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Full Length Research Article

Evaluation of Chemical and Non-chemical Options to Manage Onion Purple Blotch (*Alternaria porri*) in Toke Kutaye District, West Shewa, Ethiopia

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Abstract

Purple Leaf Blotch (PLB) caused by *Alternaria porri* is one of the most important diseases and considered as the major constraint of onion production and productivity in Ethiopia. Therefore, the field experimental study was conducted in Agricultural Research Farm of Ambo University, Guder Mamo Mezemir Campus to manage the PLB disease with fungicides, botanicals and compost tea. The experiment was laid out in a randomized complete block design (RCBD) with three replications of each treatment. Among fourteen treatments, five fungicides (Electis 75WG, Nativo 300SC, Vitra 50WP, Acanton 280SC, and Liveshow 173SE) at 100, 200, 200, 200, and 200 ppm concentrations, respectively, five botanicals (*Datura stramonium* L, *Allium sativum* L, *Zingiber officinale* L, *Aloe vera* L and *Eucalyptus globules* L) extract materials at 200ppm and four compost tea concentrations at 25, 50, 75 and 100% were evaluated *in vitro* under lab and field conditions which were found effective against PLB pathogen and recorded significant inhibition of the test pathogen as compared to the control. *In vitro* results revealed that 100% inhibition was observed in Nativo 300SC and Electis 75WG treated followed by Liveshow (90.94%), Vitra (90.39%), Acanto (88.97%), compost tea at 100% (80.26%) and Garlic clove extracts (76.34%). The results under field conditions revealed that Nativo 300SC at 0.2% was found most effective and recorded significantly least mean disease incidence (12.33%) and severity (15.83%) and corresponding bulb yield (364.8 quintal/ha) significantly increased, followed by Electis 75WG at 0.1% and Liveshow at 0.3%, which recorded significantly mean disease incidence of 15.83 and 22.50% and severity, 20.37 and 22.22%, respectively, and also provided bulb yield, increased respectively of 357.3 and 354.6 quintals/ha. Among the botanicals tested, Garlic cloves extract at 0.2% was the most effectives against *Alternaria porri* and recorded significantly least disease incidence (51.04%) and severity (49.45%) and increased the bulb yield (335.3 quintal/ha) and also compost tea concentrations at 100% was recorded significantly least disease incidence (29.17%) and severity (28.47%) and gave increased the bulb yield (350.12 quintal/ha). Among all the treatments, the least AUDPC (945% in days) value recorded from Nativo 300SC fungicide treated plot resulted in the highest yield (364.8 quintal/ha) compared to the least yield (149.2 quintal/ha) from the control in which the highest AUDPC value was recorded. Disease parameters were negatively correlated with yield and yield components, whereas yield components were positively correlated with yield. The economic analysis of fungicides was also revealed where Nativo 300SC at 0.2% was found most economical with the net benefit and marginal rate of return 1147320 ETB and 64160%, respectively. Overall, the present study was concluded that the best effect was fungicides, Nativo 300 SC at 0.2% and Electis 75WG at 0.1% concentrations are the best remedy to manage PLB of onion that can be easily adopted by the farmers to control PLB in their field, and also the compost tea concentrations at 100% was the most effective and environmentally sound approach.

***Key words*:** Onion, Purple blotch disease, *Alternaria porri,* Management, Fungicides, Botanicals, Compost tea

Onion (*Allium cepa* L.) is one of the most important bulbous crops, among all vegetables [1-2] belongs to the family *Amaryllidaceae*, genus *Allium* that grown in different parts of the country for commercially and human consumption purpose as worldwide. China, India, USA, and Egypt are the main onion producing countries with quantities mounting to 24,966,366, 22,819,000, 3,170,270, and 3,081,047 tons, respectively. The production of fresh *Allium* (onions, shallots) and leeks

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including other Alliaceous vegetables only reached 4,491,246 tons and 2,192,467 tons, respectively [3]. In Africa, Egypt is the leading onion producing country for domestic and international markets ranks as the fourth major producers in the world [4]. In Ethiopia, onion production area coverage is 41,673.21 hectares with the productivity of 9.3t ha^{-1} [5] but decreased both in area of production and productivity in 2018 respectively to 28,185.11ha and 9.14t ha^{-1} [6].

The production of the crop is limited by several biotic and abiotic factors. The majority of biotic constraints are caused by fungal diseases, which adversely affect production and productivity as well as crop quality. The crop is highly susceptible to many foliar bulb and root pathogens which reduce its yield and quality [7]. This crop is attacked by 66 diseases (10 bacterial, 38 fungal, 6 nematodes, 3 viral, *Phytoplasma*, and phanerogamic plant parasites besides some other maladies). The major fungal diseases are Purple Leaf Blotch (PLB) (*Alternaria porri*), downy mildew (*Peronospora destructor*), basal rot (*Fusarium oxysporum* f.sp. *cepae*), *Botrytis* leaf blight (*Botrytis squamosa*), damping-off (*Pythium* sp., *Phytophthora* sp., *Rhizoctonia solani*, *Fusarium* spp) and *Stemphylium* leaf blight (*Stemphylium vesicarium*).

In Ethiopia, PLB disease is considered as the major constraint of onion production and productivity. It is prevalent in all onion-growing areas of the country. It attacks leaves, bulbs, and seed stalks and subsequently reduces yield and quality [8]. Onion is basically, the main cash crop in and around Toke Kutaye district of West Shewa, Ethiopia. Currently, the production of the onion is restricted, and yield losses increase due to the Purple Leaf Blotch (PLB) disease caused by *Alternaria porri*, which adversely affects production and productivity as well as crop quality. Nevertheless, the management of onion PLB disease has been carried out using some fungicides in some parts of the country. Accordingly, PLB management with cultural, host resistance, fungicides, and bio-control agents could be important practices to control the infestation of the disease [9]. Extracts of higher plants have insecticidal, antibacterial, and antifungal properties [10-11]. Many researchers have been reported on the efficacy of botanicals and bio-agents to control the growth of fungal pathogens of onion [12-13]. Another alternative method that has been reported with compost tea or aqueous-fermented compost extracts [14-16]. While the non-aerated compost tea was possessed considerably higher control activity than aerated compost tea [17]. Now-a-days, compost teas are getting increased attention as an alternative plant disease control measure for the sake of clean horticulture harvests [18-20]. As one of the last options, among the chemicals to control onion PLB disease, fungicides are used worldwide [21]. However, a good number of fungicides are yet to be assayed against PLB disease. Information on the management options of PLB of onion through other practices like compost tea and botanicals has not been investigated so far in Toke Kutaye district of West Shewa, Ethiopia. Due to the risk of PLB, farmers are not able to cultivate healthy onion during the main and off cropping seasons. Much work still needs to be done in Ethiopia, particularly in the Toke Kutaye district with regard to the management of onion PLB through effective fungicides, botanicals, and compost tea, since the disease is yet posing a threat to crop. Therefore, the present study was carried out *in vitro* under laboratory and *in vivo* under field conditions at Agricultural Research Farm of Ambo University, Guder Mamo Mezemir Campus, during the academic year 2020 off cropping season, which has been made to find out to improve production and productivity of onion through the management of onion PLB using fungicides, botanicals, and compost tea.

MATERIALS AND METHODS

Description of the study area

A field experimental study was conducted at Ambo University, Guder Mamo Mezimer Campus in Agricultural Research Farm during the academic year 2020 off cropping season. Guder is located in the West Shewa Zone of Oromia which is 126 km far from Addis Ababa, the capital city of Ethiopia and 12 km from Ambo town. It is located between 8° 59' 00''N latitude and 37°46'0''E longitude. The average elevation of the study area ranges from 1580.3-1900 m.a.s.l. The agro ecology of the district includes 23% highland, 60% mid attitude, and 17% low land which generally lies in the sub-tropical zone with annual temperature ranging between 10-29°C and the district is dominantly covered by a clay soil slightly acidic pH of 5.5 – 6.0 with an average rainfall of 800-1100 mm [22].

Experimental materials used

Onion (*Allium cepa* L.) *Bombay red* variety was used (most susceptible to PLB disease) and the seeds were obtained from the local market, Ambo, Ethiopia. Five fungicides (Electis 75WG, Nativo 300SC, Vitra 50WP, Acanton 280SC and Liveshow 173SE) were used for the evaluation of onion purple blotch *in vitro* and *in vivo* conditions. All the fungicides were obtained from Chemtex Company, Addis Ababa, Ethiopia. Five botanical materials (Garlic cloves, *Datura* leaves, Ginger rhizome, *Aloe vera* leaves and blue gum leaves) were used for the evaluation of PLB and obtained from the Guder farmer's area but *Aloe vera* leaves were collected from Toke Erensa farmer's area. The matured compost was made from different commercially available compost produced from plant residues (like maize straw, bean straw, green vegetative leaves, animal manure and ash) were used [17] and obtained from Liban Jawi district at Liban Gamo locality FTC. The longevity of matured compost preparation was not less than three months. These aqueous extracts compost tea made from decomposed composts.

Isolation and culturing of Alternaria porri

Naturally infested onion leaves showing typical symptoms of a purple blotch of onion were collected from the fields, brought to the laboratory, and washed thoroughly with tap water. These leaves were cut with a sharp sterilized scissor into small bits (5mm) and were surface sterilized with washing in 75% alcohol for 90 seconds followed by washing three changes with sterile distilled water to remove the traces of alcohol and blot dry. The surface-sterilized diseased leaf bits were then inoculated on the solidified and cooled at 40°C PDA (Potato Dextrose Agar) medium in Petri plates under aseptic conditions. Inoculated plates were then incubated at 24±2°C temperature. After seven days of incubation, the well-developed mycelial growth free from any contaminant was obtained. Following the hyphal-tip technique, the fungus was transformed/sub-cultured aseptically on the PDA slants in culture tubes. Through frequent sub-culturing, the fungus was purified and pure culture was maintained on agar slants in culture tubes and stored in a refrigerator for further studies. Based on cultural and morphological characters, the tested pathogen was identified as *Alternaria porri* [23].

Extraction and preparation of botanicals

After collection of fresh healthy leaves of *Aloe vera*, *Datura stramonium* and *Eucalyptus globulus, a* rhizome of ginger (*Zingiber officinale)* and cloves of garlic (*Allium sativum)* of botanical plants were immediately washed thoroughly in tap water and again washed twice using sterile distilled water. Subsequently, dried under shade at room temperature and chopped into pieces with the help of mortar and pestle. Finally, grounded into coarse powder form with an electric blender at Ambo University, Guder Mamo Mezemir Campus in Plant Pathology Laboratory. The powdered fractions were transferred into separate closed containers for soaking. About 50g of each powdered material was separately added to 1000 ml distilled water in the ratio of 1:20 (*w/v*). But, in the case of the *Aloe vera* leaves were directly crushed by using an electrical blender then filter the gel of leaves liquid and 50 ml of *Aloe vera* gel was mixed in 1 liter of distilled water in the ration of 1:20 (*v/v*) and then, all five plant extracts were gently kept on the shaker for 24 h. Finally, filtered through a double-layered cheese cloth and the filtrates obtained were further filtered through Whatman No I filter paper using funnel and volumetric flasks (1000 ml cap). The final clear plant extracts filtrates were collected in sterilized bottles and kept in a refrigerator at 4°C until used as standard plant extract solution (100%), which were evaluated *in vivo* and *in vitro* against *Alternaria porri*.

