International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

In vivo and *In vitro* Management of Purple Blotch of Onion by Using Fungicides and Plant Extracts

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Abstract: ***An investigation was carried on the management of purple blotch disease of onion (Alternaria porri) during 2015-2016 at BARI, Joydebpur, Gazipur, Bangladesh to see the effectiveness of fungicides in controlling the disease and evaluate the performance of some plant extracts in controlling purple blotch disease of onion seed crop. In in vivo, the effectiveness of 10 fungicides (Antracol, Folicur, Iindofil M-45, Metaril, Rovral, Score, Sulcox, Sun copperoxy, Unilax and Vonot 306) were screen against the disease. The fungicides were applied at 0.2%, three times at 10 days interval. Of them Rovral appeared the best followed by Score. Folicur, Antracol, Metaril, Sulcox and Indofil M-45. More or less similar trend of the fungicides became evident when they were tested against Alerternaria porri in in vitro. While fungitoxicity of seven plants extracts (Dhatura, Dholkolmi, Garlic, Ginger, Marigold, Neem and Nymbicidine) was tested in field condition. Nymbicidine showed significantly the best performance in reducing the disease incidence and giving higher yield.***

Keywords: *Alternaria porri*, Fungicides, Plant extract, Nimbicidine

1. Introduction

Onion (*Allium cepa* L.) is the most important one and familiar throughout the world and also used as popular vegetable among the spices crops. The major onion growing districts of Bangladesh are: Faridpur, Cumilla, Dhaka, Dinajpur, Jessore, Pabna and Rajshahi. It is an important vegetable in Australia, Belgium, India, Japan, United Kingdom, USA and some other countries. However, bulb onion is still the most popular here. The present production of onion is around 18, 67,000 MT from 4, 59, 000 acres of land [1],which is low compared to other onion growing countries of the world.

A number of diseases are associated with onion crops [2] -[5].Among them the well documented disease is onion purple blotch incited by *Alternaria porri* (Ellis) which is noted as a major disease throughout the world including Bangladesh [4]- [7].In India, purple blotch of onion is a major devastating and widespread disease and causes serious yield reduction [8].The disease is also a threat for seed production of onion [9]-[11].

Damage of foliage and breaking of floral stalks due to purple blotch resulting failure of seed production of onion are common [2].[12]reported that the disease causes 41-44% yield loss in Bangladesh. [13]reported that under favorable environmental conditions complete failure of the crop takes place and there will be no seed setting. In India, the disease causes 20 to 25 per cent loss in seed yield [14].

Literatures from home and abroad indicate that many explored to find out suitable control methods of the disease, viz. resistant variety, date of planting, use of fertilizers, bulb size and chemical control with fungicides [16]-[23].Available literatures indicating quite a largenumber of plant species have been reported to have the antipathogenic activity [24]-[27].

In Bangladesh, no resistant source is available. The varieties grown in the country are highly susceptible to the disease. Role of environmental factors on disease development has not yet been studied systematically. Therefore, quite a little information is available on fungicidal control; and mostly those are on bulb production only [2], [10] but not on seed production. So, the present study was undertaken with the following objectives:

1) To screen the effectiveness of fungicides in controlling the disease and
2) To evaluate the performance of some plant extracts in controlling purple blotch disease of onion seed crop.

2. Materials and Methods

Experimental site: The experiment was conducted at the Plant Pathology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh during 2015-2016 crop season. Three experiments were conducted for fulfilling the objectives. They were 1) Efficacy of some fungicides in controlling purple blotch disease of onion.2)

Bioassay of fungicides and their concentrations in controlling growth of *Alternaria porriin vitro* and 3) Effect of plant extracts in controlling purple blotch disease of onion seed crop.

Preparation of soil: The field soil was sandy loam,was prepared for well tilth using a tractor driven disc plough rotavator and harrow. Then the soil clods were broken by hammer. After ploughing the field was left for 7 days for sun and air drying. Later, fertilizers were mixed with soil. TSP, MP, Urea and decomposed cowdung were applied.

Fertilizer application: Soil was fertilized with Nitrogen (in the form of urea), Phosphorus (in the form of Triple super phosphate-TSP), Potassium (in form of muriate of potash-MP), Calcium (in the form of gypsum), Zinc (in the form of zinc oxide) and Boron (in the form of boric acid) [12]. Cowdung was applied during land preparation. Whole quantity of TSP, Gypsum, Zinc oxide, boric acid one third of Urea, were applied during final land preparation; the rest two third of urea was applied later in two installments (40 and 60 days after planting). Half of muriate of potash was applied at final land preparation and rest half was applied 40 days after planting. Cowdung was incorporated into soil at the rate of 10 tons per hectare during land opening.

Intercultural operation: A total of three times irrigation was done at 30, 60 and 90 days after transplanting by flood method.The dead or sick seedlings were replaced by healthy seedlings within a week after plantation. The damaged plants were also replaced by border plants through gap filling.Weeding and mulching were done as and when required to keep the crop free from weeds, for better soil aeration and conserve soil moisture. Mechanical support was provided in each plot using bamboo stick to keep the plant erect and to protect them from the damage caused by storm and high winds.

Collection of data: Data were recorded on lesion area, disease severity, PDI (Percent disease index), stem height, number of stem per hill, umbel diameter, weight of seeds/umbel, weight of seeds per plot, yield per plot was converted into yield per hectare. Lesion area was expressed in millimeter by measuring length and breadth of the leaves. Disease severity of purple blotch was assessed using 0-5 scale [13], as follows, by selecting 10 plants randomly from each plot and used for PDI (percent disease index) estimation.

