Original Research Article

Effect of *Trichodermaharzianum* and botanicals on Purple blotch disease of garlic (*Allium sativum* L.) caused by *Alternariaporri* (Ellis) Cif.

Comment [WU1]: There are some grammar and language mistakes that should be corrected in the whole paper.

ABSTRACT

Comment [WU2]: The abstract should contain a concise introduction, the aim of the work, a concise method of work, brief results, and recommendations.

This study was aimed to determine the effect of botanicals and bio-agent on purple blotch disease of garlic caused by *Alternariaporri*. The research work was undertaken at Central Research Farm (CRF) Sam Higginbottom University of Agriculture, Technology And Sciences, SHUATS, Naini, Prayagraj during *rabi* season in 2022-23. A randomized block design with eight treatments was employed including T_0 (Control - untreated), T_1(Azoxystrobin@0.1% as treated check), T_2 (*Trichodermaharzianum*@10g/litre) , T_3 (*Lantana camara* leaf extract@10%), T_4 (*Azadirachtaindica*leaf extract @10%), T_5 (Henna leaf extract @2% + Licorice root extract@2% + Rosemary leaf extract @2%), T_6 (Licoriceroot extract @10%) and T_7 (Neem cake @50g/m^2). All botanicals and bio-agent were tested significantly beneficial in reducing the disease intensity of purple blotch disease. The results revealed that among the treatments,T_7showed minimum disease intensity (4.33, 18.74 and 26.35%) at 30, 60 and 90 DAS respectively; while maximum disease intensity was recorded in T_5(9.46, 24.21 and 31.31%). T_7 also recorded maximum plant height (24.02, 34.01 and 45.71cm) at 30, 60 and 90 DAS, respectively and highest yield of 4.46t/ha. Maximum number of leaves were recorded withT_3 (5.53, 7.5 and 9.4) at 30, 60 and 90 DAS respectively.

Comment [WU3]: Any abbreviation should be written in detail for the first time mentioned.That should be applied on the whole paper.

Keywords: Alternariaporri, Bio-agent, Garlic (Allium sativum), Plant extracts, Purple blotch.

1. INTRODUCTION

Comment [WU4]: **Introduction should be ended with clear aim of the work.**

Garlic (*Allium sativum* L.) belongs to the family Amaryllidaceaeand is the second most important bulb crop after onion (Rubatzky and Yamaguchi, 1997) [1].Garlic is one of the important spice crops which is used as culinary item and is also used to prevent or cure various diseases /disorders in respect of human health. Whenever an epidemic has emerged, garlic has been the first preventive and curative remedy.

Garlic (*Allium sativum)* is a perennial flowering plant growing from a bulb. It has a tall, erect flowering stem that grows up to 1 m. The leaf blade is flat, linear, solid, and approximately 1.25–2.5 cm wide, with an acute apex. The economic yield is obtained from underground develop part known as bulbs. Often the bulb contains 10 to 20 cloves that are asymmetric in shape. The small central cloves are not usually used because they produce small plants and hence small bulbs (Purseglove, 1975) [2].

In 2020, China had the highest production of garlic throughout the Asia-Pacific region, in which over 20.7 million tons of garlic was produced. Madhya Pradesh recorded the highest production of garlic across India in financial year 2022, amounting to over two million metric tons followed by Rajasthan, Uttar Pradesh and Gujarat. The country produced over 3.1 million metric tons of the garlic in 2021 (Minhas, 2023) [3].

Alternariaporri causing purple blotch of garlic is a common saprophyte on plant debris and plant tissue. It leads to considerable loss in yield and quality of garlic. It is the most destructive disease of Allium spp. (onions, garlic, shallots, leeks, scallions and chives). The pathogen of Allium was first designated as *Macrosporiumporri*(Cooke and Ellis, 1879) [4] and *Alternariaallii*(Nolla, 1927) [5]. Later both species were called *Alternariaporri* (Ciferri, 1930) [6].

The pathogenicity of *Alternaria*spp. is due to production of host specific or nonspecific toxins that may induce disease. These toxins are mainly secondary metabolites that destroy susceptible cultivars by leaf necrosis (Mamgain*et al.,* 2013) [7]. The disease usually affects the leaves and bulbs of a plant, and reducing their yield up to 97% (Kareem *et al.,* 2012) [8].

