by isolating the infected garlic samples and developed the pure culture under favourable conditions. Later, the symptoms were developed due to the sporulation of *A. porri* on the healthy plant under favourable conditions.

5.4 *In vitro* evaluation of non-systemic fungicides against *A. porri*

Two non-systemic fungicides namely Propineb 70% WP and Copper oxychloride 35%EC were evaluated at different concentrations viz., 50ppm, 100ppm, 250ppm and 500ppm against *A. porri* under *in vitro* conditions and mycelial inhibition was compared with control (untreated) by using poison food technique. Maximum mycelial inhibition was recorded in propineb (78.66%). Whereas, copper oxychloride showed 77.11 per cent mycelial inhibition of *A. porri*. The mycelial inhibition of *A. porri* with propineb (80.49%) and copper oxychloride (70.99%) was also reported by Rahman *et al.* (2015) and Arunakumara and Satyanarayana (2018).

5.5 *In vitro* evaluation of systemic fungicides against *A. porri*

Four systemic fungicides namely azoxystrobin 23%SC, tebuconazole 25.9%EC, propiconazole 25% EC and difenoconazole 35%EC were evaluated under *in vitro* conditions with different concentrations such as 10ppm, 25ppm, 50ppm and 100ppm against *A. porri*. difenoconazole (100%) and tebuconazole (96.66%) showed maximum mycelial inhibition followed by Propiconazole (78.66%) and Azoxystrobin (46.00%). The efficiency of these fungicides had been reported by Maharana *et al.* 2016

that 100 percent mycelial inhibition was recorded in difenoconazole and also reported by other coworkers (Wangikar 2012, Savitha and Ajith Kumar2016, Yadav *et al.,* 2017)

5.6 *In vitro* evaluation of botanicals against *A. porri*

Three botanicals namely Neem leaf extract, Bhang leaf extract, and Datura leaf extract were evaluated under *in vitro* conditions at 10, 15 and 20 per cent concentrations against *A. porri*. Results showed that maximum mycelial inhibition was observed with treatment of Datura leaf extract (82.66%) followed by Bhang leaf extract (77.7%) and Neem leaf extract (62.66%). Similar findings were found by Abdel-Hafez *et al.* (2014) that the mycelial inhibition was observed in Datura leaf extract 8.6mm and in neem leaf extract 7.2mm.

5.7 Management of purple blotch of garlic under field conditions

A trial was carried out under field conditions to evaluate six fungicides and three botanicals under epiphytotic conditions. Among six fungicides difenoconazole (63.29%) and tebuconazole (58.6%) showed maximum disease reduction. Similar findings were also reported by Yadav *et al.* (2017) that the maximum disease reduction was observed in difenoconazole (53.84%). Whereas in botanicals Datura leaf extract showed (25.66%) disease reduction as compared with control, followed by Bhang leaf extract (16.61%) and Neem leaf extract (10.08%). These findings were also supported by Abdel-Hafez *et al.* (2014) and reported that Datura shows maximum disease reduction (60.95%).

5.8 Yield and Cost benefit ratio

The maximum yield was recorded in difenoconazole (119.33q/ha) plots with 1:7.43 cost benefit ratio, followed by tebuconazole (117.00q/ha) with 1:7.37 cost benefit ratio, propineb (116.00q/ha) with 1:7.32 cost benefit ratio, copper oxychloride (114.33q/ha) with 1:7.18, Propiconazole (112.66q/ha) with 1:7.13 cost benefit ratio and minimum yield was recorded in azoxystrobin (111.67q/ha) with 1:6.90 cost benefit ratio. In botanicals the maximum yield was occurred in the treatment of Datura leaf extract (110.52q/ha) with 1:7.02 followed by bhang leaf extract (109.52q/ha) with 1:6.95 while, minimum yield was occurred in the treatment of neem leaf extract (107.66q/ha) with 1:6.83. Similar findings were reported by Yadav *et al*. (2017) and observed the maximum yield was recorded in difenoconazole (17.64 t/ha) with maximum cost benefit ratio (7.95:1).

Chapter-6

Summary and Conclusions

CHAPTER-6

SUMMARY AND CONCLUSIONS

Garlic (*Allium sativum* L.) is the most important crop which is cultivated after the onion of *Allium* spp. as well as most widely used spice crop all over the world. Allicin is the active element in garlic cloves which gives pungency flavour to garlic. Mostly garlic is used in aurvedic for curing paralysis and even in recent approaches it is used in inhibiting the cancer cells. Garlic was restricted by several fungal diseases and causes limiting factor in garlic production. Among the fungal diseases, purple blotch (*Alternaria porri*) disease is the problematic disease causes severe yield losses.