0 = no disease symptoms
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/stems from the centre
5 = complete drying of the leaves/stems or breaking of the leaves/stems from the base.

The per cent disease index (PDI) was calculated by using formula given by [28], [29] as follows:

$$PDI = \frac{\text{Total sum of numerical ratings}}{\text{Number of observation x Maximum grading}} \times 100$$

Umbel diameter was taken by randomly selecting 10 umbels from each replication. Weight of seeds/umbel was assessed by recording seed weight of 10 umbels per replication.The crop was harvested within 100 -125 days after transplanting.

Efficacy of some Fungicides in Controlling Purple Blotchof Onion

Seedlings of local cultivars were included under the study. The unit plot size was 2.0 x 2.0m, keeping 20cm and 10cm spacing respectively for row to row and plant to plant.Apparently healthy seedlings were transplanted on 20.12.15.

Treatments (Fungicides): The experiment consisted of 11 treatments including control. The treatments were as follows:

T_1 =	Antracol	T_7 =	Sulcox
T_2 =	Folicur	T_8 =	Sun copperoxy
T_3 =	Indofil M-45	T_9 =	Unilax
T_4 =	Metaril	T_{10} =	Vondozeb
T_5 =	Rovral	T_{11} =	Control
T_6 =	Score		

Application of fungicides: Spray of fungicides was initiated after the disease symptoms detected in the experimental plot. A total of three sprays were performed at an interval of 10 days. The experimentwas scheduled following RCBDhaving three replications.

Bioassay of Fungicides and their Concentrations in ControllingGrowth of *Alternaria porri* in*in vitro*

Collection and Isolation of the fungus

Ideal purple blotch diseased samples of onion was collected from experimental field of BARI, Gazipur and brought in the Plant Pathology Central Laboratory. Diseased samples were processed into small pieces, sterilized with 10% chlorox solution for three minutes, rinsed with sterile water and finally placed on Petri plates (9 cm dia.) containing host extract media. The composition of the host extract Media were onion leaf (200g), dextrose (15g), agar (20g) and water (1000 ml). Onion leaf was cut into small pieces, put in 500 ml water andboiled for 30 minutes. Then supernatant extract was decanted. Within the supernatant other ingredients were added with rest quantity of water to make one litre. The medium was then autoclaved at 121^{o}C at15 PSI for 20 minutes. Aftersterilization the medium (at 40-45^{o}C) was poured at the rate of 20 ml per Petri plates. After solidifying of the media inoculated Petri plates were incubated at 25±1^{o}C for five days. The isolated fungus was identified by using the keys outlined by [30].

Multiplication of *A. porri*: Pure culture of *A. porri* was multiplied on PDA (Potato 200 g, Dextrose 15 g, Agar 20 g, water 1000 ml) Petri plates by hyphal tip method.

Fungicides used: Ten fungicides namely, Antracol, Folicur, Indofil M-45, Metaril, Rovral, Score, Sulcox, Sun Copperoxy, Unilax and Vondozeb were included in the study.

Concentration of Fungicides and its preparation: Fungicides were used in four concentrations. Those were

2000, 1000, 500 and 250 ppm. Requisite quantities of fungicides were mixed in fixed quantity of distilled water to achieve desired concentrations. In case of control, only sterile water was used. Each concentration was replicated thrice.

Bioassay of Fungicides: Poisoned food technique was followed [31]. Potato dextrose agar medium was used and poured at the rate of 15 ml per Petri plate (9 cm). Before pouring of medium one ml of fungicidal solution (for each concentration of fungicides) was added in each Petri plate. After adding medium the plates were shaken in swirling motion for uniform mixing.
After solidifying of the media, the centre of each Petri plate was inoculated with a 3 mm mycelial disc, cut from the edge of 10 days old fresh culture of *A. porri*. The inoculated Petri plates were then incubated at 25 ± 1°C for 10 days.

Collection of data: After incubation the mycelia growth of the fungus from each concentration of the fungicide was recorded.

Design: The experiment was arranged following Completely Randomised Design.

Effect of Plant Extracts in Controlling Purple Blotch Disease ofOnion Seed Crop

Treatments (Plant extracts): There were eight treatment including control. The treatments were as follows:

Treatment	*Common Name*	*Scientific Name*
T_1	Dhatura	*Datura alba*
T_2	Dholkalmi	*Ipomoea fistulosa*
T_3	Garlic	*Allium sativum*
T_4	Ginger	*Gingiberofficinale*
T_5	Marigold	*Tagetespatula*
T_6	Neem	*Azadirachta indica*
T_7	Nymbicidine	*Azadirachta indica*
T_8	Control	-

From T_1 to T_6, the dose of each extract was used at the rate of 15 ml per 1000 ml water. Treatment T_7, Nymbicidine was applied at the rate of 0.2% per 1000 ml water.

Application of Plant Extracts: A total of five sprays were scheduled at 10 days interval, initiating just after the onset of disease symptom in experimental field.

Analysis of data: Data were analysed statistically using MSTAT-C computer Program. Data were transformed, whenever necessary, following Arcsine transformation. Means of treatments were separated using Duncan's Multiple Range Test (DMRT) [32].