Purple blotch disease is severe in high humidity and moderate temperature of 80–90% and 25–30°C, respectively. The initial symptoms on host leaves and floral stalks are white flecks which enlarge and produce sunken purple lesions sometimes surrounded by a yellow to pale brown border. The leaves shrivel, usually from the tip. The fungus does not persist in the soil. Air-borne spores often invade plants through wounds, bruises or uncured neck tissue. The pathogens survive in infected cloves (Dicklow, 2013) [9]. Since the leaves are the only photosynthetic organ, this foliar pathogen directly influence the bulb yield. Significant reduction in bulb yield (25-60 %) due to drying of leaves has been observed in garlic (Bisht and Agarwal, 1993)[10].

Conidia of *A. porri* are normally ovoid, obclavate, ellipsoid and sub cylindrical with multiple transverse and longitudinal septa. The body of the conidium is oblong with its formal end protruded out and the terminal part tapered into a beak. It is produced from a bud formed by the conidiophores. Conidiophores are solitary or found in groups. They are purple when young and brown when old. They are 120 µm long and 5-10 µm thick with one or numerous well defined conidial scars (Dar et al., 2020) [11].

In the absence of resistant cultivars farmers must rely on repeated application of fungicides, which has significant environmental and economic consequences. In order to reduce fungicide use, an assessment needed to be made of how much disease can be tolerated without significant yield loss, and the amount of loss attributable to the disease also needed to be defined accurately (Bisht and Agarwal, 1994) [12]. Many types of composted material have been shown to suppress diseases like cattle manure and FYM (Reuveni*et al.,* 2002) [13]. Recently, trends to use extracts of many higher plants have an effective and safe role against plant fungal diseases (Draz*et al.,* 2019; Ragupathi*et al.,* 2020) [14] [15]. Biological control of plant pathogens through antagonistic microorganisms is proved as an effective, not harmful to the environment and a suitable strategy other than an optimistic alternative of chemical uses (Kumar and Palakshappa, 2008) [16]. Plant extract possess an anti-fungal activity in opposition to a wide range of plant pathogenic fungi. These are less phytotoxic, biodegradable and host metabolism stimulatory. Various experiments were undertaken over the past many years to manage purple blotch disease through bio-agents, botanicals and fungicides (Ali *et al.* 2016; Jhala*et al.,* 2017; Yadav*et al.,* 2017) [17-19].

2. MATERIALS AND METHODS

The experiment was carried out at Crop Research Farm, Department of Plant Pathology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (UP)during the *Rabi* season of 2022-23. Field experiment was laid out in Randomized Block Design with eight treatments having three replications.

2.1 Field preparation

The selected field area was well prepared and plot marked as per the layout plan. The selected field was ploughed, cleaned and the soil was well pulverized after which the total area was divided into sub-plots. A total of 24 sub-plots were made (8 treatments × 3 replications).

2.1.1 Sowing

Garlic was sown manually with spacing of 15cm between row to row and 10cm between plant to plant. Sowing of cloves was done at a depth of 5cm keeping their growing heads upwards. Then the cloves were covered with soil and light irrigation was given.

2.2.Isolation and identification of pathogen

The diseased garlic leaves that had typical symptoms of purple blotch were collected from the experimental field area. They were washed thoroughly with tap water to remove dirt. Then the leaves were cut into small pieces and surface sterilized with sodium hypochloritesolution 1% for 30 seconds. The surface sterilized pieces were washed with sterilized distilled water for 3 times and dried on filter papers, then placed on Potato Dextrose Agar medium in Petri plates. The

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Petri plates were incubated at 27±2℃ for 48 hours. To obtain pure culture of fungus, single spore technique was used. The focus point of dissecting microscope was adjusted to the surface of media to find germinating spores, a small piece of media with the target spore attached was picked up using a sterilized syringe or glass needle and transferred onto a 60 mm media plate. Around 10 spores were picked and transferred individually in each Petri plate and cultured under room temperature (25℃) to get pure colonies.Examination of fungal colony characteristics was done through microscopic examination. Using a sterile needle, a small portion of the culture was taken and placed on a glass slide. One drop of lactophenol was dropped over it and then it was stained using cotton blue. Then, the microscope was used for the examination of morphology and culture characteristics of fungal structures (Grahovac*et al.,* 2012) [20].

