

Maximum Congenial Period for Outbreak of Die-Back and Scab Diseases in Citrus and Their Management under Sub-Tropical Region

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ABSTRACT

The popularity of lemon (*Citrus limon* L.) is a popular fruit in throughout the world is increasing especially for the major source of vitamins C and minerals. However, the production of citrus across globe is severely affected due to the infection of scab and dieback diseases. Since these two diseases are considered as major diseases of citrus. The present study was therefore carried out to find out the maximum congenial periods of two diseases such as scab and dieback and their adverse effect of citrus production. The study also highlights the mitigation strategies of the diseases scab and dieback for sustainability of citrus production in sub-tropical countries. To find out the effective management of these diseases, mustard oil cake, urea, triple super phosphate (TSP), murate of potash (MOP), cowdung, 'Bavistin' (fungicide), irrigation, and pruning alone or combined on citrus die-back and scab disease. After observation, the present study noticed that the sub-tropical countries like Bangladesh, generally heavy rainfall is occurred in the monsoon (April to July) with temperature 25–30°C, which is congenial period for the outbreak of die-back and scab disease. Considering on controlling efficiency of all management approaches, die-back and scab infection was found the lowest, when mustard oil cake was applied, followed cow dung, pruning and in combination of mustard oil cake and urea, TSP, MOP, and the combination of mustard oil cake and cowdung. While, fungicide 'Bavistin' could not work well due to use of low quality chemicals available in the market or the disease causal organism have already developed resistance against the chemical used. Therefore, it may be recommended that application of mustard oil cake, urea, TSP, MOP, cowdung, irrigation and fungicide 'Bavistin' in alone or their combination may be suggested for better plant growth with the reduction of die-back and scab of citrus in sub-tropical countries like Bangladesh.

Keywords: Citrus, die-back, scab, disease, mitigation strategies

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INTRODUCTION

Citrus is one of the most important fruit crop as a potential source of vitamin C and minerals, and its demand is increasing day by day in around the globe (Figure 1: Sfgate, 2017). It is cultivating more than 140 countries (Actualilix, 2018), while considering on the percent production, about 53.5% (from 2006 to 2016) of the world's total

citrus production is grown in the Asia, 37.7% was in Africa, while only 8.8% were in Americas, Europe and Oceania (Figure 1: Actualilix, 2018; FAOSTAT, 2018; Statista, 2018). Although citrus is originated in Southeast– Asia, but average production is low as compared to other citrus producing countries in the world, due to high production and marketing costs, and diseases infestation as Southeast– Asia is under sub–tropical environment (FAOSTAT, 2018).

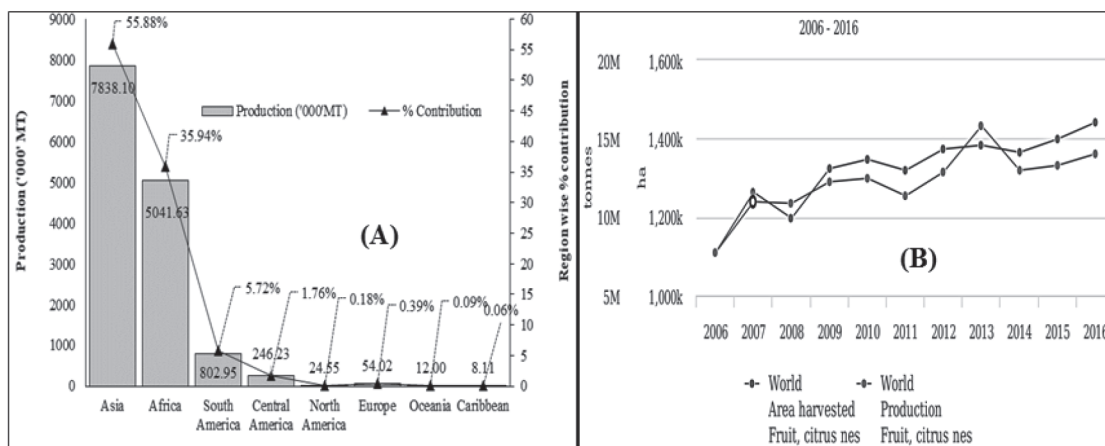


Figure 1 Total production with region wise % contribution of citrus in the year 2016 (A) and change in production in last 10 years (2006 to 2016) the world (A) as well as percent region based average production (B).

Source: FAOSTAT (2018) and Statista (2018)

In Bangladesh, citrus is a popular fruit and has a great demand due to its taste, aroma and nutrient value (Yesmin *et al.*, 2017). Where, about 91% people of Bangladesh are suffering from the deficiency of vitamin C (Haque, 2005; Sfgate, 2017). Therefore, citrus fruits are the important as a source of vitamin C. In Bangladesh, eight species of citrus are cultivated, among them, three species citrus are common to grow in Bangladesh such as lemon (*Citrus limon* L), lime (*Citrus qurantifolia* Swing) and pummelo (*Citrus grandis* (L) Osbeck) (Al Mamun and Feroz, 2017; Yesmin *et al.*, 2017). The annual citrus production of all types citrus is over 110 million tons covering an area of nearly

18.7 million acres among it around 13.7 million tons of lemon and limes (Sarker *et al.*, 2017; Yara, 2017). In 2017, citrus fruit production for Bangladesh was 158,656 tonnes. Citrus fruit production of Bangladesh increased from 21,000 tonnes in 1968 to 158,656 tonnes in 2017 growing at an average annual rate of 5.21% (Knoema, 2020).

However, average production is very low as compared with other citrus producing countries. Several factors affect the growth and productivity of citrus. Among these, different types of diseases play as an important role for limiting the yield of citrus (Freeman, 1992; Alam, 2003; Haque, 2005; Yesmin *et al.*, 2017). Among the diseases die–back (caused

by *Colletotricum gloeosporioides*) and scab (caused by *Elsinoe fawcettii*) are the most commonly widely occurring diseases of citrus (*Citrus limon* L) in all over the World including Southeast–Asia (including Bangladesh) (Zekri, 2011; Sarker *et al.*, 2017). Miah and Fakir (1987) found, the incidence of die–back on Elachi lemon and Kagzi lime (local variety) by 89.9% and 100%, respectively in Bangladesh. In case of scab, about 66–72.2% of the fruitlets may be dropped down (Huang and Huang, 1999), under favorable condition and about 25–55% of yield loss incurred due to scab of citrus (Siddiquee *et al.*, 2011).

Initially, twigs and branches are mainly infected by the die–back, while leaf and fruit of citrus are infected by scab (Figure 2A, B). Scab of citrus, primarily small, semi–translucent dots like lesion develops on leaves, which ultimately become abruptly pustular elevations (Burrow *et al.*, 2017). The opposite surface of leaf consistent to the warty growth appearances a circular depression with a pink to red center. The lesions consist of corky projections on the fruit which often break into larger areas on the fruits (Kumar, 2015; Figure 2A, B).

Citrus scab is a common problem all over the world including tropical and sub–tropical region of Asia, wherever conditions are suitable. The optimum temperature for infestation of the disease is range from 21 to 27°C and can also survive in a wider range temperature (18–30°C) (FFTC, 2018). Scab of citrus has remarkable adverse effect on production, quality and market price (Sarker *et al.*, 2017) and the losses can be minimized by proper diseases' management practices. Application of different fungicides for controlling these diseases already reported by many researchers (Mele *et al.*, 2017; Islam *et al.*, 2017a; Islam *et al.*, 2017b). However, there is a little research has been conducted by using mustard oil cake, urea, triple super phosphate (TSP), murate of potash (MOP), cow dung, 'Bavistin 50 WP', irrigation, and pruning alone or combined on citrus die–back and scab disease. It is judicious, if the disease can be controlled by nutrients and cultural practices with minimum application of chemicals, in

order to have healthy nature and getting balanced environment for improving the production and quality of citrus. Considering the present situation of citrus diseases in all over the globe including Bangladesh, an appropriate management practices for citrus diseases is required. Therefore, the present research work was undertaken for understanding the adverse effect of two major citrus diseases such as scab and dieback and their mitigation strategies for sustainability of citrus production in sub–tropical countries.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted in the Citrus Garden, at the field laboratory of Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh during April to November 2016. The land type was medium high, non–calcareous, dark–gray floods plains soil type (UNDP and FAO, 1988.) under the Agro–Ecological Zone–9, Old Brahmaputra Flood Plain having non–calcareous dark flood plain (UNDP and FAO, 1988; FRG, 2012). The land type was medium high with loamy soil texture having pH range 5.5–6.8, low in organic matter content and medium potassium bearing minerals (FRG, 2012).