3. Results

3.1 Efficacy of Some Fungicides in Controlling Purple Blotch Disease of Onion

There was significant variations among the fungicides in relation to disease parameters of purple blotch disease of onion and the corresponding effects on yield (Table 1 and 2).

The effect of fungicides on plant height ranged from 27.8 – 37.9 cm. The highest plant height was recorded in plants where Rovral was applied and it appeared statistically similar to those of Antracol, Folicur, Indofil M-45, Metaril, Score, Sulcox and Sun Copperoxy. Significantly the lowest plant height was recorded under the control treatment, where only plain water was sprayed; but it showed statistically insignificant compared with the fungicides like Sun Copperoxy, Unilax and Vondozeb.

In case of leaf number per seedling existence of difference among the treatments became evident. It ranged from 3.9 – 6.4. The effect of fungicides like Antracol, Folicur, Rovral and score on producing leaf number per seedling were insignificant. The minimum of 3.9 leaves per seedling was recorded under control and it gave statistically similar response after treatments with lndofil M-45, Sun Copperoxy, Unilax and Vondozeb. The maximum (31.9 mm^2) and the minimum (14.33 mm^2) lesion area were assessed respectively under control and Rovral. Among the tested fungicides, Rovralappeared the best in minimizing lesion area of purple blotch; followed by Score (15.93 mm^2), Folicur (17.13 mm^2),Antracol (19.20 mm^2), Metaril (19.20 mm^2), Sulcox (20.4mm^2), Indofil M-45 (21.56 mm^2), Sun Copperoxy (22.1 mm^2), Unilax (23.06 mm^2) and Vondozeb (29.63 mm^2). The fungitoxicities of Antracol, Folicur, Indofil M-45, Metaril, Rovral, Score, Sulcox and Sun Copperoxy in reducing lesion area of *A. porri*, were statistically similar. These fungicides, however, varied significantly withUnilax, Vondozeb and control. The effect of Unilax was statistically similar to that of Vondozeb but it (Unilax) differed significantly with the control.

The effectiveness of the fungicides in reducing PDI of purple blotch can be arranged in ascending order as: Rovral(32.0%), Score (36.0%), Folicur (40.66%), Antracol (42.0%), Metaril (45.33%), Sulcox (50.66%), Indofil M-45 (52.00%), Sun Copperoxy (56.0%), Unilax (57.33%), Vondozeb (58.66%) and Control (72.00%). When statistical analysis was performed it was found that Rovral proved to be the best one in minimizing PDI significantly and it appeared statistically similar to that of Score (Fig. 1), Folicur and Antracol but differed significantly with the rest of the treatments. Among the fungicides Vondozeb appeared as least effective and gave the maximum PDI value of the disease numerically but the values was statistically identical with Unilax, Sun copperoxy, Sulcox and Indofil M-45. Through Indofil M-45 appeared statistically insignificant to Antracol and Folicur but it gave significantly higher PDI compared to Score and Rovral (Fig. 2). Based on the parameter of reduction of PDI over control, it was found that the maximum PDI of purple blotch was reduced by the application of Rovral (55.55%), followed by score (50.0%), Folicur (43.52%), Antracol (41.66%), Metaril (37.04%), Sulcox (29.63%), Indofil M-45 (27.77%), Sun Copperoxy (22.22%), Unilax (20.37%) and Vondozeb (18.52%).

Results obtained from yield contributing parameters indicated the presence of significant differences among the used fungicides. Bulb diameter among the treatments, ranged from 24.17-30.64 mm; where the minimum and the maximum was recorded from control and Rovral, respectively. There was no other significant difference

among the fungicides on this parameter. Significantly lower bulb diameter was measuredfrom control and it was statistically alike with Indofil M-45, Sulcox, Sun Copperoxy, Unilax and Vondozeb.

In respect of bulb weight per plant, the highest bulb weight was assessed from Rovral treated plants (26.63g) which was followed by Score (25.9g), Folicur (24.85g), Antracol (23.65g), Metaril (20.94g), Sulcox (18.86g), Indofil (18.22g), Sun Copperoxy (18.06g), Unilax (18.05g), Vondozeb (15.86g) and control (15.03g). Statistical analysis revealed that significantly higher per plant bulb weight was incurred by Rovral; its differences were insignificant with Score, Folicur, Antracol and Metaril. Metaril again showed statistical similar it's in terms of effect on bulb weight per plant, with Indofil, Sulcox, Sun Copperoxy, Unilax, Vondozeb and the Control. Regarding, bulb weight, the performance of fungicides in order of descending, can be arranged as : Rovral (2.79kg), Score (2.72 kg), Folicur (2.64 kg), Antracol (2.54 kg), Metaril (2.47 kg), Sulcox (2.35 kg), Indofil (2.22 kg), Sun Copperoxy (2.08 kg), Unilax (2.07 kg), Vondozeb (2.04 kg) and Control (1.98 kg). However, significantly lower bulb yield was harvested from control which was statistically at par with Vondozeb, Unilax, Sun Copperoxy, Sulcox and Indofil. When bulb yield was converted to determine the percent yield increased over control, due to application of fungicides it appeared that 28.28, 33.33, 12.12, 24.72, 40.90, 37.37, 18.68, 5.05, 4.54 and 3.03% more yields were obtained respectively (Fig. 2), by using Antracol, Folicur, Indofil, Metaril, Rovral, Score, Sulcox, Sun Copperoxy, Unilax and Vondozeb.