Compost tea preparation and applications

The aqueous non-compost tea was prepared by mixing matured compost with distilled water at the ratio of 1:10 (wt: v) (compost: water) in a 20L plastic container according to [24]. Then, the container was loosely covered and incubated in the dark for 7-14 days at 21ºC and it was supplemented with 0.3% molasses for microbial growth stimulation for one to two weeks. Throughout fermentation, non-aerated compost tea was stirred every other day for 20 minutes. However, the end product is not stirred for 8 hours before filtration because to avoid clogging spray equipment, decanted and mixed with a proper wetter/sticker agent to ensure full plant coverage [25]. Compost teas were filtered through two layers of cheese cloth before they were applied to plants and it was incorporated with different rates of water. This means dilution of compost tea with distilled water (1:1, 1:1.5, 1:2 and 1:4) (*v:v*) and for further studies, it is possible to stored at 4ºC before mixing compost tea with water [26]. It was applied to start from disease onset [27].

In vitro evaluation of fungicides, botanicals and compost tea against onion purple blotch

In vitro efficacy of fungicides: Efficacy of three systemic fungicides *(*Nativo 300SC, Liveshow173SE, Acanton 280 SC) and two non-systemic (contact) fungicides (Electis 75 WG and Vitra 50WP) were evaluated *in vitro* against *Alternaria porri* applying poisoned food technique [28] at three concentrations viz., 50, 100 and 200 ppm for preliminary evaluated before use each fungicide for evaluation purpose. Depending on preliminary concentrations of Nativo 300 SC fungicide was most effective at 100 ppm and the rest four fungicides were most effective at 200 ppm. Then, the calculated quantities of each fungicide were thoroughly mixed individually in PDA about fifteen to twenty percent of medium (15 to 20 ml/plate) was poured into sterilized 90 mm glass Petri-plates under aseptic conditions and allowed the medium to solidify at room temperature. The plates were aseptically inoculated with a 5mm disc carefully cut by using a cork borer from the periphery of seven days old cultures of *Alternaria porri* and the disc was placed on PDA in an inverted position in the center of the Petri plate. The Petri plates containing PDA medium without any fungicides were served as control check. The experiments were conducted in completely randomized design (CRD) with three replications in each treatment and the inoculated Petri plates were wrapped with para-film to minimize the chances of contamination and plates were incubated at 24 ± 2°C in an incubator. The observations on colony diameter of each fungus were recorded at 24h intervals up to the Petri plates in control were filled with the mycelial growth of the respective fungus. Percent inhibition of mycelial growth in treated plates was calculated by applying the formula given by Vincent [29]:

$$Percent\ of\ Inhibition\ \ (I) = (C - T) / C * 100$$

Where, C = Growth (mm) of test fungus in untreated control plates

T = Growth (mm) of test fungus in treated plates

In vitro efficacy of botanical extracts

Plant extract of botanicals (*Allium sativum, Aloe vera, Zingiber officinale, Eucalyptus globulus, and Datura stramonium)* was evaluated *in vitro* against *Alternaria porri* applying poisoned food technique [11], [28]. Likewise of fungicides, botanicals plant extracts also preliminary evaluated most effective concentrations viz., 10, 15, and 20% before use of each botanical. Then the most effective concentrations were selected and used for evaluation purposes. On basis of the above concentrations, about twenty percent (20%) was most effective for each botanical. About twenty percent of an appropriate quantity of each plant extracts were incorporated separately with PDA medium (15 to 20 ml/plate) was poured into 90 mm sterilized glass Petri-plates under aseptic conditions and allowed the medium to solidify at room temperature. At the next steps, the actively growing periphery of the seven-day-old culture of *Alternaria porri* was carefully cut using a cork borer and transferred aseptically to the center of each Petri dish containing the poisoned solid medium, and the inoculated Petri plates were wrapped with para-film to minimize the chances of contamination and the plates were incubated at 24 ± 2°C in an incubator. Each plant extracts and its respective concentrations were replicated thrice. Suitable control was maintained by growing the cultures on PDA without the plant extracts [30]. Later on, these plates were incubated at 24 ± 2°C temperature for a week and the observations on radial mycelial growth/colony diameter of the test fungus was recorded at each treatment wisely at 24h interval and continued till mycelial growth of the test fungus was fully covered in the untreated control plates.

Percent inhibition of mycelial growth over untreated control was calculated by applying the formula given by Vincent (29) as detailed below.

$$Percent\ of\ Inhibition\ (I) = (C - T) / C * 100$$

Where C = Growth (mm) of test fungus in untreated control plates

T = Growth (mm) of test fungus in treated plates

In vitro efficacy of compost tea

Four concentrations, at the rate of compost tea viz., 25, 50, 75, and 100% were evaluated *in vitro* against *Alternaria porri* applying dual culture technique [31]. Seven-day old cultures of pure test fungus, *Alternaria porri* grown on PDA media was used for the study and then 5mm disc was cut out by using cork borer from the periphery of seven days old cultures of *Alternaria porri*, and the disc was placed on PDA in an inverted position in the edge of the Petri plate. The PDA media along with culture growth of the test fungus and compost tea concentration [32]. That means two cultures one each of the test fungus and compost tea concentrations were placed at equidistance and exactly opposite with each other on solidified PDA medium in Petri plates under aseptic conditions and the inoculated Petri plates were wrapped with para-film to minimize the chances of contamination and plates were incubated at 24 ± 2°C in the incubator. Plates inoculated with a culture disc of test fungus were maintained as untreated control. Observations on the mycelial radial growth of test fungus and compost tea were recorded at an interval of 24h and continued until the untreated control plate was fully covered with the mycelial growth of the test fungus.

Percent inhibition of the test fungus over untreated control was calculated by applying the formula given by Otadoh *et al.* [33].

$$Percent\ of\ Inhibition\ (I) = (C - T) / C * 100$$

Where, I= Percent inhibition (Reduction)
C= Growth diameter of the pathogen agent in the untreated plate and
T= Growth diameter of the pathogen agent in treatment.

Evaluation of fungicides, botanicals and compost tea against onion purple blotch under field conditions

Crop establishment

Seeds of onion (bomby red variety) were seeded on a 5m^2 raised nursery bed on October, 17th, 2020 and watered regularly twice a day till the full growth at transplanting and the seedlings were transplanted into the experimental field farm of the Ambo University, Guder Mamo Mezemir Campus on December, 5th, 2020. Each plot area was 2.4 m^2 with five rows. Spaces used between blocks, plots, rows, and plants were 1m, 0.5m, 0.3m, and 0.2m respectively. Total plants per plot and plant population on the total area were 40 and 1800, respectively. The experimental field was irrigated two times per week for the first three weeks when transplant and weekly thereafter. The field was fertilized with NPS and urea at 200 kg and 150 kg per hectare, respectively. The NPS was applied during transplanting and urea was applied split into two times. The first half was applied during transplanting and the remaining half after 30 days transplanted. Other recommended agronomic practices were carried out as required [34]. Total experimental areas were expressed as follows: Width = 8.5m; Length = 33m; Total Area = width x Length= 280.5m^2.

Field experimental design and treatments

The treatments were arranged in randomized complete block design (RCBD) with three replications. Treatments have consisted of five fungicides, botanicals, four rates of compost tea, and control with three replications. Forty-five days old seedlings of onion were transplanted into ready the experimental field. The crop was raised as per the suggested package of practices and protecting irrigation was given as and when it was required. Four sprayings of all the treatments were taken at an interval of 15 days, starting first spraying at 45 days after transplanting of the crop i.e., when first symptoms of disease occurred/onset. While applied to treatments on experimental units (plots) to reduce the chance of contamination to other plots using plastic sheets. On each plot of replication was maintained as unsprayed control without receiving any fungicides, botanicals, and compost tea. Observations on disease incidence and severity were recorded before each spray treatment and lastly, 15 days post spraying [35]. The recommended rate per hectare of each fungicide (based on chemicals labeled) in 200 L/ha of water and regarding botanicals recommended rate still now is not well known. However, according to some researchers reported at earlier, botanical applications most of the time at an interval of about 2-8 kg/ha [36-37]. According to Ingham [38] suggested as a general guideline of the application of about 50 L/ha of compost tea for foliar application and 150 L/ha for a soil drench.

Data collected - Disease parameters

Disease incidence and severity were assessed 5 times on each plot every fifteen days starting from the first occurrence of disease symptoms up to maturity of the crop. Disease incidence was recorded by counting of plants that showed visible symptoms of purple blotch (number of plants infected) at 15 days intervals in each of the plants within each of the plots and the data were expressed as a percentage of the total assessed plants. Observations on disease incidence were recorded by counting treatment-wise the number of plants affected with purple blotch disease and percent disease incidence was calculated by applying the formula used by wheeler [39]:

$$\text{Incidence (\%)} = \frac{\text{No. of plants showing disease symptoms}}{\text{Total No. of plants / Plot}} \times 100$$

Disease severity was recorded by visually estimating the percentage of leaf area diseased from twelve [12] random plants taken and pre-tagged and six leaves per plant in the middle three rows of each plot were selected for recording purple blotch severity. The severity was recorded every fifteen [15] days interval starting from the onset of the disease until the non-spray treatment was no longer increased in disease severity. The data on disease severity was recorded using a 1–5 rating scale according to Mayee and Datar [40] (Table 1). Lastly, each severity scale was converted into the Percentage Severity Index (PSI) for analysis [41].

$$\text{PDI} = \frac{\text{Summation of numerical ratings}}{\text{No. of leaves / plants observed} \times \text{Maximum rating}} \times 100$$

Further, the percent of disease control (Efficacy %) was worked out by applying the formula:

$$\text{Efficacy (\%)} = \frac{\text{Control - Treatment}}{\text{Control}} \times 100$$

Table 1 The scale score of disease severity and their Percent Index Severity scoring scale purple blotch

Rating scale	Description
0	No disease symptoms in the plant
1	A few spots towards the tip, covering less than 10% leaf area
2	Several dark purplish-brown patches covering less than 20% leaf area
3	Several patches with paler outer zone, covering up to 40% leaf area
4	Long streaks covering up to 75% leaf area or breaking of leaves/stalks from the center
5	Complete drying of the leaves/ stalks or breaking of the leaves/stalks from the base

Source: Islam [42]

Area under disease progress curve (AUDPC)

AUDPC was computed from the PSI data recorded at each date of assessment as described by Campbell and Madden [43]. AUDPC was expressed in percent-days because the severity (x) is expressed in percent and time (t) in days. The area under Disease Progress Curves (AUDPC) was calculated using the following formula:

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{y_i + y_{i+1}}{2} \right) (t_{i+1} - t_i)$$

Where, Yi= disease severity on the ith date, Y (i+1) = disease severity on the i+1th date, n = number of dates.

Relative yield loss and percentage yield increase
Relative yield loss (RYL)

Purple leaf blotch was measured as percentage yield reduction of unsprayed plots compared with the most protected plot using the following formula of Robert and Janes [44].

$$\text{RYL (\%)} = \frac{(\text{Yp} - \text{Yt})}{\text{Yp}} \text{ x } 100$$

Where, RYL = relative yield loss in percent,
Yp = yield from the maximum protected plots and
YT = yield from other plots

The percent yield increase (PYI): was calculated based on the following formula by Lung'aho *et al.* [45].

$$PYI = Yp - Yc / Yc * 100$$

Where PYI = Percent of yield increase,
Yp = maximum of yield protected and
Yc = untreated yield or unprotected plot

Growth, yield and yield component parameters

Data on plant height, leaf number per plant, leaf length, bulb fresh weight, and total fresh biomass were collected from twelve randomly selected plants. However, days to maturity, marketable, unmarketable, and total bulb yields were recorded per plot base. Plants in the central three rows were used for data collection leaving aside plants in the border rows and those at the end of each row. The number of days from seedling transplanting to a day at which more than 80% of the plants in a plot showed yellowing of leaves or attained physiological maturity. The plant height (cm) was measured using a scale ruler from the ground level to the tip of the terminal leaves of twelve randomly selected plants at the maturity time. The total number of leaves per plant was counted from twelve randomly selected plants at maturity. Leaf length (cm) was measured at physiological maturity from the sheath to the tip of the leaf of twelve plants using a ruler and the average of twelve plants was used for statistical analysis. The fresh weight (g) of twelve randomly taken mature bulbs was measured using sensitive balance and finally then expressed in grams. An average of twelve plants was used for analysis. The bulb weight (g) of twelve plants were selected chopped and dried in an oven-dry at a temperature of 70°C until the constant dry weight was attained and immediately weighed and recorded as dry weight.