Climatic Condition During Observation

The experimental field was located at 24.75°N latitude and 90.50°E longitude at an altitude of 18m above the sea level. The macro climate of the experimental area (Bangladesh Agricultural University, Mymensingh) is sub–tropical in nature which is characterized by two distinct seasons, the Monsoon or Rainy season extending from April to September and Rabi season extending from October to March (Table 1). Detail of meteorological data in respect of temperature, rainfall, relative humidity and total sunshine having during the period of the experiment were collected from the weather station, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh.

Table 1 Maximum, minimum and mean temperature, and rainfall during the experimental period (in the year 2016)

Months	Temperature (°C)			Rainfall (mm)
	Mean	Maximum	Minimum	
January	11.50	15.70	7.20	10
February	13.10	17.30	8.90	30
March	16.50	20.50	12.50	80
April	18.10	21.70	14.50	190
May	19.30	22.40	16.10	220
June	20.30	22.70	17.90	250
July	20.10	22.00	18.10	290
August	20.60	22.90	18.20	260
September	20.20	22.70	17.50	210
October	19.30	22.70	15.80	90
November	16.40	20.40	12.30	20
December	12.70	17.00	8.30	10

Experimental Design and Treatments

The experiment was laid out in Complete Randomized Design (CRD) with three replications. Twenty nine (29) treatments including a control were assigned randomly to each unit plot in the form of prepared pit. The treatments were: T₁, control; T₂, mustard oil cake; T₃, urea, TSP (triple super phosphate), MOP (muriate of potash); T₄, cowdung; T₅, “Bavistin 50 WP”; T₆, irrigation; T₇, pruning; T₈ is the combination of T₂ + T₃; T₉ is the combination of T₂ + T₄; T₁₀ is the combination of T₂ + T₅; T₁₁ is the combination of T₂ + T₆; T₁₂ is the combination of T₂ + T₇; T₁₃ is combination of T₃ + T₄; T₁₄ is the combination of T₃ + T₅; T₁₅ is the combination of T₃ + T₆; T₁₆ is the combination of T₃ + T₇; T₁₇ is the combination of T₄ + T₅; T₁₈ is the combination of T₄ + T₆; T₁₉ is the combination of T₄ + T₇; T₂₀ is the combination of T₅ + T₆; T₂₁ is the combination of T₅ + T₇; T₂₂ is the combination of T₆ + T₇; T₂₃ is the combination of T₂ + T₃ + T₄; T₂₄ is the combination of T₂ + T₃ + T₅; T₂₅ is the combination of T₂ + T₃ + T₆; T₂₆ is the combination of T₂ + T₃ + T₇; T₂₇ is the combination

of T₂ + T₃ + T₄ + T₅; T₂₈ is the combination of T₂ + T₃ + T₄ + T₆; T₂₉ is the combination of T₂ + T₃ + T₄ + T₆ + T₇. Fungicide, “Bavistin 50 WP” was sprayed at 15 days interval @ 0.1% concentration starting from 1st April to 2nd November 2016. The fungicide was sprayed with compressed hand sprayer.

Fertilization, Irrigation, Weeding and Pruning

Manure and fertilizer were applied at the time of before rainy season following ring method at the rate of cow dung 10 kg, mustard oil cake 300 g, and urea, TSP and MOP were applied 200 g plant⁻¹. Plant to plant and row to row spacing was 2.5 m × 2.5 m. The infected branch of the plants for each treatment was pruned at 15 days interval and it is destroyed. All intercultural operations were done as per requirement. Irrigation was done at day interval with a cane @ two cane plant⁻¹. Weeding was done as per requirement. Infected branch of the plants for each treatment was pruned at 15 days interval and then destroyed by firing.

Data Collection for Dieback

The following data were recorded after two years of the crop growth. Data on total number of branches and die-back infected branches plant⁻¹ were recorded at 30 days interval started from 1st April 2016. The following formula was used for the calculation of percent die-back infected branches plant⁻¹:

$$\text{Percent die-back infected branches} = \frac{\text{Number of infected branches/plant}}{\text{Total number of branches/plant}} \times 100$$

Data Collection for Scab and Total Number of Leaves Plant⁻¹

Data on leaf scab and total number of leaves plant⁻¹ were also recorded at 30 days interval started from 1st April 2016 and continued upto 2nd November 2016. The percent leaf scab infection was calculated using the following formula:

$$\text{Percent leaf scab infection} = \frac{\text{Number of infected branches/plant}}{\text{Total number of branches/plant}} \times 100$$

Percent Leaf Area Diseased

Percent leaf area diseased was recorded at 30 days interval based on eye estimation. Leaves were selected at random. Percent leaf area diseased was calculated as follows:

$$\% \text{ leaf area diseases} = \frac{\text{Number of infected branches/plant}}{\text{Total number of branches/plant}} \times 100$$

Incidence of Die-back and Percent Die-back Infected Branches Plant⁻¹

The number of die-back infected plants was recorded at 30 days interval for the determination of incidence of die-back. The number of affected plants was expressed in percent. Moreover, numbers of die-back infected branches plant⁻¹ were also recorded. The incidence was calculated using the following formula:

$$\% \text{ die-back infected plants} = \frac{\text{Number of infected branches/plant}}{\text{Total number of branches/plant}} \times 100$$

Total Number of Fruits and Scab Infected Fruits Plant⁻¹

Data on total number of fruits and scab infected fruits of each plant were counted at 30 days interval and the average number of infected fruits per plant was calculated. Percent fruit infection was calculated using the following formula:

$$\% \text{ fruit infection} = \frac{\text{Number of infected branches/plant}}{\text{Total number of branches/plant}} \times 100$$

Laboratory Experiments

Collection of the infected parts of plants

For conformation of the causal micro-organism, the infected stems/twigs and leaves/fruits were collected. The diseased stems/twigs and leaves/fruits having only typical symptoms were collected from the infected plants of the experimental field for the isolation and identification of the causal organism.

Isolation of the organism by blotter method

Terile blotting papers soaked in sterile water and were then placed in the sterile petridish. The diseased samples were washed in running tap water for few minutes and then cut into small pieces (1–1.5 cm) with some healthy portion. Then the small pieces of the diseased specimen were placed on moist blotting paper. The petridishes were then kept for incubation at room temperature for growth of the fungus.

Identification of fungi

Fungal inocula were transferred from blotting paper to fresh potato dextrose agar (PDA) media. Slides were prepared for identification of pathogens in the laboratory of Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh.

The identifications of pathogen were done according to the methods as described by Barnett (1965), Kulshrestha *et al.* (1976), Punithalingam (1976) and Timmer (2000).

Data Analysis

The collected data were analyzed to find out the significant differences among the treatments using Duncan's Multiple Range Test (DMRT; R Core Team, 2013).

RESULTS AND DISCUSSION

Die-back and scab diseases are the common and widely occurring diseases of citrus in all over the world. The occurrence of die-back and scab of citrus has been reported from almost all citrus growing countries of the world including Southeast-Asia (FFTC, 2018). Twigs and branches are mainly infected by the die-back while leaf and fruit of citrus are infected by scab (Figures 2A and 2B).