Table 1: Effect of different fungicides in controlling purple blotch diseaseof onion

Treatment	*No. of leaf/ seedling*	*Plant height (cm)*	*Lesion area (sq.mm)*	*%PDI*
T_1 = Antracol	5.5 abc	35.9 a	19.20 cd	42.00 def (6.47)
T_2 = Folicur	5.8 ab	36.7 a	17.13 cd	40.66 def (6.67)
T_3=Indofil M-45	4.5 cd	33.5 abc	21.56 cd	52.00 bcd (7.20)
T_4 = Metaril	5.3 bc	35.1 a	19.40 cd	45.33 cde (6.72)
T_5 = Rovral	6.4 a	37.9 a	14.33 d	32.00 f (5.65)
T_6 = Score	6.1 ab	36.8 a	15.93 cd	36.00 ef (5.99)
T_7 = Sulcox	5.2 bc	34.5 ab	20.40 cd	50.66 bcd (7.09)
T_8 = Sun Copperoxy	4.5 cd	33.2 abc	22.10 cd	56.00 bc (7.46)
T_9 = Unilax	4.1 d	29.3 bc	23.06 bc	57.33 b (7.56)
T_{10} = Vondozeb	4.1 d	28.0 c	29.63 ab	58.66 b (7.62)
T_{11}= Control	3.9 d	27.8 c	31.90 a	72.00 a (8.47)

— Means bearing same letter within the same column do not differ significantly at 5% level following DMRT.
— Figures in parenthesis indicate transformed value.

Table 2: Effect of different fungicides on yield contributing characters of purple blotch of onion

Treatment	*Diameter (mm)/bulb*	*Weight (gm)/bulb*	*Bulb weight (kg)/plot*
T_1 = Antracol	29.84 a	23.65 a	2.54 ab
T_2 = Folicur	30.40 a	24.85 a	2.64 ab
T_3 = Indofil M-45	28.50 ab	18.22 b	2.22 bcd
T_4 = Metaril	29.5 a	20.94 ab	2.47 abc
T_5 = Rovral	30.64 a	26.63 a	2.79 a
T_6 = Score	30.45 a	25.90 a	2.72 a
T_7 = Sulcox	28.73 ab	18.86 b	2.35a bcd
T_8 = Sun Copperoxy	28.05 ab	18.06 b	2.08 cd
T_9 = Unilax	26.89 ab	18.05 b	2.07 cd
T_{10} = Vondozeb	25.70 ab	15.86 b	2.04 cd
T_{11} = Control	24.17 b	15.03 b	1.98 d

-Means bearing same letter within the same column do not differ significantly at 5% level following DMRT

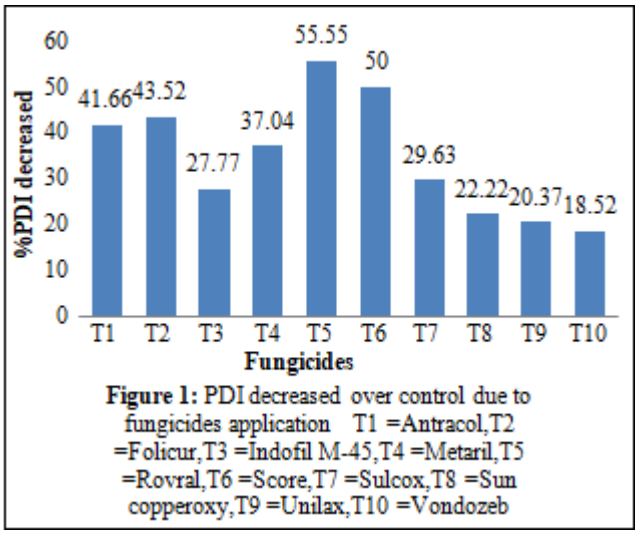

Figure 1: PDI decreased over control due to fungicides application T1 =Antracol,T2 =Folicur,T3 =Indofil M-45,T4 =Metaril,T5 =Rovral,T6 =Score,T7 =Sulcox,T8 =Sun copperoxy,T9 =Unilax,T10 =Vondozeb

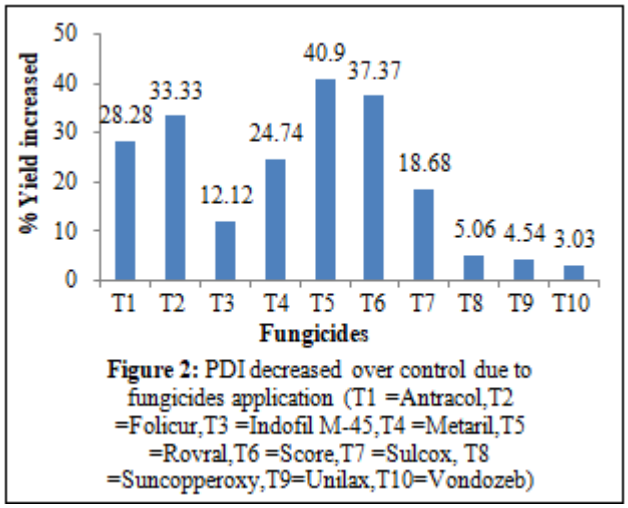

Figure 2: PDI decreased over control due to fungicides application (T1 =Antracol,T2 =Folicur,T3 =Indofil M-45,T4 =Metaril,T5 =Rovral,T6 =Score,T7 =Sulcox, T8 =Suncopperoxy,T9=Unilax,T10=Vondozeb)