2.3. Plant materials and preparation of extracts

Fresh and healthy leaves of *Azadirachtaindica*, *Lantana camara*, Rosemary (*Salvia rosmarinus*), Henna (*Lawsoniainermis*), roots of licorice (*Glycyrrhizaglabra*) were collected from local area. The collected leaves and roots of licorice were first washed under running tap water to remove extraneous materials and then washed in distilled water.

*2.3.1. Azadirachtaindica*and *Lantana camara*

One hundred grams (100 g) leaves from each sample were mixed with sterile water (100 ml) at 1:1 (w/w) with the help of mortar and pestle, after that the extract was filtered through muslin cloth followed by Whatman filter paper. The extract is used as standard plant extract solution of 100% concentration (stock solution).Prepared plant extract was heated at 60^0 C for 15 minutes to inactivate the microbial contaminants. The final volume was adjusted to 1000 ml with distilled water.

2.3.2. Licorice (*Glycyrrhizaglabra*), Rosemary (*Salvia rosmarinus*)

All plant materials were air dried and crushed in the electrical mill to prepare plant powder. Ten grams of plant powder of licorice and rosermary were soaked in 100 ml of distilled water and shaked thoroughly. Supernatant of each extract was separated from the residue by squeezing through double layers of muslin cloth and then obtained aqueous extracts were filtered through Whatman filter paper no. 1. (Satish*et al.,* 2007) [21].The final volume was adjusted to 1000 ml with distilled water.

2.3.3. Henna (*Lawsoniainermis*)

The leaves of henna were obtained from local market. They were air dried and crushed in the grinder to prepare plant powder. The aqueous extract of henna was prepared by soaking 10 grams of henna powder in 100 ml of distilled water and then boiled for 20 minutes (Kumar and Kathireswari, 2016) [22]. After cooling, supernatant of extract was separated from the residue by squeezing through double layers of muslin cloth and then obtained aqueous extracts were filtered through Whatman filter paper no. 1. The final volume was adjusted to 1000 ml with distilled water.

2.4. Spraying of treatments on garlic plants

After the initial appearance of disease at 30 days after sowing (DAS), the foliar spray of botanicals was applied given for 3 times at 15 days interval.

2.5. Effect of treatments on disease intensity and plant growth parameters

Data were noted on disease intensity (%), plant height (cm), number of leaves per plant at 30, 60 and 90 DAS respectively. Five randomly selected plants were chosen from each plot to study these parameters. Total yield (t/ha) was determined for each experimental plot after harvesting. The garlic plants were solar dried for 10 days before determining the yield.

2.5.1. Disease assessment

Disease intensity (%) was recorded according to Mayee and Datar, (1986) [23]. (Fig.1).

Fig.1. Disease rating scale (0-9) of purple blotch (Mayee and Datar, 1986)

Table1: Rating scale for disease intensity on foliage

Grade	Leaf area covered (%)
0	No disease symptoms
1	1%
2	2-5%
3	6-10%
4	11-15%
5	16-25%
6	26-40%
7	41-60%
8	61-75%
9	>75% in addition to dryness of most leaves

$$Disease\ intensity\ (\%) = \frac{Sum\ of\ all\ diseased\ ratings}{Total\ number\ of\ rating\ \times Maximum\ disease\ grade} \times 100$$

2.6. Statistical analysis

The Data recorded throughout the course of investigation was subjected to Statistical analysis using analysis of variance (ANOVA) for randomized block design (RBD) (Fischer and Yates, 1963) [24]. Whenever 'F' test was found significant for comparing the means of two treatments, a critical difference (C. D. at 5%) was worked out.