Extensive survey was conducted in the month of February and March 2021 to assess the status of purple blotch disease in major garlic growing areas in Jammu district. Four tehsils *viz*., Akhnoor, R. S. Pura, Bishnah and Jammu were selected and survey was conducted and from each tehsil five villages were selected and from each village three fields were selected randomly. In Akhnoor block the maximum disease severity was observed in Mattu village (32.68%) and minimum disease severity was recorded in Garkhal village (21.89%). In Bishnah block the maximum disease severity was recorded in Pandori village (33.65%) and minimum disease severity was observed in Salehar village (22.71%). While in R. S. Pura block the maximum disease severity was recorded in Kotli village (33.82%) and the minimum disease severity was recorded in Samka village (24.62%) and in Jammu block the maximum disease severity was observed in Chatha village (31.26%) and the minimum disease severity recorded in Bansultan village (24.32%). Survey data states that purple blotch disease severity ranged from 21.89 - 33.82 in Jammu district with overall mean 29.49.

Epidemiological studies revealed that the maximum temperature, minimum temperature, showed positive significant relationship with disease development and relative humidity showed negative correlation with disease development. Whereas, rainfall showed non-significant relationship with disease development. During 2nd meteorological standard week the initiation of disease severity was observed (2.77%) and it rapidly increases till the 16th meteorological standard week (47.22%).

Different fungicides and botanicals were evaluated at different concentrations under *in vitro* conditions. Two non-systemic, four systemic and three botanicals were evaluated under laboratory conditions against *A. porri* causing purple blotch disease. In

non-systemic fungicides propineb 70% WP and copper oxychloride 35% EC showed significant mycelial growth reduction at different concentrations viz., 50ppm, 100ppm, 250ppm and 500ppm. Among the both fungicides copper oxychloride (78.66%) showed maximum mycelial inhibition followed by propineb (77.11%), with the mycelial growth when both were compared with control (untreated)

In systemic fungicides Azoxystrobin 23% SC, Tebuconazole 25.9%, Propiconazole 25% EC and Difenoconazole 35% EC were evaluated at different concentrations 10 ppm, 25 ppm, 50 ppm and 100 ppm against *A. porri*. It was observed that difenoconazole (100%) and Tebuconazole (96.66%) showed maximum mycelial inhibition followed by Propiconazole (78.66%) and Azoxystrobin (46.00%). Whereas three botanicals namely Neem leaf extract (*Azadirachta indica*), Datura leaf extract (*Datura stramonium*) and Bhang leaf extract (*Cannabis sativus*) were evaluated against *A. porri* at different concentrations viz., 10, 15 and 20% and it was found that Datura leaf extract showed 82.66% mycelial inhibition followed by Bhang leaf extract (71.77%) and Neem leaf extract (62.66%). .

In field conditions six fungicides and three botanicals were evaluated under epiphytotic conditions. Among those conditions the maximum disease reduction was observed with difenoconazole 35% EC (63.29%), followed by tebuconazole (58.6%). In botanicals datura leaf extract (22.75%) showed maximum disease reduction as compared to other botanicals.

To sum up, the following conclusion was thus drawn from present investigations:

- During survey the maximum disease severity was recorded in the village of Kotli (33.82%) in R. S. Pura block and the minimum disease severity was recorded in the village of Garkhal (21.89%) of Akhnoor block. This studies revealed that the purple blotch disease is the most prevalent in Jammu district
- The first time disease was appeared at 2nd meteorological standard week (2.77%) and rapidly progressed up to 16th meteorological standard week (47.22%)
- Epidemiological studies revealed that the maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity showed significance relationship in the development of the disease. Whereas, rainfall showed non-significance relationship in disease development.

- During pathogenicity test, after inoculation on the healthy plant the similar symptoms were observed after 8th day of inoculation.
- Different fungicides were evaluated under laboratory conditions and the results revealed that in non - systemic fungicides the maximum mycelial inhibition was observed in the treatment of copper oxychloride. Whereas, in systemic fungicides difenoconazole and tebuconazole at 100ppm showed maximum mycelial inhibition. In botanicals Datura leaf extract showed maximum mycelial inhibition followed by Bhang leaf extract and Neem leaf extract at 25% concentrations.
- Under field conditions, difenoconazole (63.29%) and tebuconazole (58.6%) showed maximum disease reduction as compared with control. Whereas, in botanicals Datura leaf extract (22.75%) showed maximum disease reduction.
- Maximum yield was occurred in the difenoconazole (119.00q/ha) with 1:7.43 cost benefit ratio as compared to control (95.00q/ha) with 1:6.06 cost benefit ratio.

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