The total biomass was measured from the randomly selected twelve pants per plot as a sum weight of the bulb and finally the average of twelve plants was used for statistical analysis. Marketable bulb yield (quintal ha^{-1}) is referred to as the weight of healthy and marketable bulbs that range from 20 to 160 g in weight of bulbs from the net plot area at the time of harvesting Unmarketable bulb yield are undersized (<20g), diseased, decayed, and bulbs from plants with physiological disorders such as thick neck and split were measured from a net plot at final harvest and expressed in quintal ha^{-1} [46]. The total bulb yield was measured from the total harvest of the net plot as a sum weight of marketable and unmarketable bulb yields that were measured in kg per plot and finally converted into quintal ha^{-1}.

Profitability analysis

To determine the least cost and profitable treatments, the partial budget technique was applied to the yield results. The mean prices of chemicals (fungicides) were collected during management time and the market sale price of the onion bulb was obtained at harvest. All costs and benefits were calculated on a hectare basis in Ethiopian Birr (ETB ha^{-1}). The average yield was adjusted downwards by 10% to reflect the difference between the experimental yield and the local farmer's yield. Potentially profitable treatments were selected from the range that was tested using a dominance analysis procedure as described by CIMMYT [47]. Non-dominated treatments were ranked from the lowest (framers practice) to the highest cost treatments. For each pair of ranked treatments, the Marginal Rate of Return (MRR) was calculated. The percentage of MRR between any pair of non-dominated treatments denotes the return per unit of investment in fungicides expressed as a percentage. The Partial Budget Analysis (PBA) was calculated by the following equations:

Adjusted Yield = Average Yield - (Average Yield × 0.1)
Gross benefit = Adjusted Yield × price of the product at harvest
Net benefit = Gross benefit – Total variable cost

The MRR was computed between any pair of treatments for the estimation of extra return per unit of investment using the following formula:

MRR (%) = (The difference between sequential net benefit) / (The difference of respective total variable cost)*100. *OR*

$$MRR = DNI / DIC * 100$$

Where, MRR - marginal rate of return,
DNI- Difference in net income compared with control and
DIC - Difference in input cost compared with control

Statistical analysis

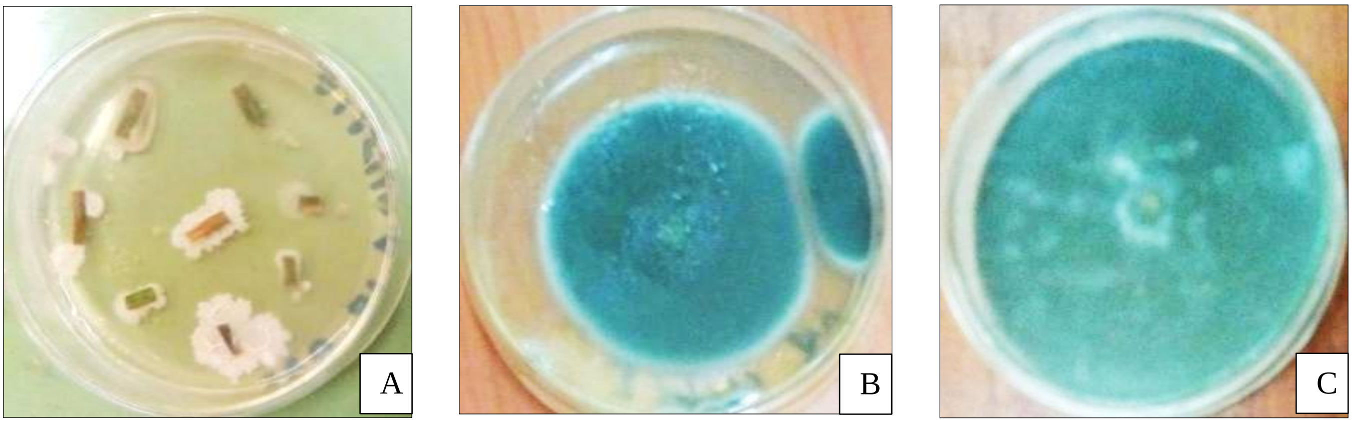
The data of Laboratory studies and field experiments were subjected to Analysis of Variance (ANOVA) as per completely randomized design (CRD) and randomized complete block design (RCBD) using SAS (Statistical Analysis System) version 9.4 (48) Mean separation was done using Least Significant Difference (LSD) at a 5% probability level. By using Pearson Correlations among the disease parameters and all yield and yield components were computed at a 5% probability level. The data were subjected to analysis of variance and correlations between parameters were done.

RESULTS AND DISCUSSION

Cultural and morphological studies

The colony growth of *Alternaria porri* appeared creamy white after three days of incubation (Fig 1A), which eventually changed to greenish-grey and finally turned light olivaceous with distinct light white zonations (Fig 1B-C). The colony was found slightly with light green raised margins in a uniform concentric fashion with a radial diameter of 90 mm on the 7th day of the incubation period (Fig 1C). The present findings were in line with the earlier report by Shahnaz *et al.* [49] who studied the cultural characteristics of different isolates of *Alternaria porri* and recorded that most of the isolates had fluffy growth on PDA with colony color varying from pinkish-white through dull orange to olivaceous and white with distinct to diffuse patterns of zonation.

The pure culture of the pathogen, *Alternaria porri* was regularly examined under the microscope for morphological characteristics viz., color, shape, and septation. As the microscopic study of *Alternaria porri* revealed that the mycelium of the fungus was initially hyaline which later became pale brown to olivaceous brown or smoky blended with a purplish tinge. The conidiophores arose singly or in groups, straight or flexuous pale to mid brown and blunt at the tips. Basal cells of the conidiophore were somewhat wider than the tip cells and the mycelium of the fungus has septate structure forms. The present findings are in close conformity with those earlier reported by Mohsin [50], Priyanka *et al.* [51].



A. Inoculated samples on PDA (After three days old) B. Five days old pure culture of *Alternaria porri* on PDA C. Seven days old pure culture of *Alternaria porri* on PDA

Fig 1 PLB infected leaves of onion plated on PDA culture medium

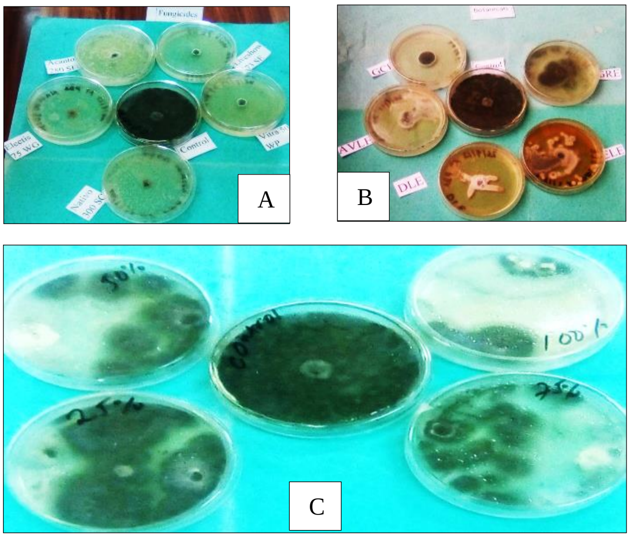


Fig 2 Percent inhibition mycelial growth of *Alternaria porri* through Fungicides, Botanicals, and Compost tea concentrations

Where, A- Efficacy of fungicides - Nativo 300SC at 0.1% and Electis 75WG at 0.2% Live show 173SE at 0.2%, Vitra 50WP at 0.2%, Acanto 280SC at 0.2% and Control
B- Efficacy of botanicals extracts - GCE - Garlic Leaf Extract, ELE - Eucalyptus Leaf Extract, DLE - *Datura* Leaf Extract, AVLE - *Aloe vera* leaf extract and GRE - Ginger rhizome extract and control
C- Efficacy of compost tea at different concentrations at 100, 75, 50, 25% and Control

Antifungal antagonistic assay - Percent inhibition

Results of *in vitro* study on percent inhibition of *Alternaria porri* by fungicides, Botanicals and compost tea showed a highly significant (P < 0.01) mycelial growth reduction (Table 2, Fig 2 A-C). The highest PIMG (100.00%) was obtained from Nativo 300SC at 0.1% and Electis 75WG at 0.2% followed by in decreasing order Liveshow 173SE (90.94%), Vitra 50WP (90.39%), Acanto 280SC (88.97%), compost tea concentration at 100% (80.26%), garlic clove extracts (76.34%), *Aloe vera* leaf extract (72.67%), compost tea concentrations at 75% (71.61%), at 50% (70.74%), Ginger rhizome extract (66.48%), *Datura* leaf extract (61.97%), *Eucalyptus globulus* leaf extracts (50.74%) and compost tea concentration at 25% (41.48%) (Table 2, Fig 2A-C). Therefore, there were highly significant (P<0.01) differences observed in the radial growth of mycelia of *Alternaria porri* as compared with the untreated plate. The highest growth of mycelia (90 mm) was measured from the control plate (*Alternaria porri* alone) (Fig 2). Particularly, among the plant extracts, Garlic cloves and *Aloe vera* leaf extracts were also the most inhibition percent of *Alternaria porri* over untreated treatment respectively and the same was true among the compost teas concentrations at 100% were significantly inhibited mycelial growth of *Alternaria porri* over the untreated plate. Compost tea concentration at 75% was at par with compost tea concentration at 50% and *Aloe vera* leaf extract, which means that they were statistically non-significant in terms of mycelia growth inhibition. In addition, there was no significant difference between the treatments of Vitra 50WP and Acanto 280SC as compared with the untreated plates. Vitra 50WP treatment was also statistically at par with Liveshow 173 SE as compared with the control plate.

Furthermore, it was found that the percentage of mycelia growth inhibition of the test pathogen increased with the increase in the concentration of the fungicides, botanicals, and compost teas tested over control. Overall, these results indicated that all the treatments significant effect on *Alternaria porri* as compared with the untreated control plates. The results of the present study conform to those reported earlier by Hibar *et al.* [52], Jhala *et al.* [53]. Similarly, a group of researchers also tested and reported earlier as different fungicides, botanicals, and compost teas were found most inhibiting of mycelial radial growth of fungal disease which is in agreement with the present results of Ekabote [54], Nisar *et al*. [55].

Evaluation of fungicides, botanicals, and compost tea against Alternaria porri under field conditions

Symptomatology of onion purple blotch disease

The initial symptoms of PLB were noticed at 45 days after transplanting, which assumed spots on the leaves were at first small with a white center but expanded rapidly into an oval, brown to purple blotches, several centimeters long. While the blotches grow around the leaves or merge, the parts above the blotch wilt, collapse, and die i.e., the tip making it shriveled and extensively progressing downwards followed by the development of elongated small spindle-shaped whitish to light-yellow water-soaked lesions. As lesions turned brown, extended in both directions along the leaf blade and it became coalesced, causing extensive blight of the leaves zonate (Fig 3A).