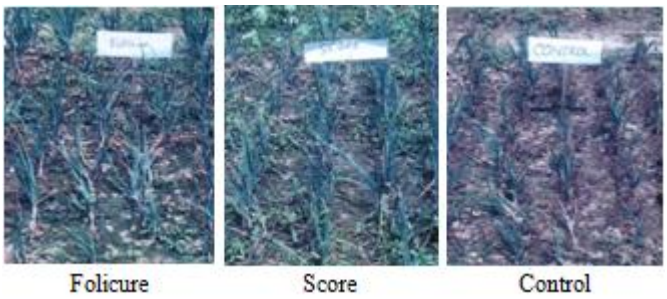

Plate 1: Effectiveness of fungicides in controlling purple blotch of onion

3.2 Bioassay of fungicides and their concentrations in controllinggrowth of *Alternaria porri* in *vitro*

Results on the effectiveness of fungicides and their concentrations on mycelial growth of *A. porri* are presented in Table 3. Irrespective of concentrations, Rovral and Score appeared the best in controlling growth of *A. porri* and they showed statistically similar effect. The fungicide Folicur

was highly effective at higher concentrations (2000 and 1000 ppm) and showed statistically similar with Rovral and Score even at their lowest concentration (250 ppm). Folicur at 500 and 250 ppm has shown statistically insignificant effect on mycelial growth of the fungus. The fungicides; Antracol, Sulcox and Metaril exhibited statistically similar effect with their highest concentration (2000 ppm) against *A. porri* and they showed statistically insignificant with Folicur at 500 ppm. Vondozeb failed to prove its effectiveness in restricting the growth of the fungus even at its highest concentration. More or less similar trend of in effectivness of Unilax became evident during performing of the study. Sun Copperoxy and Indofil M-45 was less effective against *A. porri* to check the growth even at the highest concentration. The maximum mycelia growth of the fungus was recorded in control (9.0 cm) where plain sterile water was added and the growth was statistically similar to those of Sulcox (500 and 250 ppm), Sun Copperoxy (500 and 250 ppm), Metaril (250 ppm),Vondozeb (2000, 1000, 500 and 250 ppm) and Unilax (500 and 250 ppm).

Table 3: Efficacy of some fungicides and their concentrations on mycelial growth of *Alternaria porri* in *In vitro*

Fungicide	*Mycelial growth (cm)*			
	2000 ppm	*1000 ppm*	*500 ppm*	*250 ppm*
T_1 = Antracol	2.967 j	3.233 ij	5.883 fgh	6.987 b-f
T_2 = Folicur	1.167 k	1.617 k	3.083 ij	4.517 hi
T_3 = Indofil M-45	5.317 gh	6.283 d-g	6.283 d-g	7.133 b-f
T_4 = Metaril	3.450 ij	5.350 gh	7.100 b-f	7.750 a-d
T_5 = Rovral	0.650 k	1.000 k	1.283 k	1.333 k
T_6 = Score	0.766 k	1.050 k	1.277 k	1.503 k
T_7 = Sulcox	3.483 ij	7.050 b-f	8.000 abc	8.367 ab
T_8=Sun Copperoxy	6.017 efg	6.550 c-g	7.717 a-d	8.067 abc
T_9 = Unilax	6.850 b-f	6.400 d-g	7.467 a-e	8.750 a
T_{10} = Vondozeb	7.817 a-d	8.067 abc	8.210 a-b	8.967 a
T_{11} = Control	9.000 a	9.000 a	9.000 a	9.000 a

-Means bearing same letter within the same column do not differ significantly at 5% level following DMRT.

3.3 Effect of Plant Extracts in Controlling Purple Blotch Disease of Onion Seed Crop

Significant differences among the effects of plant extracts became evident in controlling purple blotch of onion as well as in the seed contributing characters (Tables 4 and 5). The maximum stem height was recorded in the crops where Dhatura (T_1) extract (62.09 cm) was applied followed by T_6 (Neem), T_7 (Nymbicidine), T_4 (Ginger), T_3 (Garlic), T_8 (Control), T_5 (Marigold) and T_2 (Dholkalmi). Statistical analysis revealed that significantly higher stem height was measured under the treatment T_1 and this was statistically similar to T_6 and Nymbicidine (T_7) but differed significantly with the rest of the treatments (Table 4). The treatment T_2 gave the lowest stem height and the differences were statistically insignificant with T_3, T_5 and T_8. In case of stem number per hill, it ranged from 1.86-2.47, where the minimum and the maximum number of stem per hill were recorded in T_8 and T_1, respectively. The effect of treatments on producing number of stem per hill under the treatments T_1, T_2, T_4, T_5, T_6 and T_7 were insignificant. Significantly fewer numberof stem per hill was recorded in T_8 which was statistically similar to those of T_2 and T_3.