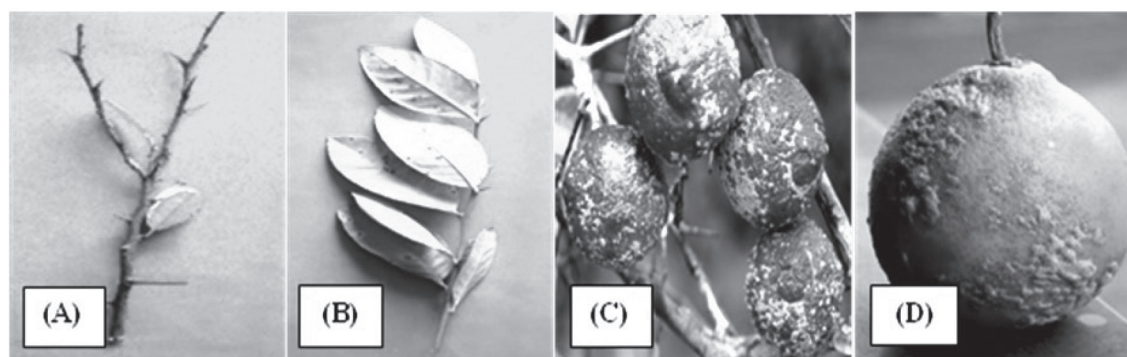


Figure 2 Symptoms of die-back (A) leaf scab (B), green (C) and mature (D) fruit scab of citrus

Disease Symptom of Die-back

Die-back disease symptoms were observed by drying of the shoot tip downwards to the stem resulting in the death of twigs and/or branches (Figure 2A). The first symptom appeared at the tip of small twigs as a minute dark color lesion which progress downwards following a change in color of the surrounding leaves from dark green to pale green. Sometimes light yellow and finally become reddish. The infected twigs gradually drying tip to downward. After the first visible symptom, the drying of the twig was usually rapid which extended 5 to 12 cm downwards ending in a sharp line within a week. Afterwards, the disease progress slowly or rapidly in the similar way towards the stem often affecting more twigs and branches. Later on, in some cases black dot like structures *Acervuli* could be found to develop on the light or grayish brown to whitish ashy membranous dead twig or branches.

In severe cases, most of the twigs and branches died resulting a bare look to the affected plant. In the present study, symptoms of die-back on Elachi lemon were observed which is quite similar to those described by various workers from different parts of the world (Knorr *et al.*, 1957; Thind and Rawla, 1961; Bhatnagar and Prasad, 1966; Miah and Fakir, 1988). *Colletotricum gloeosporioides* was isolated from the diseased plant parts having distinct die-back symptom which is supported by Smith (1936), BARI (1985), Miah and Fakir (1988) and Rahman (2011).

Disease Symptoms of Scab

The symptoms of the disease were first noticed as raised irregular corky and crateri lesions on leaves and fruits. *Elesione fawcettii*. Disease symptoms of scab of citrus caused by *Elesione fawcettii* was confirmed earlier by Doidge and Butler

(1924), Ikata (1927), Zekri and Rouse (2002), Graca (2004), Rawal, (2005) and Akhter *et al.* (2013). Since no disease symptom was observed on flowers. Severe infection of scab on citrus (*C. limon*) was observed from April to September, 2016. The spots ranged from a few mm to 1 cm in diameter. They became warty and erupted with cracks and scabby on the leaves (Figure 2B). Badly infected leaves became crinkled and stunted. The spots were found few often on the lower surface of leaves than on the upper surface of the fruits, the warty growth surrounded by yellowish or chlorate halo was found in the severely infected leaves and the leaves were dropped. Several spots coalesced to form large patches of corky out growth. In case of severe infection, the twig became distorted. In case of citrus scab, the symptoms of the disease were first noticed as raised irregular corky and crateri lesions on leaves and fruits. Since, no disease symptom was observed on flowers. Severe infection of scab on citrus (*C. limon*) was observed from April to September, 2016. The disease has been reported to occur on different *Citrus* spp., including Elachi lemon and Kagazi lime in Bangladesh by Miah and Fakir (1988), Haque (2005) and Siddiquee *et al.* (2011).

Effect of Different Treatments on Die Back Infected Leaves Plant⁻¹

Application of different fungicides for controlling these diseases already reported by many researchers (Islam *et al.*, 2017a; Islam *et al.*, 2017b; Mele *et al.*, 2017). Yesmin *et al.* (2017) observed that different fungicides such as, Cupravit 50 WP, Dithane M-45 and Rovral 50 WP, Tilt 250 EC, Bavistin, and Bordeaux mixture etc could effectively

control both die-back and scab of citrus. They also found that plant extracts such as Neem leaf extract, Ginger extract, Garlic extract, Onion extract, Lemon grass and clove tree can also control the citrus diseases like. Since chemical management is not environmentally friendly and costly, therefore it is judicious, if the disease can be controlled by nutrients and cultural practices with minimum application of chemicals, in order to have healthy nature and getting balanced environment for improving the production and quality of citrus.

Effects of different treatments against die-back infected leaves plant⁻¹ were recorded from April to November, 2016 and are presented in the Figure 3. The effect of different treatments on die-back infected leaves plant⁻¹ was found to vary significantly at different month of counting. In April 2016, the minimum die-back infected leaves plant⁻¹ was found in T₁₀, T₂₄, T₂₇, T₂₉ and the maximum was found in T₁₁. Similarly, In May, June and July 2016 the maximum die-back infected leaves plant⁻¹ was found in T₁₁, whereas the minimum die-back infected leaves plant⁻¹ was found in T₁, T₃, T₁₀, T₂₄, T₂₇, and T₂₉ treatment. Whereas, in the month of August, September and November the maximum die-back infected leaves plant⁻¹ was found in T₂₃, T₂₅, T₂₉, while minimum was recorded from T₆ treatment in the month of August, September. But, in November minimum number of die-back infected leaves plant⁻¹ was found the treatment T₁₁, followed by T₁₂. However, in October, the maximum die-back infected leaves plant⁻¹ was found from T₁₃, T₂₃, T₂₈ treatment and the minimum die-back infected leaves plant⁻¹ was found in T₁₂, followed by T₄ treatment (Figure 3).

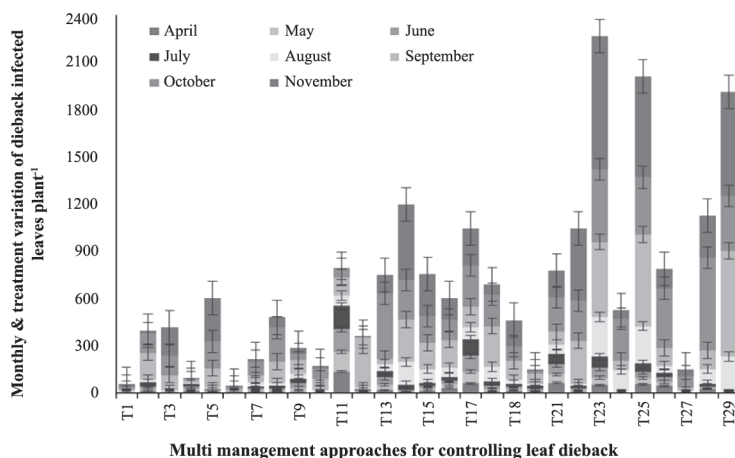


Figure 3 Effects of different treatments and their combination on % die-back affected leaves plant⁻¹. Treatments details: T₁, control; T₂, mustard oil cake; T₃, urea, TSP, MOP; T₄, cowdung; T₅, 'Bavistin'; T₆, irrigation; T₇, pruning; T₈ is the combination of T₂ + T₃; T₉ is the combination of T₂ + T₄; T₁₀ is the combination of T₂ + T₅; T₁₁ is the combination of T₂ + T₆; T₁₂ is the combination of T₂ + T₇; T₁₃ is combination of T₃ + T₄; T₁₄ is the combination of T₃ + T₅; T₁₅ is the combination of T₃ + T₆; T₁₆ is the combination of T₃ + T₇; T₁₇ is the combination of T₄ + T₅; T₁₈ is the combination of T₄ + T₆; T₁₉ is the combination of T₄ + T₇; T₂₀ is the combination of T₅ + T₆; T₂₁ is the combination of T₅ + T₇; T₂₂ is the combination of T₆ + T₇; T₂₃ is the combination of T₂ + T₃ + T₄; T₂₄ is the combination of T₂ + T₃ + T₅; T₂₅ is the combination of T₂ + T₃ + T₆; T₂₆ is the combination of T₂ + T₃ + T₇; T₂₇ is the combination of T₂ + T₃ + T₄ + T₅; T₂₈ is the combination of T₂ + T₃ + T₄ + T₆; T₂₉ is the combination of T₂ + T₃ + T₄ + T₆ + T₇