Table 2: Details of Treatments:

S.No.	Treatments	Treatment Details	Application
1	T_0	Control (Untreated)	Distilled water spray
2	T_1	Azoxystrobin @0.1 % (Check)	Foliar Spray
3	T_2	*Trichodermaharzianum* @10g/litre	Foliar Spray
4	T_3	*Lantana camara* @10%	Foliar Spray (leaf extract)
5	T_4	*Azadirachtaindica* @10%	Foliar Spray (leaf extract)
6	T_5	Henna Powder(2%)+ Licorice Powder(2%)+ Rosemary Powder(2%) @6%	Foliar Spray (leaf and root extract)
7	T_6	Licorice Powder @10%	Foliar spray (root extract)
8	T_7	Neem Cake @ 50g/m^2	Soil Application

3. RESULTS AND DISCUSSION

Effect of treatments on disease severity of purple blotch in garlic

The data presented in table 3revealthat the minimum disease intensity (%) was recorded in treatment T_7 - Neem cake @50g/m^2 (26.35), which was superior to overall treatments, followed by T_4 - *Azadirachtaindica* @10% (27.65), T_3 - Lantana camara @10% (28.42), T_2 - *Trichodermaharzianum* @10g/L (29.45), T_6 -Licorice @10% (30.48), T_5 - Henna + Licorice + Rosemary @6% (31.31) as compared to treated check T_1 - Azoxystrobin @0.1% (25.36) and T_0 - Control untreated check (34.68). Similar findings are in accordance with the studies conducted by Singh *et al.* (2010 a), Singh *et al.* (2010 b) and Bhonde*et al.* (1999)[25-27] who showed that neem has anti-microbial activity. Neem has been reported to exhibit antifungal, antibacterial and insecticidal properties. The ethanolic extract of neem leaves stops the growth of fungi.

Effect of treatments on plant height (cm) of garlic

The data presented in table 4 reveal that the maximum plant height (cm) was recorded in treatment T_7 - Neem cake @50g/m^2 (45.71), which was superior to overall treatments, followed by T_4 - *Azadirachtaindica*@10% (43.81), T_3 - *Lantana camara* @10% (40.81), T_2 - *Trichodermaharzianum*@10g/L (38.03), T_6 - Licorice @10% (35.43), T_5 - Henna + Licorice + Rosemary @6% (33.93) as compared to treated check T_1 -Azoxystrobin @0.1% (47.30) and T_0 - Control untreated check (20.04). The result is in agreement with the study conducted byKatyayan(2012) [28] who reported that
neem cake supplies available N for long time in soil resulting in promoting vegetative growth. Neem cake also reduces nitrification. Neem seed cake acts as a nutrient reservoir providing favourable pH, aeration and improving other physical and chemical properties of soil.

Effect of treatments on number of leaves of garlic

The data presented in table 5 reveal that the maximum number of leaves were recorded in treatment T_3 - *Lantana camara* @10% (9.4), which was superior to overall treatments, followed by T_4 - *Azadirachtaindica*@10% (9.1), T_2 - *Trichodermaharzianum*@10g/L (8.8), T_7 - Neem cake @50g/m^2 (8.6), T_6 - Licorice @10% (8.3), T_5 - Henna + Licorice + Rosemary @6% (8.4) as compared to treated check T_1 - Azoxystrobin @0.1% (9.7) and T_0 - Control untreated check (8.1). Study found that the application of *Lantana camara*had a positive effect on the number of leaves of garlic, which is similar to the findings of Ambika*et al.* (2003) [29] who reported that the *Lantana camara*showed positive allelopathy effect and this effect depended on allelochemicals concentrations and it was also specific to different plant species. Different parts of lantana weed have various allelochemicals like carbohydrates, flavonoids and tannins. Such chemicals or compounds enhance or reduce growth and yield of different crops.

Effect of treatments on average yield of garlic

The data presented in table 6 reveal that all the treatments application has significantly increased the total yield. The maximum yield of garlic was recorded in treatment T_7 - Neem cake @50g/m^2 (4.46), which was superior to overall treatments, followed by T_4 - *Azadirachtaindica*@10% (4.06), T_3 - *Lantana camara* @10% (3.7), T_2 - *Trichodermaharzianum*@10g/L (3.35), T_6 - Licorice @10% (3.06), T_5 - Henna + Licorice + Rosemary @6% (2.96) as

compared to treated check T_1 - Azoxystrobin @0.1% (5.56) and T_0 - Control untreated check (2.62). The probable reason for such findings may be that neem cake is a rich source of organic carbon and hence organic matter content which is rich source of plant nutrients. This was in agreement with the findings of Shivakumar*et al.* (2011)[30] who reported an increase in organic carbon content from 0.03 to 0.06% after application of neem seed cake in finger millet. Similar results were ascribed by Uma Singh and Pokhriyal (1997) and Kumar *et al.* (2009) [31-32]who reported thatneem seed cake acts as nutrient reservoir and on decomposition release organic acids and the crops might absorb ions through their roots for the entire growth period leading to higher yields.