The differences on the effects of plant extracts on the lesion-area were also pronounced under the study and it ranged from 18.40-25.90mm^2. In order of affectivity of plant extracts in reducing the lesion area of purple blotch, the treatments can be arranged as: T_7 (18.40 mm^2), T_6 (19.13 mm^2), T_3 (19.20 mm^2), T_1 (20.40 mm^2), T_2 (20.60 mm^2), T_4 (21.33 mm^2), T_8 (25.10 mm$_2$) and T_5 (25.90 mm^2). Significantly better response in minimizing the purple blotch lesion area was measured under the treatment T_7 which differed significantly with all the rest of the treatments. The effect of treatments noted at T_1, T_2, T_3, T_4 and T_6 showed statistically similar in reducing lesion area and they showed significantly lower lesion area compared to those of T_5 and T_8. Regarding PDI value, the minimum PDI was computed at T_7 (37.66%). The treatment, T_1; ranked next to T_7 followed by T_6 (43.66%); T_2 (45.66%), T_4 (52.00%), T_3 (64.00); T_5 (64.00%) and T_8 (86.33%). Statistical analysis revealed that, among the plant extracts, Nymbicidine (T_7) was the best, which significantly reduced the PDI of purple blotch compared to the others ones except T_1. The differences between the reductions of PDI under the treatments T_1 and T_6 was insignificant and the treatments gave significantly lower PDI compared to T_2, T_3, T_4, T_5 and T_8(Fig. 3). The treatments T_2, T_4 and T_6 showed statistically similar performance on reduction of PDI. Treatment T_8 has shown significantly higher PDI and it differed significantly with the rest of the treatments. The maximum PDI reduced over control was shown by T_7 (56.37%) followed by T_6 (51.20%), T_1 (49.84%), T_2 (47.10%), T_4 (39.76%) and T_3 and T_5 (30.49%).

The treatments showed a wide variation on yield contributing parameters both numerically and statistically. The influence of treatments (Plant extracts) on umbel diameters ranged from 46.23- 53.83 mm. The maximum umbel diameter was recorded in T_7 followed by T_6 (52.46 mm), T_1 (51.69 mm), T_4 (50.55 mm), T_5 (49.67mm), T_3 (48.67 mm), T_2 (48.43 mm) and T_8 (46.23 mm). The umbel diameter recorded by T_7 differed significantly with those of other treatments (Table5). However, there was no significant variation between the treatments, T_1 and T_6 on umbel diameter; so were T_4 and T_5. Significantly lowerumbel diameter was recorded in T_8 and it differed significantly with the rest of the treatments.

In case of weight of seed per umbel, significantly higher amount of seed was harvested from the umbels of T_6 treated plots but statistically it showed similar effects with all the rest of the treatments except T_8, where no plant extract was sprayed. Though significantly lower seed weight per umbel was assessed in T_8, it was statistically similar to those of T_2, T_3, T_4, T_5 and T_7.

The yield per plot ranged from 55.00-135.00g with the minimum and the maximum given by T_8 and T_7, respectively. The treatment T_6 gave the second highest per plot seed yield (109.30 g) followed by T_1 (92.67g), T_5 (82.67g), T_4 (72.00g), T_3 (66.00g) and T_2 (65.00g) (Table 5). Statistical analysis indicated that significantly higher seed yield was harvested under the treatment T_7 and it differed significantly with all other treatments. The treatment T_6 gave significantly lower seed yield than T_7, but gave significantly higher per plot seed yield over T_1, T_2, T_3, T_4, T_5 and T_8. The effect of T_1 and T_5 on per plot seed yield was insignificant.

Again, the effect of T_2, T_3 and T_4 on same parameters was insignificant among themselves. About 68.49, 18.18, 20.00, 30.90, 50.30, 98.72 and 145.45% yield increased over control was estimated respectively, by those of T_1, T_2, T_3, T_4, T_5, T_6 and T_7 treatments (Fig.4).

Table 4: Fungi toxicity of some plant extracts in controlling purpleblotch of onion seed crop

Treatment	*Stem ht. (cm)*	*Stem/hill*	*Lesion area (mm^2)*	*%PDI*
T_1= Dhatura	62.09 a	2.47 a	20.40 b	43.30 de (6.58)
T_2 = Dholkalmi	57.74 d	2.17 abc	20.60 b	45.66 c (6.75)
T_3 = Garlic	59.42 bcd	1.93 bc	19.20 b	64.00 b (8.00)
T_4 = Ginger	59.87 bc	2.23 ab	21.33 b	52.00 c (7.21)
T_5 = Marigold	58.13 cd	2.20 ab	25.90 a	64.00 b (8.00)
T_6 = Neem	61.22 ab	2.40 a	19.13 b	43.66 cd (6.60)
T_7= Nymbicidine	61.19 ab	2.43 a	18.40 c	37.66 e (6.13)
T_8 = Control	58.48 cd	1.86 c	25.10 a	86.33 a (9.29)

-Means bearing same letter within the same column do not differ significantly at 5% level following DMRT.
- Figures in parenthesis indicate transformed value.