Table 2 *In vitro* effect of fungicides, botanicals, and compost tea on radial growth of mycelia and PIMG of *Alternaria porri*

Treatments	Mycelial parameters		
	*Concentrations (%)	Radial growth of mycelia (mm)	Percentage inhibition of mycelial growth (PIMG)
Control	Water	90.00^{a}	0.00
Eucalyptus leaf extract	0.2	44.34^{c}	50.74
Datura leaf extract	0.2	34.23^{d}	61.97
Ginger rhizome extract	0.2	30.17^{e}	66.48
Aloe vera leaf extract	0.2	24.60^{g}	72.67
Garlic clove extract	0.2	21.29^{h}	76.34
Compost Tea (25%)	0.25	52.67^{b}	41.48
Compost Tea (50%)	0.50	26.33^{f}	70.74
Compost Tea (75%)	0.75	25.55^{fg}	71.61
Compost tea (100%)	1	17.77^{i}	80.26
Acanto 280SC	0.2	9.93^{j}	88.97
Vitra 50WP	0.2	8.65^{jk}	90.39
Liveshow 173SE	0.2	8.15^{k}	90.94
Electis 75WG	0.2	0.00^{l}	100.00
Nativo 300SC	0.1	0.00^{l}	100.00
LSD at ($p < 0.01$)	-	1.68	-
C.V%	-	3.82	-

*Mean values in a column sharing similar letters do not differ significantly as determined by the LSD test ($P<0.01$)

(A) Tip necrosis of leaves. Notice the formation of tiny, spindle-shaped whitish/light-yellowish water-soaked specks scattered on the leaf lamina

(B) The specks progress to typical blight symptoms on leaves. Notice the prominent white chlorotic halo around the blotch and the progressive necrosis

(C) Typical blotch symptom with pinkish to purplish sunken spots

(D) Advanced stage of Leaf blotch symptoms. Notices that the pigmentation has turned dark with the soot of heavy sporulation and followed by rapid and severe chlorosis of foliage/stalks of onion

Fig 3 Symptoms of onion PLB

Soon, though gradually the lesions appeared somewhat sunken and more or less pinkish or purplish with a reddish border surrounded by a white halo (Fig 3B). Later, the blighted areas turned dark brown, non-delineated in size and enlarged rapidly as the weather became warm and humid. With the progressive aging of plants and rise in temperature, the center of the patches finally turned dark olive-brown to black (Fig 3C-D). Similar to leaves, purplish to pinkish lesions also appeared on the floral stalks. The fungus sporulates in the diseased tissue which became dark purplish to black in late March (Fig 3D). Therefore, the infected leaves and floral stalks showed chlorosis and die-back symptoms and collapsed under weather becomes warm and humid conditions. The present findings were in line with the earlier reported by Suheri and Price [56]. Similarly, Agale *et al.* [57] also recorded and reported initial symptoms as the appearance of white flecks on the older leaves which, under favorable environmental conditions expanded and turned elliptical to oblong sunken zonate purple lesions with a yellow to pale brown border.

Disease incidence (%)

The first symptoms of onion purple blotch disease were observed 45 days after transplanting (DAT) on the onion crop. The symptoms appeared on lower leaves as small, light white to yellow, and circular to irregularly shaped, water-soaked lesions were observed. The data presented in (Table 3) revealed that all the treatments were significantly influenced the PLB disease incidence on onion. The mean purple leaf blotch disease incidence was recorded after 1st, 2nd, 3rd and 4th spray treatments which ranged from 12.33-98.17%. Among all the treatments tested, fungicide (Nativo 300 SC) was recorded significantly the least mean disease incidence (12.33%) which was statistically similar with Electis 75WG (15.83%) over the control plot. Among the compost teas, compost tea concentration at 100% was recorded least mean disease incidence (29.17%) and statistically, it was similar with compost tea concentration at 75% (30.83%).

Similarly, compost tea concentration at 50% and ginger rhizome extracts had a similar effect on onion purple leaf blotch disease incidence (Table 3). Among the botanical extracts tested, Garlic clove extracts were recorded significantly the least mean disease incidence (51.04%) over the control plot. This was followed by *Aloe vera* leaf extract (53.30%). Thus, plant extracts (botanicals) tested was also found equally effective as that of the fungicides and compost tea concentrations tested over control plots. Overall, while application of fungicides, botanicals and compost tea were observed that incidence percent gradually decreased with the applications of Nativo 300SC, Electis 75WG, Liveshow 173SE, compost tea concentrations at 100% and 75%, Vitra 50WP, Acanto 280SC, Garlic clove extract, *Aloe vera* leaf extract, Ginger rhizome extract, compost tea concentration at 50%, *Datura* leaf extract, compost tea concentration at 25% and *Eucalyptus globulus* leaf extract (Table 3). The highest percent reduction in purple leaf blotch incidence over untreated control plots obtained from fungicide that treated by (Nativo 300 SC) percentage over control caused the highest reduction (87.44%) in the disease incidence. This was followed by Electis 75WG (83.87%), Liveshow 173SE (77.08%), Vitra 50WP (71.99%), compost tea concentrations at 100% (70.29%), compost tea concentration at 75% (68.59%), Acanto 280SC (66.05%), Garlic clove extract (48.01%), *Aloe vera* leaf extract (45.70%), compost tea concentration at 50% (42.21%), Ginger rhizome extract (41.57%), and *Datura* leaf extract (37.72%). Compost tea concentration at 25% and *Eucalyptus globulus* leaf extracts were found least effective with a minimum incidence reduction of 28.61% and 23.39% percent, respectively in disease incidence (%). Among the fungicides tested Acanto 280SC was found least effective and recorded minimum disease reduction (66.05%). Generally, the present study revealed that Nativo 300SC at 0.2%, Electis 75WG at 0.1%, Liveshow 173SE at 0.3%, Vitra 50WP at 0.1%, and among plant extracts of *Allium sativum* and *Aloe vera* were found most effective in reducing the purple leaf blotch incidence in onion Bombay red cultivar over control plots. Similarly, among compost teas compost tea concentrations at 100% and 75% were also most effective on onion purple leaf blotch disease over control plots (Table 3).

Disease severity index (PSI)

The percent of disease severity was recorded when the crop was at 45 days, 60 days, 75 days, 90 days, and 105 days, and the percent disease reduction over control was calculated (Fig 4A-C).

A. Initial symptoms of purple blotch on the leaves   B. Severely infected leaves on the control plot   C. Healthy leaves from Nativo 300SC treated plants

Fig 4 The severity of purple blotch disease on onion

The results revealed that all the treatments significantly influenced onion purple blotch disease severity and effectively reduced over the unsprayed plot (Table 3). The percentage of disease severity recorded ranged from 15.83 to 94.45 percent. Among the fungicides tested, Nativo 300SC recorded significantly the least mean disease severity (15.83%), which was statistically at par with Electis 75WG (20.37%). Overall, while applied fungicides, botanicals and compost tea were disease severity gradually decreased with the application of Nativo 300SC (15.83%), Electis 75WG, (20.37%), Liveshow 173SE (22.22%), Vitra 50WP (25.93%), compost tea concentration at 100% (28.47%), Acanto 280SC (31.02%), compost tea concentration at 75% (36.11%), Garlic clove extract (49.45%), *Aloe vera* leaf extract (52.22%), Ginger rhizome extract (54.44%), compost tea concentration at 50%, (55.00%), *Datura* leaf extract (57.22%), compost tea concentration at 25% (67.17%) and *Eucalyptus globulus* leaf extract (70.11%). Among the botanicals tested, Garlic clove extract and *Aloe vera* leaf extracts gave significantly least mean disease severity of 49.45% and 52.22% respectively over control plots.

In addition, *Datura* leaf extract and compost tea concentration at 50% had also similar effects on PLB severity onion crop. Similarly, compost tea concentrations applied at 100% was resulted to the least mean disease severity (69.85%) and statistically at par with Vitra 50WP and Acanto 280SC as compared with the over control plots (Table 3). These results indicated that both plant extracts and compost tea were found have to impact in reducing on onion purple blotch disease caused by *Alternaria porri*. Indicating that application of plant extract was also most effective against onion purple blotch as chemical because the application of natural products to increase phenol and antioxidants contents that consequently increases the resistance of onion against the pathogens were two-fold strategy, which makes the onion self-suppressive to the pathogens and to increase its nutritional and medical values. Among the all-treatments control plot was recorded highest percent of severity index 94.45 and highly significant difference over each treated plot. This variation might be due to the effective management practice to resist the epidemics of purple blotch over the control plot. Hence, the present finding results indicated that foliar application of fungicides, botanicals, and compost tea concentration could be most effective to reduce the severity of onion purple blotch as compared with the control plot. The present findings were closely related with the earlier works reported as fungicides (Hexaconazole, Mancozeb 75WP, Tebuconazole, and chlorothalonil) were found most effective against purple leaf blotch of *Allium spp*, potato, mustard, and other crops [58-59]. According to earlier reporters were reported as aqueous plant extracts were most effective on purple blotch of *Allium spp* caused by *Alternaria spp.* in other crops [60-61].

Table 3 *In vitro* effect of fungicides, botanicals, and compost tea on onion PLB disease incidence (PDI) and severity (PSI)

Treatments	Disease parameters				
	Conc (%)	Mean PDI (%)	Mean PDI reduction (%) over control	Mean PSI (%)	Mean PSI reduction over control
Control	Water	98.17[a]	00.00	94.45[a]	0.00
Eucalyptus globulus leaf extract	0.05	75.21[b]	23.39	70.11[b]	25.76
Garlic clove extracts	0.05	51.04[f]	48.01	49.45[e]	47.64
Datura leaf extracts	0.05	61.14[d]	37.72	57.22[d]	39.41
Aloe vera leaf extracts	0.05	53.30[ef]	45.70	52.22[de]	44.71
Ginger rhizome extracts	0.05	57.36[de]	41.57	54.44[de]	42.35
Vitra 50 WP	0.1	27.50[h]	71.99	25.93[gh]	72.54
Acanto 280SC	0.4	33.33[g]	66.05	31.02[fg]	67.15
Nativo 300SC	0.2	12.33[j]	87.44	15.83[j]	83.24
Electis 75 WG	0.1	15.83[j]	83.87	20.37[ij]	78.43
Liveshow 173SE	0.3	22.50[i]	77.08	22.22[hi]	76.47
Compost tea (100%)	1	29.17[gh]	70.29	28.47[g]	69.85
Compost tea (75%)	0.75	30.83[gh]	68.59	36.11[f]	61.77
Compost tea (50%)	0.5	56.74[de]	42.21	55.00[d]	41.76
Compost tea (25%)	0.25	70.08[c]	28.61	67.17[c]	28.88
Grand mean	-	45.86	-	45.34	-
LSD (P<0.05)	-	5.06	-	5.54	-
C.V %	-	6.59	-	7.24	-

Conc. – Concentration, PDI – Percent Disease Incidence, PSI – Percent Severity Index.
CV-Coefficient of Variation; LSD, Least Significant Difference
Means in the column with the same letter (s) in superscript indicate no significant differences between treatments at P < 0.05 level of significance

Table 4 AUDPC calculations of fungicides, botanicals, and compost tea on Bombay Red variety of onion at different dates of observations

Treatments	AUDPC % in days
Control	3745[a]
Eucalyptus globulus leaf extract	3467.5[a]
Garlic clove extracts	2707.5[bc]
Datura leaf extracts	2490[cd]
Aloe vera leaf extracts	2320[d]
Ginger rhizome extracts	1825[e]
Vitra 50 WP	3020[b]
Acanto 280SC	2495[cd]
Nativo 300SC	1410[fg]
Electis 75 WG	1285[fgh]
Liveshow 173SE	1562.5[fg]
Compost tea (100%)	1450[ef]
Compost tea (75%)	1130[ghi]
Compost tea (50%)	1030[hi]
Compost tea (25%)	945[i]
Grand mean	2058.8
LSD (P<0.05)	330.18
C.V %	9.59

Note: CV, Coefficient of variation; LSD, least significant difference. Means in the column with the same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance

Area under disease progress curve (AUDPC)

The present study results revealed that statistically highly significant (P< 0.05) differences had shown on the AUDPC almost at all treatments with the highest AUDPC value of 3745%-days on the unsprayed plot and the lowest AUDPC values of 945% days were obtained from the fungicides treated with Nativo 300SC application (Table 4). However, among all the treatments tested, as mentioned above control plot recorded the significantly highest mean AUDPC (3745% in days) which was at par with *Eucalyptus globulus* leaf extract (3467.5% in days). Overall, it was observed that AUDPC gradually decreased with the application of Nativo 300SC (945% in days), Electis 75WG (1030% in days), Liveshow 173SE (1130% in days), compost tea concentration at 100% (1285% in days), compost tea concentration at 75% (1410% in days), Vitra 50WP (1450% in days), Acanto 280SC (1562% in days), Garlic clove extract (1825% in days), *Aloe vera* leaf extract (2320% in days), Ginger rhizome extract (2490% in days), compost tea concentration at 50% (2495% in days), *Datura* leaf extract (2707.5% in days), compost tea concentration at 25% (3020% in days), and *Eucalyptus globulus* leaf extract (3467.5% in days), respectively.