Table 3: Effect of treatments on disease severity of purple blotch in garlic at 30, 60 and 90 DAS

Treatment Combinations		30 DAS	60 DAS	90 DAS	MEAN
T_0	Control	10.42[a]	25.52[a]	**34.68[a]**	23.54[a]
T_1	Azoxystrobin	3.69[h]	16.52[g]	**25.36[h]**	15.19[f]
T_2	*Trichodermaharzianum*	7.30[d]	21.49[c]	**29.45[d]**	19.413[c]
T_3	*Lantana camara*	6.47[e]	20.6[d]	**28.42[e]**	18.497[cd]
T_4	*Azadirachtaindica*	5.48[f]	19.55[e]	**27.65[f]**	17.56[d]
T_5	Henna + Licorice+ Rosemary	9.46[b]	24.21[b]	**31.31[b]**	21.66[b]
T_6	Licorice	8.36[c]	23.58[b]	**30.48[c]**	20.807[b]
T_7	**Neem Cake**	**4.33[g]**	**18.47[f]**	**26.35[g]**	**16.383[e]**
C.D. (5%)		0.590	0.715	**0.394**	0.967
S.Em(±)		0.053	0.078	**0.024**	0.143

*Mean of three replications

*Figures followed by similar alphabets in same column indicates non-significant to each other at 5% level

Table 4: Effect of treatments on plant height (cm) of garlic at 30, 60 and 90 DAS

Sr. no.	Treatments	30 DAS	60 DAS	90 DAS
T_0	Control	15.57[f]	22.31[g]	29.04[h]
T_1	Azoxystrobin	26.19[a]	35.43[a]	47.30[a]
T_2	*Trichodermaharzianum*	18.10[d]	28.50[de]	38.03[e]
T_3	*Lantana camara*	21.20[c]	29.27[d]	40.81[d]
T_4	*Azadirachtaindica*	22.43[c]	32.06[c]	43.81[c]
T_5	Henna + Licorice + Rosemary	16.65[ef]	26.64[f]	33.93[g]
T_6	Licorice	17.06[de]	27.75[ef]	35.43[f]
T_7	**Neem cake**	**24.02[b]**	**34.01[b]**	**45.71[b]**
C.D. (5%)		1.425	1.407	1.470
S. Em (±)		0.312	0.304	0.331

*Mean of three replications
*Figures followed by similar alphabets in same column indicates non-significant to each other at 5% level

Table 5: Effect of treatments on number of leaves of garlic at 30, 60 and 90 DAS

Sr. no.	Treatments	30 DAS	60 DAS	90 DAS
T_0	Control	4.33^{f}	6.26^{e}	8.1^{g}
T_1	Azoxystrobin	5.60^{a}	7.8^{a}	9.7^{a}
T_2	*Trichodermaharzianum*	5.07^{cd}	7.06^{bc}	8.8^{d}
T_3	*Azadirachtaindica*	5.27^{bc}	7.33^{ab}	9.1^{c}
T_4	***Lantana camara***	**5.53^{ab}**	**7.5^{ab}**	**9.4^{b}**
T_5	Henna + Licorice + Rosemary	4.53^{e}	6.4^{de}	8.4^{ef}
T_6	Licorice	4.60^{e}	6.53^{de}	8.3^{fg}
T_7	Neem cake	4.80^{de}	6.93^{cd}	8.6^{de}
C.D. (5%)		0.241	0.470	0.218
S. Em (±)		0.008	0.033	0.007

*Mean of three replications

*Figures followed by similar alphabets in same column indicates non-significant to each other at 5% level