Table 5: Effect of different plant extracts on yield contributing charactersof purple blotch of onion

Treatment	*Umbel diameter (mm)*	*Weight of seed (g)/umbel*	*Seed yield(g)/ plot*
T_1= Dhatura	51.69 b	0.960 a	92.67 c
T_2 = Dholkalmi	48.43 d	0.840 ab	65.00 ef
T_3 = Garlic	48.67 d	0.723 ab	66.00 ef
T_4 = Ginger	50.55 c	0.766 ab	72.00 de
T_5 = Marigold	49.67 c	0.726 ab	82.67 cd
T_6 = Neem	52.46 b	1.067 a	109.30 b
T_7= Nymbicidine	53.83 a	0.853 ab	135.00 a
T_8 = Control	46.23 e	0.473 b	55.00 f

-Means bearing same letter within the same column do not differ significantly at 5% level following DMRT

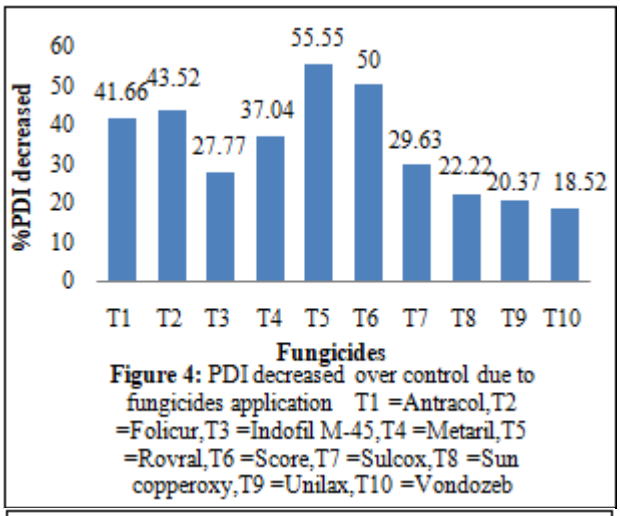

Figure 4: PDI decreased over control due to fungicides application T1 =Antracol,T2 =Folicur,T3 =Indofil M-45,T4 =Metaril,T5 =Rovral,T6 =Score,T7 =Sulcox,T8 =Sun copperoxy,T9 =Unilax,T10 =Vondozeb

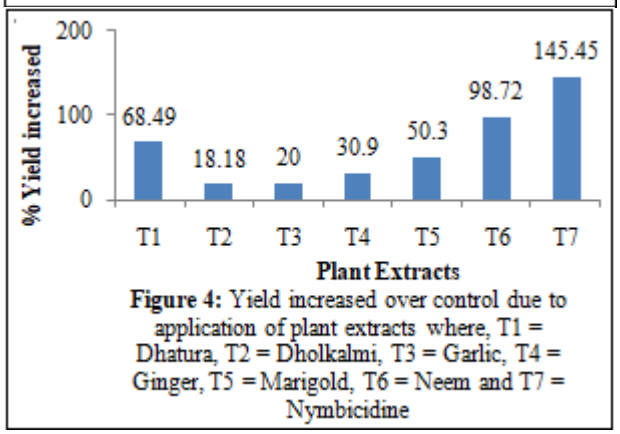

Figure 4: Yield increased over control due to application of plant extracts where, T1 = Dhatura, T2 = Dholkalmi, T3 = Garlic, T4 = Ginger, T5 = Marigold, T6 = Neem and T7 = Nymbicidine

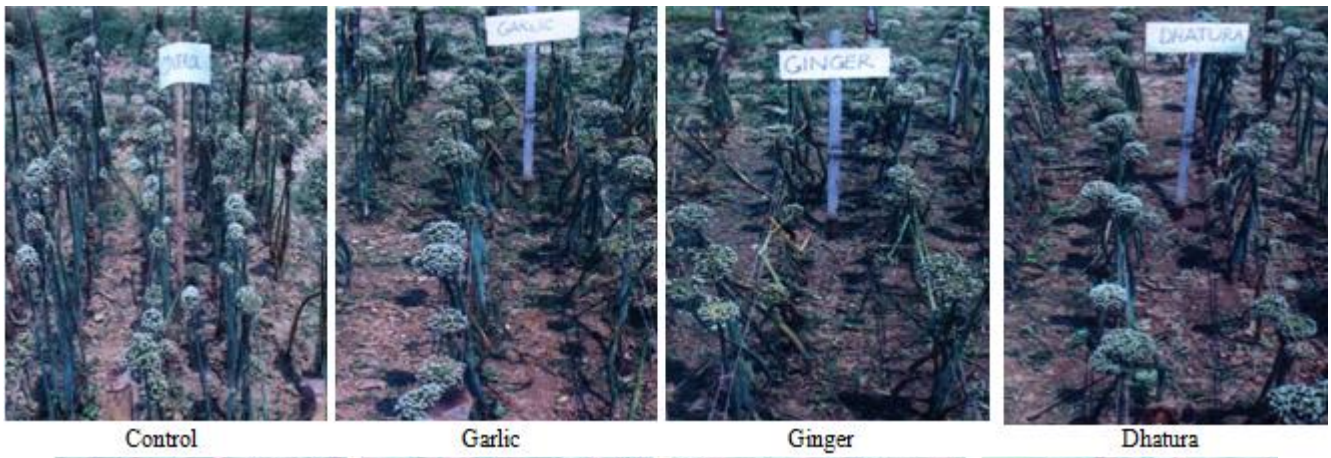

Plate 2: Fungitoxicity of some plant extracts in minimizing purple blotch disease of onion