Furthermore, compost tea concentration at 50% was at par with Ginger rhizome extract. Similarly, compost tea concentration at 75% and Acanto 280SC were also statistically at par with each other on AUDPC (Table 4). From the present study, plots that were treated with fungicides (Nativo 300SC) was the most effective to protect *Alternaria porri*, statistically, which was at par with (Electis 75WG) and Liveshow 173SE, and gave the lowest AUDPC (945% in days), (1030% in days) and Liveshow (1130% in days) (Fig 5, Table 4), respectively. Generally, these results indicated that all evaluated fungicides, botanicals, and compost tea foliar spray frequencies at the 15-day intervals had a significant reduction of purple blotch disease development on onion crops as compared with their unsprayed check. This result is supported by earlier reports by Rao *et al.* [62], Parenu *et al.* [37].

Growth parameters

The effect of fungicides, plant extracts (botanicals), and a compost tea concentration on the plant height of onion was significantly effective and that ranged from 38.13cm to 59.15cm (Table 5). Significantly enhanced plant height (59.15cm) was recorded in plants where Nativo 300SC was applied, which was statistically similar with Electis 75WG (56.39 cm). Conversely, the shortest plant height (38.13cm) was found in the control plot treatment, where plain water was sprayed alone. It was observed that plant height gradually decreased with the application of Nativo 300SC, Electis 75WG, liveshow 173 SE, compost tea concentration at 100%, compost tea concentration at 75%, Vitra 50WG, Acanto 280SC, Garlic clove extract, *Aloe vera* leaf extract, Ginger rhizome extract, compost tea concentration at 50%, *Datura* leaf extract, compost tea concentration at 25% and *Eucalyptus globulus* leaf extract, respectively. The application of plant extracts and compost tea concentrations like fungicides were a significant effect on plant height over control. Although *Eucalyptus globulus* leaf extract and control plot were statistically non-significant in terms of plant height. This means they had a similar effect on plant height. Further, *Aloe vera* leaf extract and Ginger rhizome extract were statistically at par with each other. In addition, compost tea concentration at 50%, *Datura* leaf extract, and compost tea concentration at 25% were also similar effects on the plant height. Overall, these results showed that fungicides, botanicals and compost tea concentrations had found a positive and significant impact on plant height for the effectiveness of against purple blotch of onion over control plots. i.e., application of fungicides, botanicals, and compost tea might have enhanced plant height due to the encouraging ability of the fungicides, botanicals, and compost tea that reduce foliage defoliation, this is because the disease and the plant continue to grow. The present findings were closely in agreement with those researchers reported earlier [63]. The leaf length were highly significant differences (P<0.05) found while applying fungicides, botanicals, and compost tea concentration on onion purple blotch as compared with the untreated plot. The applied fungicides, botanicals, and compost tea were showed significant differences were seen on the leaf length of onion over the control plot. The maximum leaf length was recorded from Nativo 300SC (46.96 cm) treated plot which was statistically at par with Electis 75WG, Liveshow 173SE, compost tea concentration at 100%, and compost tea concentration at 75%. Conversely, the minimum leaf length of onion (35.37 cm) was found in the control treatment, where plain water was sprayed (Table 5). Further, Garlic clove extract; *Aloe vera* leaf extract; Ginger rhizome extract, and compost tea concentration at 50% were similar effects on leaf length. In addition, there was no significant difference between the treatments of *Eucalyptus globulus* leaf extract and the control plot. This means that statistically, they had a similar effect on the leaf length of onion crops. Generally, the present study result showed that applied fungicides, botanicals, and compost tea concentrations were most effective over the untreated plot on leaf length of onion. The present findings were in line with earlier reported by Nelson and Meinhardt [64], Akter *et al.* [65].

The highest number of onion leaves per plant was found in plots treated with Nativo 300SC (14.50) which were statistically at par with Electis 75WG (14.46) as compared with untreated plot plants (Table 5). Among all treatments, the lowest number of leaves (11.21) was recorded from the unsprayed plots. However, the untreated plot was a statistically no significant difference was observed among the treatments treated with *Datura* leaf extract, compost tea concentration at 25%, and *Eucalyptus globulus* leaf extract. Besides, as the present study, there were no significant differences (P<0.05) among plots treated with liveshow 173SE, compost tea concentration at 100%, compost tea concentration at 75%, Vitra 50WP, Acanto 280SC, Garlic clove extract, Aloe vera leaf extract, Ginger rhizome extract, and compost tea concentration at 50% on onion leave number. This showed that they had a similar effect on the leaf number of onions. Overall, this result indicated that a less number of leaves were observed from control plot plants. Since it is might be due to the combined actions of the purple blotch disease and inadequate availability of nutrients. The present findings were closely related to the results earlier reported by some researchers as fungicides, botanicals, and compost tea was a significant impact on leaf number [66-67].

Table 5 Effect of fungicides, botanicals and compost tea on growth parameters of onion crop (Bombay red variety) at Toke Kutaye district

Treatments	Growth parameters				
	Plant height (cm)	Leaf length (cm)	Leaf number	Neck diameter (cm)	Day of maturity
Nativo 300SC	59.15^{a}	46.96^{a}	14.5^{a}	5.29^{a}	119.67^{a}
Electis 75 WG	56.39^{ab}	46.93^{a}	14.46^{a}	5.17^{a}	119^{a}
Liveshow 173SE	54.88^{bc}	46.92^{a}	14.20^{ab}	5.06^{ab}	118^{ab}
Compost tea (100%)	53.65^{bcd}	46.92^{a}	14.02^{ab}	5.16^{a}	117^{bc}
Compost tea (75%)	52.33^{cde}	46.91^{a}	14^{ab}	5.04^{abc}	117^{bc}
Vitra 50WP	50.46^{de}	45.56^{a}	13.9^{ab}	5.04^{abc}	116^{cd}
Acanto 280SC	50.10^{e}	44.29^{ab}	13.84^{ab}	4.80^{abcd}	115.67^{cde}
Garlic clove extract	46.73^{f}	42.36^{bc}	13.56^{ab}	4.78^{abcd}	115^{def}
Aloe vera leaf extract	45.67^{fg}	42.07^{bc}	13.54^{ab}	4.75^{abcd}	114.67^{def}
Ginger rhizome extract	45.60^{fg}	42.02^{bc}	13.45^{ab}	4.71^{abcd}	114^{ef}
Compost tea (50%)	43.3^{gh}	41.62^{bc}	13^{ab}	4.64^{abcd}	113.67^{fg}
Datura leaf extract	42.67^{gh}	39.91^{c}	12.7^{bc}	4.22^{bcde}	112^{gh}
Compost tea (25%)	43.23^{gh}	40.79^{cd}	12.62^{bc}	4.13^{cde}	111.33^{h}
Eucalyptus leaf extract	40.69^{hi}	37.76^{de}	12.59^{bc}	4.02^{de}	111^{h}
Control	38.13^{i}	35.37^{e}	11.21^{c}	3.53^{e}	109^{i}
Grand mean	48.19	43.06	13.43	4.69	114.73
LSD (P<0.05)	3.25	2.74	1.66	0.91	1.75
CV%	4.03	3.81	7.38	11.63	4.44

Note: CV, Coefficient of variation; LSD, least significant difference. Means in the column with the same letter (s) in superscript indicate no significant difference between treatments at P<0.05 level of significance

Neck diameter

As shown in (Table 5) while applied fungicides, botanicals, and compost tea had significantly (P < 0.05) influenced the neck diameter of onion over the untreated plot. Among fungicides treatments, Nativo 300SC and Electis 75WG gave the highest neck diameter of (5.29cm) and (5.17cm) respectively while the control plot gave the lowest neck diameter (3.53cm). However, statistically, significant differences were not observed among the treatments treated with Nativo 300SC, Electis 75WG, and compost tea concentrations at 100%. Similarly, liveshow 173SE, compost tea concentration at 75%, and Vitra 50WP were also similar effects on neck diameter of onion crop. Finally, Acanto 280SC, Garlic clove extract, *Aloe vera* leaf extract, Ginger rhizome extract, and compost tea concentration at 50% were also at par with each other. Besides, *Eucalyptus globulus* leaf extract, compost tea concentration at 25%, *Datura* leaf extract, and untreated plot were similar effects on onion neck diameter (Table 5). Overall, increment in neck diameter with the application of fungicides, botanicals, and compost tea concentration was attributed to the enhancing vegetative growth of onion over the control plot. Therefore, the different treatment applications were a positive impact and were effective on onion neck diameter. The above finding collaborated with the earlier results that could be reported that, the superiority of the bulb neck dimensions recorded when fungicides, botanicals, and compost tea applied [68-69].

Days to maturity

Days to maturity of onion significantly (P<0.05) influenced by the application of fungicides, botanicals, and compost tea concentration over control plot (Table 5). The results showed that plants grown under untreated plots matured earlier (109 days) than the rest of the treatments. However, there were no significant differences between Nativo 300SC and Electis 75WG, compost tea concentration at 100%, compost tea concentration at 75% and also similarly in garlic clove and *Aloe vera* leaf extracts. The present findings showed that all treatments were significant (P<0.05) differences as compared with the control plot on the maturity days of onion. Furthermore, longer time of maturity of (119.67) and (119) days were observed with plots treated Nativo 300SC and Electis 75WG respectively (Table 5). Therefore, delayed maturity was increasing with the application of fungicides, plant extracts, and compost tea might be attributed to the role that plays in promoting vegetative growth and bulb development and effectively controlling pathogens from crops Parenu *et al.* [37].

Yield and yield components

Total bulb yield (quintal/ha)

The efficacy of fungicides, botanicals and compost tea concentrations against PLB and total bulb yield results indicated that all the treatments were found effective in reducing the purple blotch disease incidence and severity and thereby gave significantly increased onion bulb yield over unsprayed plot (Table 6). From this result, fungicides followed by compost tea and botanicals were found most effective in reducing the disease and increasing the bulb yield over the control plot. Among the fungicides tested, Nativo 300SC at 0.2% gave significantly highest bulb yield (364.8 quintal/ha) followed by Electis 75WG (0.1%) (357.3 quintal/ha) and recorded the highest increase of 144.50 and 139.48 %, respectively in bulb yield with mean disease incidence of 12.33 and 15.83% and severity of 15.83 and 20.37%) in bulb yield over unsprayed control (149.20 quintal/ha). However, statistically, there was no significant difference between Electis 75WG and Liveshow 173SE, and also Vitra 50WP and compost tea concentrations at 100% were at par with each other on onion total bulb yield. In addition, there was no significant difference between treatments of Acanto 280SC, Garlic clove extract, and compost tea concentrations at 75% on the total bulb yield. Similarly, a trend was found between *Eucalyptus globulus* leaf extract, compost tea concentration at 25%. Among the plant extracts, Garlic clove extract treatment resulted in bulb yield of 335.3 quintal/ha and an increase of 55.50 percent over control with disease incidence and severity respectively 51.04 and 49.95 percent (Tables 3-6) The present findings were closely related to the results earlier reported by some researchers as fungicides, botanicals, and compost tea was a significant impact on bulb yield [37].