The effect of different treatments on the total number of leaves plant⁻¹ was found to vary significantly at different month of counting (from 1st April to 1st November 2016; Table 2). In 1st April, the number of total leaves plant⁻¹ ranged from 1,044 to 5,971, where the significantly highest 5,971 number of total leaves per plant was found in T₂₆ and the lowest 1,044 number of total leaves plant⁻¹ was found in T₅. In 1st May, the number of total leaves plant⁻¹ ranged from 1,076 to 6,389, where the significantly highest 6,389 number of total leaves plant⁻¹ was found in T₂₆ and the lowest 1,076 number of total leaves plant⁻¹ was recorded in T₅. On 31st May, the number of total leaves plant⁻¹ ranged from 1,155 to 6,510, where the significantly highest 6,510 number of total leaves plant⁻¹ was found in T₂₆ and the lowest 1,155 number of total leaves plant⁻¹ was found in

T₅. On 1st July, the number of total leaves plant⁻¹ ranged from 1,148 to 6,920, where the significantly highest 6,920 number of total leaves plant⁻¹ was found in T₂₆ and the lowest 1,148 number of total leaves plant⁻¹ was found in T₅. On 1st August, the number of total leaves plant⁻¹ ranged from 1,191 to 7,217, where the significantly highest 7,217 number of total leaves plant⁻¹ was found in T₂₆ and the lowest 1,191 number of total leaves plant⁻¹ was found in T₅. On 1st September, the number of total leaves plant⁻¹ ranged from 1,659 to 7,153, where the significantly highest 7,153 number of total leaves plant⁻¹ was found in T₂₆ and the lowest 1,659 number of total leaves per plant was found in T₆. On 1st October, the number of total leaves per plant ranged from 1,527 to 7,098, where the significantly highest 7,098 of total leaves plant⁻¹

was found in T₂₇ and the lowest 1,527 number of total leaves plant was found in T₆. On 2nd November, the number of total leaves plant⁻¹ ranged from 1,448 to 7,693, where the significantly highest 7,693 number of total leaves plant⁻¹ was found in T₂₆ and the lowest 1,448 number of total leaves plant⁻¹ was found in T₅.

Table 2 Effect of different management approaches on number of leaves plant⁻¹ started from April with 30 days intervals and continued upto November

Treatment	Dates of recording data							
	01.04.16	01.05.16	31.05.16	01.07.16	1.08.16	01.09.16	01.10.16	02.11.16
T ₁	1,834 ^{h-k}	1,928 ^{e-h}	2,010 ^{fgh}	1,943 ^{g-i}	2,267 ^{de}	2,315 ^{cd}	3,314 ^{b-e}	2,450 ^{f-i}
T ₂	3,269 ^{b-k}	3,346 ^{b-h}	3,474.33 ^{b-h}	3,528 ^{b-i}	3,647 ^{b-e}	3,724 ^{bcd}	3,534 ^{b-e}	4,112 ^{b-i}
T ₃	2,057 ^{f-k}	2,250 ^{d-h}	2,279.33 ^{e-h}	2,431 ^{e-i}	2,659 ^{de}	3,704 ^{bcd}	2,604 ^{ode}	3,074 ^{e-i}
T ₄	2,832 ^{c-k}	3,587 ^{b-h}	3,732.33 ^{b-h}	3,897 ^{b-j}	3,994 ^{a-e}	4,281 ^{a-d}	4,238 ^{b-e}	4,163 ^{b-i}
T ₅	1,044 ^h	1,076 ^h	1,155 ^h	1,148 ^j	1,191 ^e	2,286 ^{cd}	3,752 ^{b-e}	1,448 ⁱ
T ₆	1,263 ^{hj}	1,291 ^{gh}	1,325.33 ^h	1,226 ^j	1,409 ^e	1,659 ^d	1,527 ^e	1,528 ⁱ
T ₇	1,556 ^{jk}	1,727 ^{fgh}	1,732 ^{gh}	1,751 ^{hij}	2,418 ^{de}	3,710 ^{bcd}	2,889 ^{b-e}	1,917 ^{ghi}
T ₈	4,477 ^{a-g}	4,742 ^{a-d}	4,828 ^{a-f}	5,089 ^{a-f}	4,521 ^{a-e}	4,166 ^{a-d}	5,033 ^{abc}	5,535 ^{a-f}
T ₉	3,683 ^{z-j}	3,929 ^{a-g}	3,989 ^{a-h}	4,182 ^{a-j}	4,479 ^{a-e}	3,135 ^{bcd}	3,541 ^{b-e}	4,669 ^{a-i}
T ₁₀	2,528 ^{d-k}	2,771 ^{c-h}	2,830 ^{d-h}	2,867 ^{d-j}	2,885 ^{de}	4,086 ^{bcd}	3,046 ^{b-e}	2,538 ^{f-i}
T ₁₁	2,682 ^{-k}	3,166 ^{b-h}	3,203 ^{c-h}	3,230 ^{c-j}	2,938 ^{de}	3,360 ^{bcd}	3,051 ^{b-e}	2,645 ^{f-i}
T ₁₂	2,082 ^{f-k}	2,275 ^{d-h}	2,330 ^{e-h}	2,350 ^{f-j}	2,372 ^{de}	3,173 ^{bcd}	2,900 ^{b-e}	2,504 ^{f-i}
T ₁₃	4,241 ^{-h}	4,567 ^{a-e}	4,724 ^{a-f}	4,887 ^{a-g}	5,151 ^{a-d}	4,524 ^{a-d}	5,557 ^{ab}	5,700 ^{a-f}
T ₁₄	2,795 ^{c-k}	3,396 ^{b-h}	3,476 ^{b-f}	3,668 ^{b-j}	3,920 ^{b-e}	3,654 ^{bcd}	4,056 ^{b-e}	4,728 ^{a-i}
T ₁₅	3,594 ^{a-j}	4,556 ^{a-e}	4,712 ^{a-f}	4,811 ^{a-h}	5,063 ^{a-d}	4,232 ^{a-d}	3,353 ^{b-e}	5,363 ^{a-f}
T ₁₆	2,974 ^{c-k}	3,109 ^{b-h}	3,170 ^{c-h}	3,191 ^{c-j}	3,374 ^{ode}	3,323 ^{bcd}	2,973 ^{b-e}	3,758 ^{c-i}
T ₁₇	1,957 ^{g-k}	2,068 ^{d-h}	2,111 ^{fgh}	2,153 ^{f-j}	2,656 ^{de}	3,803 ^{bcd}	3,335 ^{b-e}	2,342 ^{f-i}
T ₁₈	4,535 ^{a-f}	4,818 ^{a-d}	3,634 ^{b-h}	3,844 ^{b-j}	3,536 ^{b-e}	4,292 ^{a-d}	3,636 ^{b-e}	3,962 ^{c-i}
T ₁₉	2,496 ^{e-k}	2,619 ^{d-h}	2,719 ^{d-h}	2,827 ^{d-j}	2,999 ^{de}	3,852 ^{bcd}	2,293 ^{de}	3,150 ^{e-i}
T ₂₀	1,569 ^{ijk}	1,601 ^{fgh}	1,663 ^{gh}	1,677 ^{ij}	2,295 ^{de}	2,130 ^{cd}	3,249 ^{b-e}	1,790 ^{hi}
T ₂₁	1,173 ^{kl}	1,266 ^{gh}	1,369 ^h	1,376 ^j	1,435 ^e	2,522 ^{bcd}	2,054 ^{de}	1,605 ^{hi}
T ₂₂	2,519 ^{-k}	2,681 ^{c-h}	2,797 ^{d-h}	2,955 ^{d-j}	2,981 ^{de}	3,450 ^{bcd}	4,181 ^{b-e}	3,402 ^{d-i}
T ₂₃	3,123 ^{-k}	3,917 ^{a-g}	3,974 ^{a-h}	4,101 ^{a-j}	4,339 ^{a-e}	4,574 ^{a-d}	4,967 ^{abc}	5,182 ^{a-g}
T ₂₄	4,666 ^{a-e}	4,329 ^{a-f}	5,147 ^{a-e}	5,437 ^{a-e}	4,968 ^{a-d}	5,558 ^{ab}	5,117 ^{abc}	6,671 ^{a-d}
T ₂₅	3,931 ^{a-i}	4,151 ^{a-f}	4,316 ^{a-g}	4,534 ^{a-i}	3,728 ^{b-e}	4,198 ^{a-d}	4,683 ^{a-d}	4,965 ^{a-h}
T ₂₆	5,971 ^a	6,389 ^a	6,510 ^a	6,920 ^a	7,217 ^a	7,153 ^a	4,885 ^{a-d}	7,693 ^a
T ₂₇	5,610 ^{abc}	5,746 ^{ab}	5,885 ^{abc}	6,170 ^{abc}	6,432 ^{abc}	5,149 ^{abc}	7,098 ^a	6,845 ^{abc}
T ₂₈	5,158 ^{abc}	5,825 ^{ab}	6,098 ^{ab}	6,489 ^{ab}	6,789 ^{abc}	5,624 ^{ab}	4,823 ^{a-d}	7,380 ^{ab}
T ₂₉	5,039 ^{a-d}	5,402 ^{abc}	5,592 ^{a-d}	5,721 ^{a-d}	5,057 ^{a-d}	5,624 ^{ab}	5,599 ^{ab}	6,433 ^{a-e}
LSD (0.05)	2,077.83	2,279	2,366	2,513	2,718	2,489	2,347	2,776
CV (%)	65.47	60.00	62.00	56.00	51.00	59.00	61.00	71.00