4. Discussions

Under the study 10 fungicides viz. Antracol, Folicur, Indofil M-45, Metaril, Rovral, Score, Sulcox, Sun copperoxy, Unilax and Vondozeb were evaluated both *in vitro* and *in vivo* to evaluate their affectivity in controlling purple blotch of onion caused by *Alternaria porri* and their influence on yield. Results indicate that there was significant variation among the fungicides in their efficacy. All the fungicides were not equally effective. Of the fungicides tested, Rovral scored the best in performance followed by score, Folicur and Antracol*in vitro*. Metaril was only effective at 2000 ppm to inhibit the growth of *A. porri*. The fungicides performed statistically similarly almost in all parameters. But in *in-vitro* assay, Antracol and Folicur were found equally significantly effective, irrespective of concentrations. They showed to be statistically similar at only twohigher concentrations (2000 and 1000 ppm) of Rovral. Score appeared less effective compared to Antracol and Folicur, irrespective of concentrations, *in vitro*. Metaril was only effective at 2000 ppm to inhibit the growth of *A. porri.* The fungicides Indofil M-45, Sulcox, Sun Copperoxyand Unilax were more or less effective against purple blotch. The present finding on effectiveness of Rovral against *Alternaria* spp. has been corroborated with by many other researchers [9], [10] and [33]-[44].According to [45] more than 75% disease reduction was obtained using Rovral. [46]opined that iprodione (Rovral) performed excellent in reducing disease intensity of purple blotch and gave highest yield. The effectiveness of Folicur, Metaril, Antracol against purple blotch have also been suggested by [22], [23], [40], [43] and [47]-[53].Under the study Indofil M-45 (mancozeb) was found not so effective to control *A. porri* incidence compared to Rovral, Score, Folicur and Metaril. On the contrary good control of *A. porri* by Dithane M-45 (Mancozeb) have also been reported by many workers under both *in vitro* and *in vivo*[2], [8]-[11], [20], [23], [25], [39], [50] and [54]-[60]. [9], [13], [58] and [61]stated that Dithane M-45 was the best among the fungicides to reduce the purple blotch disease incidence and maximizing bulb yields. [62]reported that mancozeb reduced the purple blotch of onion by 23.6% and increased the yield by 35.0%. The potentiality of copper fungicides against *A. porri* has been documented by many researchers [10], [22], [23], [43], [50], [59]-[61] and [63]-[65]which differed with the present investigation where coper fungicides like sun Copperoxy and Sulcox appeared to be less effective to *A. porri*. According to [8], however, copperoxycloride was the best to reduce purple blotch and to maximize the highest bulb yield; which the results of this information fail to support. It may indicate the need to investigate wheather*A. porri* has developed resistance against copper based fungicides, in the meantime.

Results on evaluation of fungi toxicity of plant extracts to control purple blotch of onion indicate that all of them have some potentiality against the disease but it varied widely among the extracts of plant origin. Of them Nymbicidine, Neem leaf extracts and Datura performed better compared to rest of the plant extracts. Dholkolmi plant extract shows less effectiveness against purple blotch (*A. porri*); among the plant extracts. The fungitoxic potential of Neem and Datura have been supported by [26], [27] and [66]-[69]. The extracts of garlic, ginger and onion also showed some degree of potential to restrict the infestation of purple blotch. This was in line with the findings of [24]-[26], [67], [68] and [70]-[72] who tested these extracts against a good number of both seed and soil-borne fungi.

5. Conclusions

In a field study fungitoxicity of 10 fungicides were tested to locate effective one(s) to combat purple blotch (*A. porri*) disease of onion using seedlings of local cultivars, transplanted in unit plot of 2.0 x 1.2 m. The fungicides employed were: Antracol, Folicur, Indofil M-45, Metaril, Rovral, Score, Sulcox, Sun Copperoxy, Unilax and Vondozeb. All the fungicides were used at the rate of 0.2%. A total of three sprays were executed at 10 days interval. It appeared that there were significant variations in effectiveness among the tested fungicides against *A. porri*. Among them Rovral gave best control of the disease (lesion area and PDI) followed by score, Folicur, Antracol, Metaril,Sulcox, Indofil M-45, Sun Copperoxy, Unilax and Vondozeb. More or less similar trend were shown by fungicides in yield contributing characters.

The effectiveness of the fungicides tested *in vivo* was also evaluated *in vitro* to evaluate their performance against *A. porri* using poison food technique. The fungicides were tested at four concentrations viz. 250, 500, 1000 and 2000 ppm. Irrespective of concentrations Rovral and Score appeared the best one in inhibiting the growth of *A. porri* followed by Folicur. Among the fungicides Vondozeb and Unilax were proved ineffective to restrict the growth of *A. porri.*

The antifungal effect of six plant extracts (Datura, Dholkalmi, Garlic, Ginger, Marigold and Neem) and one commercial plant product, namely Nymbicidine (ACI crop care division) was evaluated under field condition. Under the study, bulbs of one of local cultivar was planted in unit plot size of 3.0 x 1.2 m. Nymbicidene was applied at the rate of 2 ml/litre of water while 15 ml/litre of water each plant extract was applied to best their efficiency. Each treatment was replicated thrice. As the crop was seed crop, plant extracts was applied five times at an interval of 10 days. It was found that all the plant extract had some degree of potentiality in reducing disease contributing characters. Of them Nymbicidine T_7 performed best in minimizing the purple blotch and it differed significantly from rest of the plant extracts. This was followed by T_1 (Datura), T_6 (Neem), T_2 (Dholkolim), T_4 (Ginger), T_3 (Garlic) and T_5 (marigold). Nymbicidine also gave the highest seed yield.

Based on the findings of the present investigation the following conclusions may be made.

i) Fungicides like Rovral, Score, Folicur, Metaril are highly effective to check purple blotch disease of onion
ii) Nymbicidine, Datura, Neem and Dholkolmi are potential plant extracts against *Alternaria porri*.

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