Table 6: Effect of treatments on average yield of garlic

TREATMENTS		YIELD (t/ha)
T_0	Control (untreated)	2.62^{h}
T_1	Azoxystrobin	5.56^{a}
T_2	*Trichodermaharzianum*	3.35^{e}
T_3	*Lantana camara*	3.7^{d}
T_4	*Azadirachtaindica*	4.06^{c}
T_5	Henna + Licorice + Rosemary	2.96^{g}
T_6	Licorice	3.06^{f}
T_7	**Neem Cake**	**4.46^{b}**
C.D. (5%)		2.84

S.Em (±)		1.24

*Mean of three replications

*Figures followed by similar alphabets in same column indicates non-significant to each other at 5% level

4. CONCLUSION

From the present study, it can be concluded that the treatment of garlic plants with 'Neem cake' was significant in decreasing purple blotch disease as minimum disease intensity (26.35%) was observed in treatment Neem cake @50g/m^2. Maximum plant height (45.71cm) and highest yield of garlic (4.46t/ha) was also obtained with Neem cake @50g/m^2. *Lantana camara*@10%was found significantly best to increase no. of leaves per plant (9.4). The present investigation was limited to one crop season (*Rabi*), under the agro climatic conditions of Prayagraj (U.P). Therefore, to substantiate the present result, more research is needed to be done in different seasons at different locations.

REFERENCES

1. Rubatzky, V.E. and Yamaguchi, M. World Vegetables, Principles, Production and Nutritive Values. Second edition. Chapman Hall *(International Thomson Publishing)*, New York. 1997;843.
2. Purseglove, J.W. Tropical crops. Monocotyledons. *The English Language Book Societyand Longman,London*. 1975;607.
3. Minhas, A. Production volume of garlic in India FY 2022, by leading state. *Statista Search Department* (2023).
4. Cooke, M.C. and Ellis, J.B. New Jersey fungi. *Grevillea*. 1879;8:11–16.
5. Nolla, J.A.B. A new *Alternaria*disease of onions (*Allium cepa* L.). *Phytopathology.*1927;17: 115–132.
6. Cifferi, R. Phytopathological survey of Santo domingo, 1925-1929. *Journal of Porto Rico.* Department of Agriculture (USA). 1930;14(2):5-44.
7. Mamgain, A., Roychowdhury, R. and Tah, J. *Alternaria* pathogenicity and its strategic controls. *Research Journal of Biology*. 2013;1:01–09.
8. Kareem, M.A., Murthy, K.V.M.K., Nadaf, H.A. and Waseem, M.A. Effect of temperature, relative humidity and light on lesion length due to *Alternariaporri* in onion. *Asian Journal ofEnvironmental Science. 2012;*7:47–49.
9. Dicklow, M.B. Storage diseases of Onion and Garlic. *UMass Extension-Vegetable Program. 2013.*
10. Bisht, I. S. and Agarwal, R. C. Susceptibility to purple blotch (*Alternariaporri*) in garlic. *Annals of Applied Biology*. 1993;122:31-38.
11. Dar, A.A., Sharma, S., Mahajan, R., Mushtaq, M., Ahmad, S. and Sharma, J.P. Overview of Purple Blotch Disease and understanding its management through Chemical, Biological and Genetic Approaches. *Journal of Integrated Agriculture*. 2020;19(12):3013-3024.
12. Bisht, I. S. and Agarwal, R. C. Modelling the relationship between purple blotch and yield loss in garlic and effect of leaf damage on bulb yield. *Annals ofApplied Biology*. 1994;125:293-300.
13. Reuveni, R., Raviv, M., Krasnovsky, A., Freiman, L., Medina, S. and Bar, A. Compost induces protection against *Fusariumoxysporum* in sweet basil*. Crop Protection.*2002;21(7):583-587.
14. Draz, I.S., Elkhwaga, A.A., Elzaawely, A.A., El-Zahaby, H.M. and Ismail, A.A. Application of plant extracts as inducers to challenge leaf rust of wheat. Egypt. *Journal of Biological Pest Control.*2019;29:6.