Note: Data represents the mean of three replications. Means in column having common letter (s) do not differ significantly. Treatments details are in Figure 3

Like the present study, different management approaches such as mustard oil cake, urea, TSP, MOP, cow dung, 'Bavistin', irrigation, and pruning alone or combined on citrus die-back and scab disease already confirmed by Freeman (1992), Alam (2003), Islam *et al.* (2017a, 2017b), Sarker *et al.* (2017), who found that soil amendment with combined application of cowdung, NPK fertilizers (Urea, TSP and MOP), lime and Rovral (250 ppm at 10 days interval 4 spray) gave good vigor and highest growth of the plant.

Effect of Management Practices on the Number of Branches Plant⁻¹ and Percent Die-back Infected Branches Plant⁻¹ and Plants

The effect of different treatments on the number of branches plant⁻¹ was found to vary significantly at eight different dates from 1st April

to 2nd November 2016 (Table 3). In the months of April, May and June the significantly highest number of branches plant⁻¹ was recorded in the treatment (T₂₄), where combination of chemical (urea, TSP & MOP) and organic (cowdung) fertilizers were applied before rainy season following ring method after that fungicide "Bavistin 50 WP" was sprayed at 15 days interval @ 0.1%. Whereas, the lowest number of branch plant⁻¹ was recorded in the treatment (T₅), where fungicide "Bavistin 50 WP" was sprayed at 15 days interval @ 0.1% (Table 3). During the month of July, August, September and November, the maximum number of branch plant⁻¹ was recorded in the treatment T₂₇ (combination T₂, T₃, T₄ and T₅), followed by T₂₆, while the lowest number of branch plant⁻¹ was recorded in the treatment (T₅), where fungicide "Bavistin 50 WP" was sprayed at 15 days interval @ 0.1% (Table 3).

Table 3 Effect of different management approaches on branches plant⁻¹ started from April with 30 days intervals and continued upto November

Treatment	Dates of Counting							
	01.04.16	01.05.16	31.05.16	01.07.16	1.08.16	01.09.16	01.10.16	02.11.16
T ₁	303 ^{c-f}	346 ^{a-e}	371 ^{c-g}	390 ^{c-f}	393 ^{c-g}	363 ^{b-e}	480 ^b	393 ^b
T ₂	379 ^{c-f}	394 ^{a-e}	421 ^{a-g}	422 ^{a-f}	431 ^{a-g}	453 ^{a-e}	407 ^b	443 ^b
T ₃	290 ^{c-f}	325 ^{b-e}	300 ^{d-g}	338 ^{d-f}	352 ^{c-g}	474 ^{a-e}	318 ^b	368 ^b
T ₄	356 ^{c-f}	419 ^{a-e}	447 ^{a-g}	463 ^{a-f}	477 ^{a-g}	510 ^{a-e}	538 ^b	483 ^b
T ₅	168 ^f	181 ^e	188 ^g	189 ^f	192 ^g	233 ^e	466 ^b	196 ^b
T ₆	203 ^f	208 ^e	214 ^{fg}	216 ^f	218 ^{e-g}	312 ^{cde}	202 ^b	205 ^b
T ₇	210 ^f	240 ^{c-e}	245 ^{d-g}	247 ^{d-f}	347 ^{d-g}	410 ^{b-e}	369 ^b	243 ^b
T ₈	506 ^{abc}	547 ^{a-c}	564 ^{a-g}	591 ^{a-d}	607 ^{a-d}	535 ^{a-e}	594 ^b	686 ^b
T ₉	403 ^{b-f}	442 ^{a-e}	457 ^{a-g}	474 ^{a-f}	544 ^{a-f}	352 ^{b-e}	470 ^b	501 ^b
T ₁₀	249 ^{d-f}	292 ^{c-e}	306 ^{d-g}	316 ^{d-f}	311 ^{d-g}	458 ^{a-e}	441 ^b	329 ^b
T ₁₁	317 ^{c-f}	365 ^{a-e}	372 ^{c-g}	378 ^{c-f}	328 ^{d-g}	359 ^{b-e}	333 ^b	275 ^b
T ₁₂	256 ^{d-f}	302 ^{c-e}	299 ^{d-g}	303 ^{d-f}	304 ^{d-g}	386 ^{b-e}	376 ^b	210 ^b
T ₁₃	403 ^{b-f}	460 ^{a-e}	491 ^{a-g}	507 ^{a-f}	514 ^{a-g}	458 ^{a-e}	521 ^b	755 ^a
T ₁₄	297 ^{c-f}	386 ^{a-e}	405 ^{b-g}	390 ^{c-f}	446 ^{a-g}	430 ^{a-e}	448 ^b	494 ^b
T ₁₅	377 ^{c-f}	496 ^{a-e}	517 ^{a-g}	527 ^{a-f}	555 ^{a-f}	488 ^{a-e}	384 ^b	567 ^b
T ₁₆	343 ^{c-f}	365 ^{a-e}	373 ^{c-g}	376 ^{c-f}	385 ^{c-g}	387 ^{b-e}	364 ^b	717 ^a
T ₁₇	231 ^{ef}	542 ^{a-d}	253 ^{d-g}	261 ^{d-f}	312 ^{d-g}	440 ^{a-e}	368 ^b	270 ^b
T ₁₈	404 ^{b-f}	459 ^{a-e}	496 ^{a-g}	510 ^{a-f}	439 ^{a-g}	560 ^{a-e}	444 ^b	482 ^b

Table 3 Continued.

Treatment	Dates of Counting							
	01.04.16	01.05.16	31.05.16	01.07.16	1.08.16	01.09.16	01.10.16	02.11.16
T ₁₉	357 ^{c-f}	380 ^{a-e}	399 ^{c-g}	406 ^{b-f}	415 ^{b-g}	535 ^{a-e}	363 ^b	420 ^b
T ₂₀	187 ^f	196 ^{de}	202 ^{fg}	204 ^f	263 ^{d-g}	274 ^{cde}	365 ^b	209 ^b
T ₂₁	199 ^f	212 ^{a-e}	231 ^{efg}	232 ^{fg}	210 ^{fg}	329 ^{a-e}	232 ^b	232 ^b
T ₂₂	335 ^f	368 ^{a-e}	388 ^{c-g}	413 ^{a-f}	381 ^{c-g}	434 ^{a-e}	489 ^b	435 ^b
T ₂₃	406 ^{b-f}	504 ^{a-e}	515 ^{a-f}	531 ^{a-f}	560 ^{a-e}	520 ^{a-e}	569 ^b	578 ^b
T ₂₄	638 ^a	693 ^a	735 ^a	742 ^{ab}	695 ^{abc}	646 ^{abc}	630 ^b	772 ^a
T ₂₅	468 ^{a-e}	510 ^{a-e}	538 ^{a-e}	494 ^{a-f}	566 ^{a-e}	498 ^{a-e}	536 ^b	576 ^b
T ₂₆	610 ^{ab}	689 ^a	683 ^{abc}	744 ^{ab}	766 ^a	670 ^{ab}	549 ^b	783 ^a
T ₂₇	637 ^a	659 ^{ab}	723 ^a	750 ^a	771 ^a	763 ^a	1,661 ^a	1,307 ^a
T ₂₈	624 ^{ab}	690 ^a	719 ^{abc}	718 ^{abc}	740 ^{ab}	594 ^{a-d}	810 ^b	791 ^a
T ₂₉	470 ^{a-d}	543 ^{a-d}	559 ^{a-d}	568 ^{a-e}	591 ^{a-d}	542 ^{a-e}	611	611 ^b
LSD (0.05)	192	282	260	280	281	0	571	516
CV (%)	32	41	37	39	38	35	70	63