Table 6 Effect of fungicides, botanicals and compost tea on total bulb yield, relative yield loss and % yield increase

Treatments	Yield parameters		
	Total yield quintal ha^{-1}	Relative yield loss (%)	Percentage yield increase (%)
Control	149.2^{g}	59.1	00.00
Eucalyptus leaf extracts	230.1^{f}	36.92	54.22
Garlic clove extracts	335.3^{abcd}	8.09	124.73
Datura leaf extracts	291.7^{e}	20.04	95.51
Aloe vera leaf extracts	328.9^{bcd}	9.84	120.44
Ginger rhizome extracts	321.7^{cde}	11.81	115.61
Vitra 50WG	344.1^{abc}	5.67	130.63
Acanto 280SC	339.2^{abcd}	7.02	127.35
Nativo 300SC	364.8^{a}	0	144.5
Electis 75WP	357.3^{ab}	2.06	139.48
Liveshow 173SE	354.6^{ab}	2.8	137.66
Compost tea (100%)	350.12^{abc}	4.02	134.66
Compost tea (75%)	341.9^{abcd}	6.28	129.16
Compost tea (50%)	311.5^{de}	14.61	108.78
Compost tea (25%)	251.1^{f}	31.17	68.3
Grand mean	311.51	-	-
LSD (P<0.05)	30.69	-	-
C.V%	5.89	-	-

Where; CV, Coefficient of Variation; LSD, Least Significant Difference. Means in the column with the same letter (s) in superscript indicate no significant difference between treatments at P< 0.05 level of significance

Relative yield loss (quintal/ha)

The variation in yield and yield components losses were observed between paired treatments. In untreated plots, the marketable bulb yield, total bulb yield, bulb diameter, and bulb length losses were distinctly higher than in protected plots. Yield losses were calculated comparative to the average yield from plots with the maximum protection against the disease (i.e., plots with the highest yield and lowest disease severity in each treatment). However, yield and yield components losses were substantially, reduced with the application of fungicides, botanicals, and compost tea as compared with unsprayed control plots (Table 6). The highest relative yield losses

(59.10%) happened from plots that were treated with water only. This indicates that how much purple blotch disease is damaging onion plants during favorable conditions when effective management practices have not been undertaken. Just, while the use of the most effective management practice would potentially reduce yield losses due to purple blotch and it might be an increase of the marketable value of onion production [70-71].

Percentage yield increase

The highest (144.5%) yield increase was recorded from plot treated with fungicides Nativo 300SC application. Moreover, among plant extracts the highest (124.73%) and the lowest (00.00%) bulb yield increase was obtained from botanicals treated with Garlic clove extract and un-spray plot, respectively (Table 6). The same was true in compost tea concentration where the highest (134.66%) yield increment was obtained from compost tea concentration at 100% application over the control plot.

Table 7 Effect of fungicides, botanicals and compost tea on yield parameters of onion

Treatments	Yield parameters	
	MY (Quintal/ha)	UNMY (Quintal/ha)
Nativo 300SC	349.8^{a}	15^{h}
Electis 75 WP	341.4^{ab}	15.9^{h}
Liveshow 173SE	337.5^{ab}	17.1^{gh}
Compost tea (100%)	331.1^{abc}	20.1^{gh}
Compost tea (75%)	320.6^{abcd}	21.3^{fgh}
Vitra 50WG	321.4^{abcd}	22.7^{efg}
Acanto 280SC	311.9^{bcde}	27.3^{ef}
Garlic clove extracts	306.4^{cde}	28.9^{e}
Aloe vera leaf extracts	293.3^{def}	35.6^{d}
Ginger rhizome extracts	283.5^{ef}	38.1^{d}
Compost tea (50%)	273.4^{fg}	38.2^{d}
Datura leaf extract	250.4^{g}	41.3^{d}
Compost tea (25%)	189.6^{h}	61.5^{c}
E. globulus leaf extract	159.0^{i}	71.1^{b}
Control	51.2^{j}	98^{a}
Grand Mean	274.7	36.8
LSD (P<0.05)	29.88	6.52
CV%	6.5	10.59

Note: CV, Coefficient of Variation; **LSD**, Least Significant Difference. Means in the column with the same letter (s) in superscript indicate no significant difference between treatments at P<0.05 level of significance. **MY** = Marketable yield; **UNMY** = Unmarketable yield

Marketable bulb yield

There were highly significant differences (P<0.05) in marketable bulb yield of onion treated with fungicides, botanicals, and compost tea as compared with the control plot. A maximum marketable bulb yield of 349.8 quintal/ha was obtained from the plot treated with Nativo 300SC which was statistically at par with Electis 75WG, liveshow 173SE, compost tea concentration at 100%, compost tea concentration at 75%, and Vitra 50WP (Table 7). Conversely, the minimum marketable bulb yield of 51.2 quintal/ha was obtained from the control treatment. Application of Nativo 300SC at (0.2%) increased marketable bulb yield by 298.6 quintal/ha as compared with the control plot (Table 7). Application of compost tea concentrations at 75% and Vitra 50 WP had a statistically similar effect on onion marketable bulb yield. Overall, the increment of marketable bulb yield could be due to the application of fungicides, botanicals, and compost tea concentrations which attributed to the increment in vegetative growth and increased production. The present findings were in agreement with the results that were reported earlier by BBS [72], MOA [73].

There were highly significant differences (P<0.05) on unmarketable bulb yield of onion that treated with fungicides, botanicals, and compost tea concentrations as compared with untreated plots. The mean of unmarketable bulb yield of onion ranged from 15.00 to 98.00 quintal/ha (Table 7). Among all treatments, Nativo 300SC and Electis 75WG have given the lowest unmarketable bulb yield 15 and 15.9 quintals per hectare respectively. However, there was no significant difference between the treatments of Nativo 300SC and Electis 75WG. Similarly, liveshow 173SE, and compost tea concentration at 100%, were also at par with each other. However, the highest unmarketable bulb yield of 98 quintal/ha was obtained from the control treatment. Further, in the present study, there was no significant difference (P<0.05) effects among plots treated with *Aloe vera* leaf extract, ginger rhizome extract, compost tea concentrations at 50%, and *Datura* leaf extract. The present findings were in agreement with the results that were reported earlier by Welki [16], Siddiqui *et al*. [74].

Total fresh biomass

Total fresh biomass of onion was significantly different (P < 0.05) while applied fungicides, botanicals, and compost tea concentrations were on onion purple blotch disease as compared with unsprayed control plot (Table 8). The maximum total fresh biomass of onion (114.49g) was recorded in plants treated with Nativo 300SC at 0.2%, which was statistically at par with fungicides Electis 75WG (104.8g). However, the minimum total fresh biomass (42.76g) was obtained in the unsprayed plot.

Among the compost tea concentrations, the highest total fresh biomass was recorded in plants treated with compost tea concentration at 100% which was not statistically different from compost tea concentration at 75%. Similarly, there was no significant difference in treatments of *Datura* leaf extract, and compost tea concentration at 25% (Table 8). In the case of plant extracts, the highest total fresh biomass was found in plants treated with Garlic clove extract as compared with the control plot. This was followed by *Aloe vera* leaf extract, ginger rhizome extract, *Datura* leaf extract, and *Eucalyptus globulus* leaf extract respectively. Overall, these results indicated that the lowest total fresh biomass was observed from the untreated plot might be since the plot was extremely affected by purple blotch disease. The present study could be due to the effectiveness of fungicides, botanicals and compost tea were promoting physiological and vegetative growth of crops and against purple leaf blotch disease. The present findings corroborate with the results that were reported earlier by Awad *et al*. [75], Pant *et al.* [76].

Total dry biomass

Significantly the highest total dry biomass was obtained in crops treated with fungicides, botanicals, and compost tea concentrations over untreated plot (Table 8). The maximum total dry weights were recorded on the plot that was treated with the treatment of Nativo 300SC (28.64g), which was statistically at par with Electis fungicides (25.87g). However, the lowest total dry biomass weights were recorded in control plots with the plain water (5.12g). Moreover, compost tea concentration at 100%, and compost tea concentration at 75% were also similar effects on the total dry bulb and Vitra 50WP treatment was at par with Acanto 280SC. A similar route was found between Ginger rhizome extract, compost tea concentration at 50%, and

Datura leaf extract. Overall, the total dry biomass of onion was statistically different from untreated treatment due to the effect of different fungicides, botanicals, and compost tea on onion purple blotch disease (Table 8). Therefore, these results showed that there was a significant difference among all treatments as compared with the control plot. The present findings in line with some researchers were reported earlier [77].

Fresh bulb weight

Fresh bulb weight of onion were significant differences (P<0.05) while applied fungicides, botanicals, and compost teas were on onion PLB as compared with unsprayed control plot (Table 8). Maximum fresh bulb weight of onion (80.27g) was obtained from the treatment treated with Nativo 300SC, which was at par Electis 75WG. However, the minimum fresh bulb weight of onion (33.07g) was obtained from the control plot which was treated with plain water (Table 8). In addition, compost tea concentration at 100% was at par with the compost tea concentration at 75%. Similarly, *Datura* leaf extract is at par with the treatment of compost tea concentration at 25%. Overall, while application of fungicides, botanicals, and compost teas was increased the fresh bulb weight of onion over the control plot (Table 8). This indicates that onion fresh bulb weight can be increased while application of fungicides, botanicals, and compost tea during the growing period. The above finding collaborated with the result that could be reported earlier by Edris *et al*. [68].

Dry bulb weight

Bulb dry weight of onion crops at a temperature of 70°C until the constant dry weight was attained in oven-dry was significantly lower in unsprayed plot plants than treated plants (P<0.05) (Table 8). The highest dry bulb weight was observed in plants treated with fungicides (Nativo 300SC) (21.34g), which was statistically at par with the application of Electis 75WG (18.86g). The lowest dry bulb weight was observed in plants treated with plain water (2.11g). Further, compost tea concentration at 50%, *Datura* leaf extract, compost tea concentration at 25%, and *Eucalyptus globulus* leaf extract were also had a similar effect on bulb dry weight. These results indicated that while application of fungicides, botanicals, and compost tea concentration on onion PLB was the most effective as compared with the control plot. These results indicated that the application of fungicides, botanicals, and compost tea concentrations was most effective as compared with the control plot. Similar to present findings were reported as fungicides, plant extracts, and compost tea were most effective to control the purple leaf blotch of onion [63].