15. Ragupathi, K.P., Renganayaki, P.R., Sundareswaran, S., Mohan Kumar, S. and Kamalakannan A. Efficacy of botanicals against *Alternariasolani* causing early blight of tomato. *International Journal of Chemical Studies*. 2020;8(6):17-20.
16. Kumar, T.P. and Palakshappa, M.G. Management of purple blotch of onion through bioagents. *Karnataka Journal of Agricultural Sciences.*2008;21(2):306- 308.
17. Ali, H., Nisha, H.A.C., Hossain, M.B. and Islam, M.R. Evaluation of combined effect of micronutrients (ZnSO4 + Borax) and fungicides to control the purple blotch complex of onion (*Allium cepa*). *American Journal of Plant Sciences*. 2016;7:715-723.
18. Jhala, P. and Bali, M.L. Effective management of purple blotch of onion caused by *Alternariaporri* (Ellis) through host resistance, fungicides and botanicals. *International Journal of Current Microbiology and Applied Sciences*. 2017;6(5):1737-1745.
19. Yadav, R.K., Singh, A., Jain, S. and Dhatt, A.S. Management of purple blotch complex of onion in Indian Punjab. *International Journal of Applied Sciencesand Biotechnology*. 2017;5(4):454-464.
20. Gravohac, M., Indic, D., Vukovic, S., Hrustic, J., Gvozdenac, S. and Mihajlovic, M. Morphological and Ecological features as differentiation criteria for different species. *Zemdirbyste Agriculture*. 2012;99(1): 189-196.
21. Satish, S., Mohana, D.C., Ranhavendra, M.P. and Raveesha, K.A. Antifungal activity of some plant extracts against important seed borne pathogens of *Aspergillus sp*. *Journal of Agricultural Science and Technology*. 2007;3(1):109-119.
22. Kumar, K.S. and Kathireswari, P. Biological synthesis of silver nanoparticles (Ag-NPS) by *Lawsoniainermis* (henna) plant aqueous extract and its antimicrobial activity against human pathogens. *International Journal of Current Microbiology and Applied Sciences. 2016;*5(3):926-937.
23. Mayee, C.D. and Datar, V.V. Phytopathometry. Tech Bulletin. 1 (Special Bulletin 3). Marathwada Agricultural University, Parbhani (Maharashtra). 1968;66.
24. Fisher, A.R. and Yates, A.H (1968). Statistical table for Biological, Agriculture and Medical Research, 5th ed. Oliver Boyd. Edinburg. 1968.
25. Singh, U.P., Maurya, S., Singh, A. andGohain, L.. Foliar spray of aqueous extract of neem cake to control balsam powdery mildew. *Archives of Phytopathology and PlantProtection*. 2010a; 43(11):1056-1063.
26. Singh, U.P., Gohain, L., Singh, A., Maurya, S. and Sahani, S. Phenolic acid change in mycelia of *Sclerotiumrolfsii* as influenced by neem cake and *Zephyarenthes citrine* bulb. *Archives of Phytopathology and Plant Protection*. 2010b;43(2):160-167.
27. Bhonde, S. B., Deshpande, S.G. and Sharma, R.N. *In vitro* evaluation on inhibitory nature of some neem formulations against plant pathogenic fungi*. HindustanAntibiotics Bulletin*. 1999;41:22-24.
28. Katyayan, A.Manures, fertilizers and biofertilizers. Fundamentals of Agriculture. *Kushal publications and distributors, Varanasi*. 2012;1:231-254.
29. Ambika, S.R., Poornima, S., Palaniraj, R., Sati, S.C.S. and Narwal, S.S. Allelopathic plants. *Lantana camara L*. *Allelopathy Journal*. 2003;12(2):147-162.
30. Shivakumar, B.C., Girish, A.C., BalakrishnaGowda, Vijaya Kumar, G.C., MallikarjunaGowda, A.P. and Thimmegowda, M.N. Influence of Pongamia, Mahua and neem seed cakes on finger millet productivity and soil fertility. *Journal of Applied andNatural Science*. 2001;3:274-276.

31. Uma, S. and Pokhriyal, T.C. Effects of de-oiled tree seed cakes and growth and biomass production in *Dalbergiasisso* seedlings. Proceedings India National Science Academy B63 No. 6. 1997; 625-630.
32. Kumar, S., Singh, D., Nepalia, V. Performance of Fenugreek (*Trigonellafoenum-graecum*) varieties at various fertilizer levels and bio-fertilizer inoculations. *Indian Journal of Agricultural Research*. 2009;79:80-83.