Note: Data represents the mean of three replications. Means in column having common letter(s) do not differ significantly. Treatments details are in Figure 3

Effect of different treatments on the percent die-back infected branch plant⁻¹ was recorded from the period of April to November, 2016. In April 2016, the minimum die-back infected branch plant⁻¹ was found in the treatment T₂, T₄, T₇, T₈, T₉, T₁₂, T₁₃, T₁₆, T₁₈, T₁₉, T₂₁, T₂₂, T₂₄, T₂₆, T₂₇, T₂₈, & T₂₉ and the maximum die-back infected branch plant⁻¹ was found in T₁₇ (Figure 4, 8 and 9). In May 2016, the minimum percent die-back infected branch plant⁻¹ was found in T₂, T₄, T₇, T₈, T₉, T₁₀, T₁₂, T₁₃, T₁₅, T₁₆, T₁₈, T₁₉, T₂₀, T₂₁, T₂₂, T₂₄, T₂₆, T₂₇, T₂₈, T₂₉ and the maximum percent die-back infected branch plant⁻¹ was found in T₁₇ (Figure 4). In June 2016, the minimum die-back infected branch plant⁻¹ was found in T₂, T₄, T₇, T₈, T₉, T₁₀, T₁₂, T₁₃, T₁₄, T₁₅, T₁₆, T₁₈, T₁₉, T₂₀, T₂₁, T₂₂, T₂₄, T₂₆, T₂₇, T₂₈, T₂₉ and the maximum die-back infected branch plant⁻¹ was found in T₁₇ (Figure 4). In July 2016, the minimum die-back infected branch plant⁻¹ was found in T₂, T₄, T₇, T₈, T₉, T₁₀, T₁₂, T₁₃, T₁₅, T₁₆, T₁₈, T₁₉, T₂₀, T₂₁, T₂₂, T₂₄, T₂₆, T₂₇, T₂₈, T₂₉ and the maximum die-back

infected branch plant⁻¹ was found in T₂₅ (Figure 4). On August 2016, the minimum die-back infected branch plant⁻¹ was found in T₂, T₄, T₇, T₈, T₉, T₁₀, T₁₁, T₁₂, T₁₃, T₁₅, T₁₆, T₁₈, T₁₉, T₂₀, T₂₁, T₂₂, T₂₃, T₂₄, T₂₅, T₂₆, T₂₇, T₂₈, T₂₉ and the maximum die-back infected branch plant⁻¹ was found in T₁₇ (Figure 4). In September 2016, the minimum die-back infected branch plant⁻¹ was found in T₁, T₂, T₃, T₄, T₇, T₈, T₁₀, T₁₁, T₁₂, T₁₃, T₁₄, T₁₅, T₁₆, T₁₈, T₁₉, T₂₀, T₂₁, T₂₄, T₂₅, T₂₆, T₂₇, T₂₈, T₂₉ and the maximum die-back infected branch plant⁻¹ was found in T₁₇ (Figure 4). In October 2016, the minimum of percent of die-back infected branch plant⁻¹ was found in T₁, T₂, T₄, T₈, T₉, T₁₁, T₁₂, T₁₃, T₁₄, T₁₅, T₁₆, T₁₉, T₂₂, T₂₃, T₂₄, T₂₅, T₂₇, T₂₉ and the maximum die-back infected branch plant⁻¹ was found in T₁₇ (Figure 3). In November 2016, the minimum percent die-back infected branch plant⁻¹ was found in, T₂, T₄, T₇, T₈, T₉, T₁₁, T₁₂, T₁₃, T₁₆, T₁₉, T₂₁, T₂₂, T₂₄, T₂₆, T₂₈, T₂₉ and the maximum die-back infected branch plant⁻¹ was found in T₅.

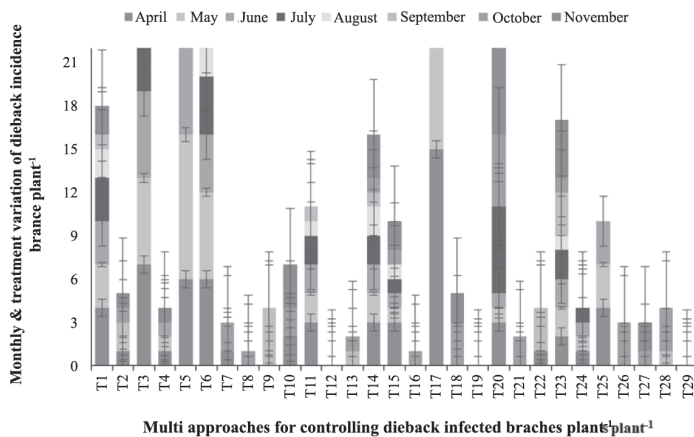


Figure 4 Effects of treatments and their combination on the die-back affected branches plant⁻¹. Treatments details are in Figure 3

Effects of different treatments against percent die-back infected plants were recorded from April to November, 2016 and are presented in the Figure 5. The effect of different treatments on percent die-back infected plant was found to vary significantly at different months of counting. In April 2016, no or minimum percent die-back infected plant was found in T₂, T₇, T₈, T₉, T₁₂, T₁₃, T₁₆, T₁₈, T₁₉, T₂₁, T₂₆, T₂₇, T₂₉ and the maximum was found in T₁₇. Similarly to April month, maximum percent die-back infected plant was found from T₁₇ in the months of May to November, 2016. However, with

little exception minimum percent of die-back infected plant was found from T₂, T₄, T₇, T₈, T₉, T₁₀, T₁₂, T₁₃, T₁₆, T₁₈, T₁₉, T₂₀, T₂₁, T₂₂, T₂₆, T₂₇, T₂₈, T₂₉ treatments for the months of May to November, 2016 (Figure 5). Regarding incidence of die-back in plant, there was no die-back infected plants were recorded during the treatment period from April month to the November month in the T₁₉ treatment. Except T₁₉ treatment, we found that the T₂₉ treatment showed the lowest die-back infected plant and this number was only two during the treatment period from April month to the November month (Table 3).

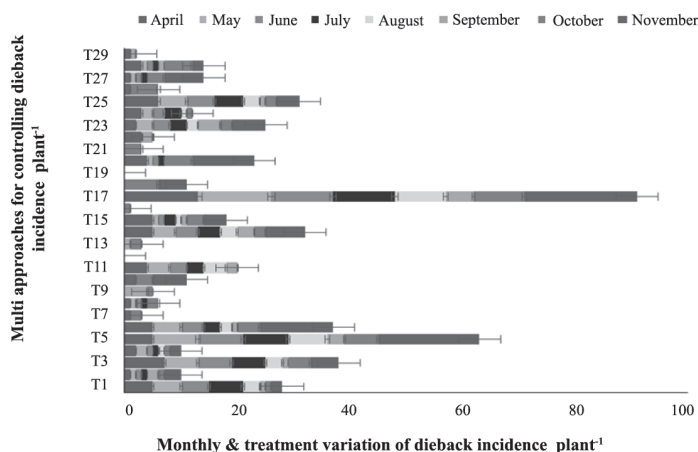


Figure 5 Effect of different treatments and their combination on the percent incidence of die-back disease plant⁻¹. Treatments details are in Figure 3

The results of our present study, related to the multi management approaches for controlling die-back and scab diseases of citrus also confirmed by Freeman (1992), Alam (2003), Islam *et al.* (2017a, 2017b) and Sarker *et al.* (2017), who found that soil amendment with combined application of cowdung, NPK fertilizers (Urea, TSP and MOP), lime and Rovral (250 ppm at 10 days interval 4 spray) gave good vigor and highest growth of the plant. Similarly, Hossain and Supoda (2006) reported that the combined effect of mustard oil cake, NPK fertilizers, cowdung and irrigation; combination of Mustard oil cake, NPK fertilizers and irrigation; combination of Mustard oil cake, NPK fertilizers and Co increased 125.00%, 117.80% and 123.00% branch per plant respectively over control.