Table 8 Effect of fungicides, botanicals, and compost tea on the fresh and dry weight of onion

Treatments	Yield parameters			
	Total fresh weight	Bulb fresh weight (g)	Total dry weight (g)	Bulb dry weight (g)
Nativo 300SC	114.49[a]	80.27[a]	28.64[a]	21.34[a]
Electis 75 WP	104.8[ab]	77.47[ab]	25.87[ab]	18.86[a]
Liveshow 173SE	97.94[bc]	71.98[bc]	22.89[bc]	15.92[b]
Compost tea (100%)	93.46[cd]	69.01[cd]	21.63[cd]	14.95[bc]
Compost tea (75%)	90.46[cd]	67.35[cd]	20.23[cd]	13.80[bcd]
Vitra 50WG	88.29[cde]	65.89[cde]	18.49[de]	12.31[cde]
Acanto 280SC	84.51[def]	62.64[def]	18.09[de]	11.97[de]
Garlic clove extracts	80.37[efg]	59.59[efg]	15.38[ef]	9.68[ef]
Aloe vera leaf extracts	76.85[fg]	57.52[fg]	14.38[ef]	8.88[fg]
Ginger rhizome extracts	73.32[gh]	54.99[gh]	13.13[fg]	7.98[fgh]
Compost tea (50%)	72.54[ghi]	54.79[ghi]	12.52[fg]	7.41[fghi]
Datura leaf extract	66.31[hi]	50.09[hi]	12.43[fg]	6.44[ghi]
Compost tea (25%)	65.22[hi]	49.27[hi]	10.16[g]	5.35[hi]
E. globulus leaf extract	62.73[i]	47.98[i]	9.85[g]	5.08[i]
Control	42.76[j]	33.07[j]	5.12[h]	2.11[j]
Grand Mean	80.94	60.13	16.587	10.81
LSD (P<0.05)	10.06	6.84	4.18	2.81
CV%	7.43	6.81	15.05	15.52

Note: CV, Coefficient of variation; LSD, least significant difference
Mean values in a column sharing similar letters do not differ significantly as determined by the LSD test (P<0.05)

Cost and benefit analysis

Total cost production of any crop includes both variable (operating) and fixed costs. Variable operating costs vary across the treatments because of local material needs and costs. Major variable costs for producing onion for hectares include investment purchase for treatments, onion seed, fungicides, and management (Labor) costs. Similarly, the cost and benefit ratio was computed for each treatment using the partial budget analysis method. The price of the onion bulbs at Guder from March to June was assessed and an average price was 35 ETB/kg and used to compute the total sale (Gross field benefit) and Net benefit of the total produce obtained. The objective of any producer is that the rate of return is as high as possible. Thus, the partial budget analysis was done for this experiment by ranking the treatments in order of increasing total variable cost. The total variable cost has been calculated from the cost of fungicides. Accordingly, the cost of the fungicides were Liveshow l/ha, Nativo l/ha, Vitra kg/ha, Acanto l/ha, and Electis were 1750, 1800, 2100, 2700, and 2850 ETB respectively (Table 9). The result of the partial budget analysis revealed that economically most advantageous bulb yield with a net benefit of 1147320 ETB and marginal rate of return 64160% was obtained from the application of Nativo fungicides (Table 9). According to the manual of CIMMYT (47) for partial budget analysis, the application of fungicides with the marginal rate of return above the minimum level (100%) is economical. Thus, Nativo at 0.2% was found to be economically feasible than the rest of the fungicide treatments.

Table 9 Partial budget and dominance analysis for onion bulb yield under applications of some fungicides

Treatments	Bulb yield quit/ha	Adjusted bulb yield quit/ha	Gross benefit (ETB/Ha)	TVC (ETB/Ha)	Net benefit (ETB/ha)	MRR (%)
Control	149.2	134.28	469980	0	469980	0
Liveshow	354.6	319.14	1116990	1750	1115240	36872
Nativo	364.8	328.32	1149120	1800	1147320	64160
Vitra	344.1	309.69	1083915	2100	1081815	D
Acanto	339.2	305.28	1068480	2700	1065780	D
Electis	357.3	321.57	1125495	2850	1122645	37910

Where, TVC =Total Variable Costs, ETB = Ethiopian birr, MRR= Marginal rate of return, D= Dominance

Association of yield and yield components and disease parameters

Correlations analysis of disease parameters with yield and yield components were showed a significant (P<0.05) negatively association with each other. However, plant height (PH), Leaf length (LL), maturity days (MD), total bulb biomass (TBM), average bulb fresh weight (ABFW), average bulb dry weight (ABDW), and marketable yield (MY) of onion were significantly differences (P<0.05) and strongly positively correlated with each other. But unmarketable bulb yield was recorded as significant differences and had a negative relationship to all biometric parameters. In general, all the plant biometric parameters were shown to have a significant and positive effect with each other but it was negative association with disease parameters.

CONCLUSION

The effectiveness of fungicides, plant extracts and compost tea on onion purple blotch disease was determined through comparison of the value of disease parameters like AUDPC, terminal disease severity, incidence and yield, and yield components. *In vitro* results revealed that 100% inhibition was observed in Nativo 300SC and Electis 75WG treated plates, followed by Liveshow (90.94%), Vitra (90.39%), Acanto (88.97%), compost tea concentration at 100% (80.26%) and Garlic clove extracts (76.34%). The minimum percent inhibition was observed in compost tea concentration at 25% (41.48%) followed by *Eucalyptus globulus* (50.74%) plant extracts. Field experiments revealed that Nativo 300SC at 0.2% was found most effective and recorded significantly least mean disease incidence (12.33%) and severity (15.83%) were recorded with corresponding significantly increased bulb yield (364.8 quintal/ha) followed by Electis 75WG at 0.1% and Liveshow 173SE at 0.3%, which recorded significantly mean disease incidence of 15.83 and 22.50%, and severity of 20.37 and 22.22%, respectively and gave correspondingly increased bulb yield, respectively of 357.3 and 354.6 quintal/ha. Among botanicals tested, Garlic cloves extract was found antifungal against *Alternaria porri* and significantly least disease incidence (51.04%) and severity (49.45%) were recorded with and increased the bulb yield (335.3 quintal/ha). Compost tea concentrations at 100% was also resulted in significantly least disease incidence (29.17%) and severity (28.47%) and gave increased bulb yield (350.12 quintal/ha). Among all treatments, the least AUDPC value recorded from Nativo 300SC sprayed plots and resulted in the highest yield (364.8 quit/ha) compared to the least yield (149.2 quit/ha) from the control in which the highest AUDPC value was recorded. The highest yield loss of 59.11% could be recovered under water foliar spray i.e., control plot. In the case of compost tea, it is an effective, eco-friendly, and alternative approach for management of purple blotch disease caused by *Alternaria porri*. It was a significant and positive effect on the biometric parameters of onion. The economic analysis of fungicides was also revealed where Nativo 300 SC at 0.2% was found most economic with the net benefit and marginal rate of return 1147320 ETB and 64160%, respectively. Overall, the present study was concluded that the best effect was fungicides that can be easily adopted by the farmers to control PLB in their field, and also the compost tea concentrations at 100% was the most effective and environmentally sound approach. Hence, based on the present findings, it is concluded and recommended that Nativo 300 SC at 0.2% and Electis 75WG at 0.1% concentrations are the best remedy to manage PLB of onion and to be recommended that the awareness of farmers to use compost tea and plant extracts as control options for a purple blotch of onion disease as priority because it should be low cost and environmental sound approach. Depending on crop stage and occurrences of a purple blotch of onion disease, further study is needed on times and time of application for increasing the efficiency of compost tea and plant extracts.

Conflicts of interest: The authors state that they have no conflicts of interest.

LITERATURE CITED

1.Galande DR, Simon S. 2019. Effect of intercropping on purple blotch (*Alternaria porri*) of onion (*Allium cepa L.*). *Int. Jr. Curr. Microbial. Appl. Sci.* 8(2): 1105-1111.

2. Teshika JD, Zakariyyah AM, Zaynab T, Zengin G, Rengasamy KR, Pandian SK, Fawzi MM. 2019. Traditional and modern uses of onion bulb (*Allium cepa L.*): A systematic review. *Critical Reviews in Food Science and Nutrition* 59(1): S39-S70.
3. FAO. 2020. Available at: http://www.fao.org/faostat/en/#data/QC. Accessed 30 Jan 2021
4. Kulkarni BS, Patil SM, Ramchandra VA. 2014. Growth trends in the area, production, and export of onion from India-An economic analysis. *Int. Jr.* 5: 159-163.
5. CSA. 2017. Report on area and production of major crops (Private peasant holdings, Maher Season). Addis Ababa, Ethiopia.
6. CSA. 2018. Report on area and production of major crops (Private peasant holdings, Maher Season). Addis Ababa, Ethiopia.
7. Cramer CS. 2000. Breeding and genetics of *Fusarium* basal rot resistance in onion. *Euphytica* 115: 159-166.
8. Wondirad M, Eshetu A, Mohammed Y, Alemu L, Yaynu H, Meki S, Fekede A, Temam H, Adane A. 2009. Review of vegetable diseases research in Ethiopia. *In*: (Eds) Tadesse A, Increasing Crop Production through Improved Plant Protection, Volume II, Plant Protection Society of Ethiopia (PPSE), PPSE and EIAR, Addis Ababa. pp 203-230.
9. Hariprasad K, Palakshappa MG, Dinesh K, Iliger KS. 2021. Efficacy of biocontrol agents under *in vitro* against *Alternaria porri* (Ellis) Cifferi. Causing purple blotch in onion. *Jr. Phyto Pathology* 8: 25.