Effect of Management Approaches on Percent Scab Infected Leaves Plant⁻¹

Number of spot leaf⁻¹ (scab) of citrus was found minimum in first counting and maximum in last counting date. Similarly percent leaf area diseased was minimum in first counting and maximum in last counting date Percent scab infected leaves plant⁻¹ of citrus under different treatments were found to vary significantly from 1st April 2016 to 2nd November, 2016 (Figure 6). In the month of April, May, June and July 2016, percent scab infected leaves plant⁻¹ were ranges from 0 to 14%, where the significantly highest percent leaf infection plant⁻¹ was found in (T₁₁) in the treatment where 300 g mustard oil cake plant⁻¹ was applied before rainy season in ring method in combination with day interval of two cane irrigation plant⁻¹; while, no infection was recorded in T₁, T₃, T₇, T₈, T₉, T₁₀, T₁₂, T₁₃, T₁₄, T₁₅, T₁₈, T₂₂, T₂₄, T₂₇ and T₂₉ treatments.

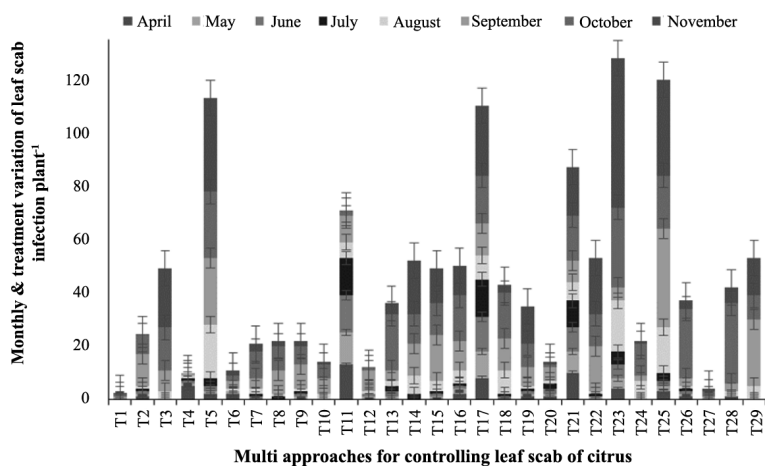


Figure 6 Effects of different treatments and their combination on the rate of scab infection leaves plant⁻¹. Treatments details are in Figure 3

While, in August 2016, percent leaf infection plant⁻¹ was ranged from 0.00 to 20.00%, where the significantly highest percent leaf infection plant⁻¹ was found in the treatment where fungicide 'Bavistin 50 WP' was applied @ 0.1% (T₅) and the leaf infection was not found in T₁ and T₂₇. In September 2016, percent leaf infection plant⁻¹ ranged from 0.00 to

37.00%, where the significantly highest percent leaf infection plant⁻¹ was found in the treatment (T₂₅) where 300 g mustard oil cake, and 200 g urea, TSP and MOP were applied plant⁻¹ before rainy season at ring method in combination with day interval of two cane irrigation plant⁻¹ and the lowest leaf infection was found in T₁, T₄, T₂₇. Where in the

month of October and November 2016, percent leaf infection plant⁻¹ ranged from 0.00 to 56.00%, where the highest percent leaf infection plant⁻¹ was found in T₂₃, T₂₈ in the month of October, whereas in November it was in treatment T₂₃. Considering on the lowest leaf infection plant⁻¹, minimum/no infection was recorded in T₄ in October and in November it was in the treatments T₄, T₁₁ and T₁₂ (Figure 6).

Leaf infection by scab (*Elsinoe fawcettii*) was lower from April to July than from August to November and there was not found effective treatment against citrus scab. Among the tested approaches T₁₁ (combination of mustard oil cake and irrigation) showed bad performance from April to July might be due to excess moisture. This result was similar to some previous results. Koo and Reese (1977) reported that irrigation increased the soil moisture that resulted an increase of citrus scab. It was also reported that environmental factor viz. humidity, rainfall and temperature had effect on scab development in citrus (Tripathi and Srivastava, 1992; Singh *et al.*, 1998). Whereas, Hyder (2006) used 14 different treatments for controlling scab of citrus and found the highest number of leaves (3,004) was produced in T₆ [Mustard oil cake (300 g per pit) + Urea (200 g per pit)], TSP (200 g per pit), MOP (200 g per pit) and the least number (916.3) in T₁ (control). The highest number of infected leaves (2.69% in May and 4.61% in June) in T₅ (irrigation) treatment but in July it was found (23.97%) in T₈ [Mustard oil cake (300 g per pit) and Irrigation]. It was also observed that T₅ (Irrigation) produced

the highest (7.17%) leaf area diseased per plant. The lowest Percent leaf infection (0.00 to 0.64%) was recorded in T₁₂ [Mustard oil cake (300 g per pit), Urea (200 g per pit) J, TSP (200 g per pit), MOP (200 g per pit) and Cowdung (10kg per pit) throughout the study period.

Effect of Management Approaches on Number of Scab Affected Fruits Plant⁻¹

The effect of different treatments on number of scab affected fruits plant⁻¹ is shown in Figure 7. The effect of different treatments on number of scab affected fruits per plant was found to vary significantly at different month of counting. In the month of April, 2016, the maximum number of scab affected fruits plant⁻¹ was found in treatment (T₈), where 300 g mustard oil cake, and 200 g urea, TSP and MOP were applied plant⁻¹ before rainy season at ring method. Whereas, in the months of May, June, July and August the maximum number of scab affected fruits plant⁻¹ was found in treatment (T₂₈), where manure and fertilizer were applied at the time of before rainy season following ring method at the rate of cow dung 10 kg, mustard oil cake 300 g, and urea, TSP and MOP were applied 200 g plant⁻¹ in combination with day interval with two cane watering plant⁻¹. However, with in little except the following management approaches such as T₅, T₆, T₇, T₁₉, T₂₀, T₂₁ showed the minimum number of scab affected fruits plant⁻¹ in the months of April, May, June, July and August (Figure 7).

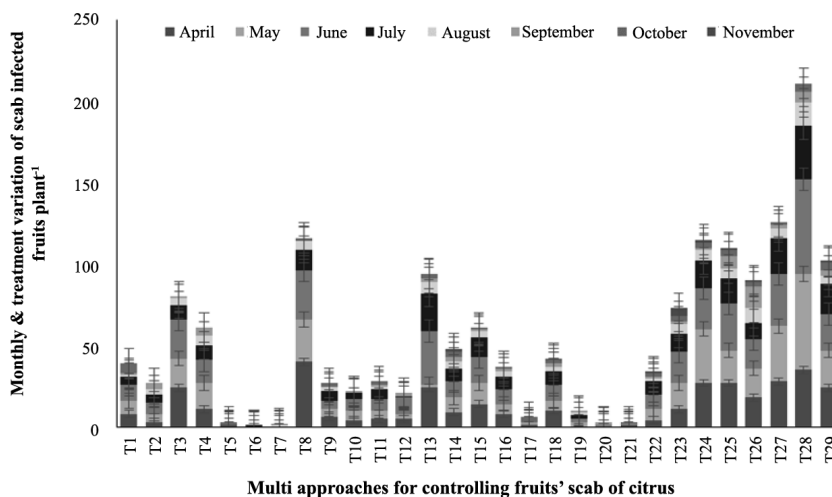


Figure 7 Effects of different treatments and their combination on the scab infected fruits plant⁻¹. Treatments details are in Figure 3

In September 2016, the minimum number of scab affected fruits plant⁻¹ was found in T₁, T₃, T₅, T₆, T₇, T₈, T₉, T₁₀, T₁₂, T₁₅, T₁₇, T₁₉, T₂₁, T₂₂, T₂₄ and the maximum number of scab affected fruits plant⁻¹ was found in T₂₆. In October 2016, the minimum number of scab affected fruits plant⁻¹ was found in T₂, T₃, T₄, T₆, T₇, T₁₀, T₁₂, T₁₅, T₁₆, T₁₉, T₂₀, T₂₁ and the maximum number of scab affected fruits plant⁻¹ was found in T₁. In November 2016, maximum treatments showed no scab affected fruits plant⁻¹, except T₁₄, T₁₈, T₂₂, T₂₃, T₂₄, T₂₅, T₂₆ and T₂₉ (Figure 7).

Regarding scab infection of fruits, the T₆ (irrigated) treatment showed the maximum scab infection fruits during the treatment period from the month of April to November (Figure 7). Country under sub-tropical region, like Bangladesh experience heavy rainfall in every year in the monsoon. Moreover, temperature during rainy season remains within 25–30°C which, is congenial for the outbreak disease scab. Under the present study, severe disease incidence was T₆ during the rainy

season. The result of the present study has also been supported by Kucharek and Whitside (1983), Timmer *et al.* (1992), Singh *et al.* (1998), (2003), Graca (2004) and Akhter *et al.* (2013).

The present research confirmed that different management approaches either alone or in their combination to control die-back and scab of citrus and to develop an economic and environment friendly management practice of die-back and scab of citrus (Figure 3 to 9 and Tables 2 and 3). Among the treatments T₁₀, T₂₄, T₂₇ and T₂₉ were controlled the infusion of die-back disease in leaves of the study plants in the months of April to July 2016. Whereas, in August to November month the T₆ (watering/irrigation) treatment showed the lowest die-back affected leaves among the treatment. There was no die-back infected branch in the treatments of T₁₂, T₁₉ and T₂₉ during the treatment period from April month to the November month (Figures 3, 8 and 9).

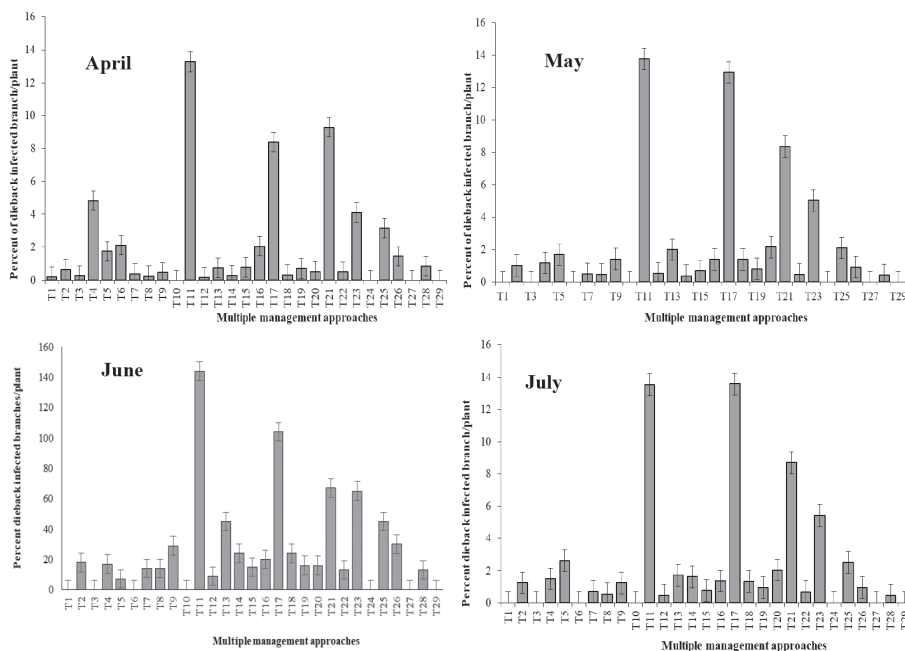


Figure 8 Multiple management practices in different months (April to July) effect on percent die-back infected braches plant¹. Treatments details are in Figure 3

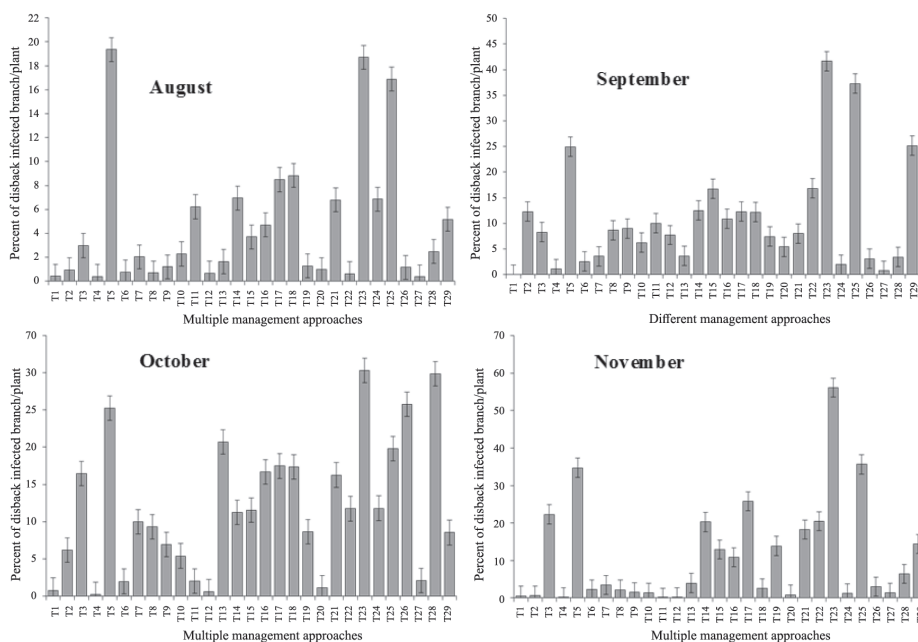


Figure 9 Multiple management practices in different months (August to November) effect on percent die-back infected braches plant¹. Treatments details are in Figure 3

The present study also noticed that the sub-tropical countries like Bangladesh experience heavy rainfall in every year in the monsoon. Moreover, temperature during rainy season remains within 25–30°C which is congenial for the outbreak disease scab. Under the present study, severe disease incidence was 6 rings the rainy season. Considering on controlling efficiency of all management approaches, die-back and scab infection was found the lowest, when mustard oil cake was applied, followed cow dung, pruning and in combination of mustard oil cake and urea, TSP, MOP, and the combination of mustard oil cake and cowdung. While, fungicide 'Bavistin' could not work well due to use of low quality chemicals available in the market or the disease causal organism have already developed resistance against the chemical used. Therefore, it can be concluded that application of mustard oil cake, urea, TSP, MOP, cowdung, irrigation and fungicide 'Bavistin' in alone or their combination may be suggested for better plant growth with the reduction of die-back and scab of citrus in sub-tropical countries like Bangladesh. The findings of present study has been supported by Benton (1946), Krishna-Murthi and Matllur (1975), BARI (1985), Diware and Kolte (1990) and Islam (2005), who also found lower die-back in citrus plants due to alone or combindly used of mustard oil cake, Urea, TSP, MOP, cowdung, 'Bavistin', irrigation and pruning.

CONCLUSION

The sub-tropical countries like Bangladesh experience heavy rainfall in every year in the monsoon. Temperature during rainy season remains within 25–30°C which is congenial for the outbreak disease scab. Under the present study, severe disease incidence was 6 rings the rainy season. Considering on controlling efficiency of all management approaches, infection of die-back and scab was found the lowest, when mustard oil cake was applied, followed by application of cow dung, pruning, combination of mustard oil cake and urea, Triple Super Phosphate (TSP), Muriate of Potash (MOP), and the combination of mustard oil cake and cowling. However, fungicide 'Bavistin' could not work well to control the dieback. May be due to use of low quality chemicals available in the market or the disease causal organism might have developed resistance against the chemical used. Therefore, it can be concluded that combined application of mustard oil cake, Urea, TSP, MOP, Cowdung, Irrigation and 'Bavistin' may be suggested for better plant growth with the reduction of die-back and scab of citrus in sub-tropical countries including Bangladesh.

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