10. Abdelkhalek A, Salem MZ, Kordy AM, Salem AZ, Behiry SI. 2020. Antiviral, anti-fungal and insecticidal activities of Eucalyptus bark extract: HPLC analysis of polyphenolic compounds. *Microbial Pathogenesis* 147: 104383.
11. Ghasemi G, Alirezalu A, Ghosta Y, Jarrahi A, Safavi SA, Abbas-Mohammad M, Barba FJ, Munekata PE, Dominguez R, Lorenzo JM. 2020. Composition, antifungal, phytotoxic, and insecticidal activities of thymus kotschyanus essential oil. *Molecules* 25(5): 1152.
12. Singh SR, Prajapati RK, SSL Srivastava SSL, Pandey PK, Gupta RK. 2007. Evaluation of different botanicals and non-target pesticides against *Sclerotium rolfsii* causing collar rot of lentil. *Indian Phyto Pathology* 60: 499-501.
13. Mishra RK, Jaiswal RK, Kumar D, Saabale PR, Singh A. 2014. Management of major diseases insect pests of onion and garlic: A comprehensive review. *Journal of Plant Breeding and Crop Science* 6(11): 160-170.
14. Diver S. 2001. Notes on compost teas: A 2001 supplement to the ATTRA publication compost teas for plant disease control. ATTRA Publication, Fayetteville, Arkansas.
15. Abbasi PA, Al-Dahmani J, Sahin F, Hoitink, HAJ, Miller SA. 2002. Effect of compost amendments on disease severity and yield of onion in organic and conventional production systems. *Plant Disease* 86: 156-161.
16. Welke SE. 2005. The effect of compost extract on the yield of strawberries and the severity of *Botrytis cinerea*. *Journal of Sustainable Agriculture* 25: 57-68.
17. Haggag WM, Saber MSM. 2007. Suppression of early blight on tomato and a purple blight on onion by foliar sprays of aerated and non-aerated compost teas. *Journal of Food, Agriculture, and Environment* 5: 302-309.
18. Martin CS. 2014. Potential of compost tea for suppressing plant diseases. *CAB Reviews* 9(32): 1-38.
19. Milinković M, Lalević B, Jovičić-Petrović J, Golubović-Ćurguz V, Kljujev I, Raičević V. 2019. Biopotential of compost and compost products derived from a horticultural waste effect on plant growth and plant pathogens' suppression. *Process Safety and Environmental Protection* 121: 299-306.
20. González-Hernández AI, Suarez-Fernández MB, Pérez-Sánchez R, Gómez-Sánchez MÁ, Morales-Corts MR. 2021. Compost tea induces growth and resistance against rhizoctonia solani and phytophthora capsicum in pepper. *Agronomy* 11(4): 781.
21. Bachkar SACPB, Bhalckar MN. 2018. Control of *Alternaria porri* causing purple blotch of onion during kharif season. *Jr. Allium Research* 1: 57-59.
22. Toke Kutaye District Agriculture and Natural Resource Office (TKDANO). 2020. Elevation and geographical location of district data, Annual Report.
23. Chethana BS, Ganeshan G, Rao AS, Bellishree K. 2018. Morphological and molecular characterization of *Alternaria* isolates causing purple blotch disease of onion. *International Journal of Current Microbiology and Applied Sciences* 7: 3478-3493.
24. Al-Dahmani JH, Abbasi PA, Miller SA, Hoitink HAJ. 2003. Suppression of bacterial spot of onion with foliar sprays of compost extracts under greenhouse and field conditions. *Plant Diseases* 87: 913-919.
25. Koné SB, Dionne A, Tweddell RJ, Antoun H, Avis TJ. 2010. Suppressive effect of non-aerated compost teas on foliar fungal pathogens of tomato. *Biological Control* 52(2): 167-173.
26. Weltzien HC. 1991. Biocontrol of foliar fungal diseases with compost extracts. *In*: (Eds) Andrews J.H & Hirano S.S. Microbial Ecology of Leaves. Brock/Springer Series in Contemporary Bioscience. Springer, New York NY. pp 499.
27. AL-Mughrabi KI, Berthélémé C, Livingston T, Burgoyne A, Poirier R, Vikram A. 2008. Aerobic compost tea, compost, and a combination of both reduce the severity of common scab (*S. scabiei*) on potato tubers. *Jr. Plant Pathology* 23: 45-56.
28. Nene YL, Thapliyal PN. 1993. Evaluation of fungicides. *In*: Fungicides in plant disease control (3rd Eds). Oxford, IBH Public, New Delhi (India).
29. Vincent JM. 1947. Distortion of fungal hyphae in the presence of certain inhibitors. *Nature* 159: 850.
30. Verma A, Kumar S, Harshita AS, Jaiswal S. 2018. Control agents and botanicals against the early blight of tomato caused by *Alternaria solani. Journal of Sustainable Agriculture* 36: 258-265.
31. Dennis C, Webster J. 1971. Antagonistic properties of species of group *Trichoderma* production and non-volatile antibiotics. *Transactions of British Mycological Society* 57: 25-39.
32. Hussain WA, Elzaawely AA, El Sheery1 NI, Ismail AA, ElZahaby HM. 2017. Biological control of onion white rot disease caused by *Sclerotium cepivorum*. *Environment, Biodiversity and Soil Security* 1: 101-107.
33. Otadoh JA, Okoth SA, Ochanda J, Kahindi JP. 2011. Assessment of *Trichoderma* isolates for virulence efficacy on *Fusarium oxysporum* F. sp. *phaseolina*. *Tropical and Subtropical Agroecosystems* 13: 99-107.
34. Olani N, Fikre M. 2010. Onion seed production techniques. A manual for extensions agents and seed producers. FAO- Crop Diversification and Marketing Development Project. FAO, Rome, Italy.
35. Sharma S. 1986. Effect of fungicidal sprays on purple blotch and bulb yield of onion. *Indian Phyto Pathology* 39: 78-82.
36. Shiberu T, Negeri M, Selvaraj T. 2013. Evaluation of some botanicals and entomopathogenic fungi for the control of onion thrips (*Thrips tabaci* L.) in West Showa, Ethiopia. *Jr. Plant Pathol. Microb.* 4: 161. doi:10.4172/2157-7471.1000161
37. Parenu N, Pragya A, Puja T. 2020. Management of purple blotch complex of onion (*Allium cepa CV Red creole*) under field condition in Rukum-West, Nepal. *Malaysia Journal of Sustainable Agriculture* 2(4): 71-74.
38. Ingham ER. 2005. *The Compost Tea Brewing Manual: Latest Methods and Research*. Soil Food Web Inc., Corvallis, OR.
39. Wheeler BEJ. 1969. *An Introduction to Plant Diseases*. John Willey and Sons Ltd. London. pp 301.
40. Mayee CD, Datar VV. 1986. *Phytopathometry*. Tech. Bull-1 Marathwada Agriculture University, Parbhani (M.S.) India.
41. Shakyawar RC, Debashish Sen, Krishna ST, Pathak M. 2014. Eco-friendly approaches for managing leaf blight of taro (*Colocasia esculenta var*. Anti-quorum). *International Journal of Bio-resource Science* 1(1): 31-35.
42. Islam Z. 2013. Seed yield loss assessment for purple blotch complex of onion. *Doctoral Dissertation, Ph. D. Thesis,* Department of Plant Pathology Fac. of Agric. Sher-E-Bangla Agric. University, Dhaka.
43. Campbell Madden LV. 1990. *Introduction to Plant Disease Epidemiology*. Wiley Inter Science, New York.
44. Robert K, Janes N. 1991. *Seed Pathology* (Revised Eds.). Edition Vol. II. The Mac Millan Press Ltd.
45. Lung'aho C, Nyongesa M, Wakahiu M. 2003. Evaluation of globe (6% cymoxanil/ 70% mancozeb) for potato late blight management. At http://www.kari.org/fileadmin/publications/10thproceedings/Volone/EvaluationGlobe.pdf/ 05-10-2018

46. Mekdes A.2012. Influence of intra-row spacing on plant growth, yield, and quality of onion (*Allium cepa* L.) varieties at Dawro, South-western Ethiopia. *M Sc. Thesis*, School of Graduate Studies, Jimma University College of Agriculture and Veterinary Medicine.
47. CIMMYT. 1988. From agronomic data for farmer recommendations: An economics training manual (completely) Mexico. D.F.
48. SAS. 2014. Statistically application of software micro soft E Window R version 9.3 SAS Institute Inc. Cory, North Caromlina. pp 22-25.
49. Shahanaz E, Razdan VK, Raina PK. 2007. Survival, dispersal, and management of foliar blight pathogen of onion. *Jr. Mycol. Pl. Pathology* 37(2): 100-115.
50. Mohsin SM, Islam R, Abu, NF, Hosna AC, Mirza H. 2016. Cultural, morphological and pathogenic characterization of *Alternaria porri* causing purple blotch of onion. *Not. Bot. Horti. Agrobo.* 44(1): 222-227.
51. Priyanka J, Mali BL. 2017. Effective management of purple blotch of onion caused by *Alternaria porri* (Ellis) through host resistance, fungicides and botanicals. *Int. Jr. Curr. Microbiol. App. Sci.* 6(5): 1737-1745.
52. Hibar K, Daami-Remadi M, Jahnoun-Khiareddine H, Znaidi IE, El-Mahjoub M. 2006. Effect of compost tea on mycelial growth and disease severity of *Fusarium oxysporum* f. sp, radices-lycopersici.*Biotechnology, Agronomy, Society and Environment* 10: 101-108.
53. Jhala P, Meena MK, Mali BL. 2017. Impact of abiotic factors and age of host plant on purple blotch of onion caused by *Alternaria porri* (Ellis) and estimation of yield losses. *Journal of Plant Development Sciences* 9(5): 447-451.
54. Ekabote SD. 2020. Bio-efficacy and phytotoxicity of tebuconazole 430 SC on onion purple blotch under field condition. *Chem. Sci. Rev. Letters* 9(35): 646-650.
55. Nisar U, Naseer A, Shahid M, Muhammad N, Ali N. 2020. *In vitro* evaluation of fungicides and plant extracts to control purple blotch disease of onion in *Pakistan. Plant Pathology Journal* 19(2): 77-88.
56. Suheri H, Price TV. 2001. The epidemiology of purple leaf blotch on leeks in Victoria, Australia. *European Journal of Plant Pathology* 107: 503-510.
57. Agale RC, Kadam JJ, Joshi MS, Borkar PG. 2014. Symptomatology of purple blotch disease of onion and exploration of fungicides, phyto extract and bio-agents against causal fungus *Alternaria porri. Species* 11: 63-69.
58. Aujila IS, Amrate PK, Kumar P, Thind TS. 2013. Efficacy of some new fungicides in controlling purple blotch of onion under Punjab conditions. *Pl. Dis. Research* 28: 171-73.
59. Yadav RK, Singh A, Jain S, Dhatt AS. 2017. Management of purple blotch complex of onion in Indian Punjab. *International Journal of Applied Sciences and Biotechnology* 5(4): 454-465.
60. Saha AK, Hossain I, Monsur MA, Quais MK, Akter M. 2009. Effect of amistar and garlic extract in controlling purple blotch and storage diseases of onion. *Bangladesh Jr. Plant Pathology* 25(1/2): 67-70.
61. Nabi SU, Malik G, Selvakumari R, Raja, WH, Sharma A, Singh DB, Sheikh1 MA, Rasool R, Shafi M. 2019. Bioactivity of methanolic plant extracts under *in vitro* conditions on inhibition of *Stemphylium vesicarium*, an incitant of Stemphylium blight in onion. *Journal of Applied Horticulture* 21(3): 209-212.
62. Rao AS, Ganeshan G, Ramachandra YL, Chethana BS. 2014. Field evaluation of fungicides against *Alternaria porri (Ellis)* Cif, causing purple blotch of onion (*Allium cepa* L.). *Int. Jr. Agric. Environ. Biotechnology* 8(1): 89.
63. Abdelnaser A. Elzaawely (elzaawelyatagr.tanta.edu.eg) DOI: 10.21608/ jenvbs. 2017. 1547. 1008 © 2017. *National Information and Documentation Center* (NIDOC)
64. Nelson KA, Meinhardt CG. 2011. Foliar Boron and Pyraclostrobin effects on corn yield. *Agron. Jr*. 103: 1352-1358.
65. Akter RI, Sarifun U, Rashid H, Rahman A. 2015. Effect of the treatments in controlling purple blotch complex of onion (*Allium cepa L.). Acad. Jr. Plant Science* 7(2): 14-19.
66. Bhardwaj SK. 2012. Evaluation of plant extracts as antifungal agents against *Fusarium solani* (Mart.) Sacc. *World Jr. Agric. Sci.* 8: 385-388.
67. Amin MM, Fawaz SBM, Shalaby SIM. 2016. Suppression effect of vermicompost tea on onion white rot. *Assiut Journal of Agricultural Sciences* 47(6): 87-99.
68. Edris AE, Shalaby A, Fadel HI. 2003. Effect of organic agriculture practices on the volatile aroma components of some essential oil plants growing in Egypt. II. Sweet marjoram essential oil. *Flavour and Frage. Journal* 18: 345-351.
69. Abdel-Hafez SII, Abo-Elyousr KAM, Ismail RA. 2014. Effectiveness of plant extracts to control purple blotch and *Stemphylium* blight diseases of onion (*Allium cepa* L.) in Assiut. *Egypt Arch Phytopath Plant Prot.* 47: 377-387.
70. Bal S, Maity TK, Sharangi AB, Maji A. 2019. Screening of onion (*Allium cepa L.*) germplasm against purple blotch disease. *Jr. Pharmacogn. Phytochem.* 8(6): 546-548.
71. Younas M, Atiq M, Rajput NA, Abbas W, Bashir MR, Ahmad S, Ullah MS, Bhatti WA, Liaqat N, Ahmad I. 2021. Induction of resistance in onion against purple leaf blotch disease through chemicals. *Asian Jr. Agric. Biol.* 4: 67-76.
72. Bangladesh Bureau of Statistics (BBS). 2003. Year Book of Agricultural Statistics of Bangladesh, 2002-03. Statistics Division, Ministry of Planning, Dhaka.
73. MOA. 2016. Statistical yearbook of Agricultural of Bangladesh. Statistics Division, Ministry of Agriculture, Govt. of the People's Republic of Bangladesh, Dhaka. pp 119.
74. Siddiqui Y, Meon S, Ismail MR, Ali A. 2008. *Trichoderma* fortified compost extracts for the control of choanephora wet rot in okra production. *Crop Protection* 27: 385-390.
75. Awad MA, EI-Shenawy Z, Omran AF, Shatla MN. 2007. Cultural practices to purple blotch disease of onion. *Scientia Horticulture* 9: 237-243.
76. Pant AP, Radovich TJ, Hue NV, Paull RE. 2012. Biochemical properties of compost tea associated with compost quality and effects on pak choi growth. *Scientia Horticulture* 148: 138-146.
77. Mistry J, Mukherjee S. 2015. Vermicompost tea and its role in the control of pest: A Review. *International Journal of Advanced Research in Biological Sciences* 2(3): 111-113.