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Evaluation of different fungicides against stalk rot of Maize caused by *Fusarium moniliforme*

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Abstract

Maize is the world's leading crop and is widely cultivated as a cereal grain, it is the only food cereal crop that can be grown in diverse seasons, ecologies and uses. Maize yields in Pakistan are very poor due to insect pests and diseases. Among them, the stalk rot of maize caused by *Fusarium moniliforme* is very important. Keeping in view the huge losses caused by the disease, the present study was conducted to evaluate the efficacy of selected fungicides against the disease development under field conditions and on the plant growth and yield parameters. A total of six fungicides were used such as Scoure, Plyrem, Topguard, Ridomil, Fenatac M, and Cobox with three different concentrations *i.e.*, (50, 100 and 200 ppm). The effect on disease incidence, growth and yield parameters such as plant height, root length, root weight, leaf weight per plant, grain weight, and biological yield (t acre^{-1}) were recorded. The results showed that all applied fungicides significantly affect against stalk rot of maize caused by *F. moniliforme*. The maximum plant height, root length, root weight, leaf weight per plant, grain weight and biological yield (t acre^{-1}) was noted under Ridomil and Scoure fungicides, followed by Topguard, Cobox, Plyrem and Fenatac M. Whereas, the minimum plant height, root length, root weight, leaf weight per plant, grain weight, and biological yield (t acre^{-1}) was observed under control plants where no fungicides were applied.

Keywords: Fungicide, Evaluation, *Fusarium moniliforme*, Maize, Stalk rot

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1. INTRODUCTION

Compared to rice and wheat, maize is one of the world's main food crops with higher yields. It is the most versatile crop grown in more than 166 countries around the world, with tropical, subtropical, and temperate regions ranging from sea level up to 3,000 meters [1]. In the agricultural economy Maize is the most essential crop, providing food (33.3%) and animal feed (66.6%). It is the basic raw material for making starch, oil, beverage, food sweetener and the latest fuel [2]. The planting area of the world is 140 million hectares and the annual output is 577 million tons [3]. Pakistan's annual corn planting area is 11.394 million ha, with a total yield of 49.971 billion tons and an average yield of 4268 kg per ha. In the tropical, sub-tropical, and marine world's regions, it can be utilized as both food and feed. Corn is consumed for many

uses, such as bread, corn flakes, corn syrup, corn starch, textile, paper, and food industries. Due to the existence of unsaturated fatty acids, Corn oil is suitable to be used for humans. Corn is the main food crop, 3.5% of the production of agricultural products [4]. Maize yields in Pakistan are very poor due to insufficient use of chemical fertilizers, lack of water, maximum planting density, weed growth, insect pests, and key factors affecting the suitable types of crops [5].

Stalk rot and ear rot of Maize are caused by many *Fusarium* species. Though, *Fusarium graminearum* and *Fusarium moniliforme* are pathogenic on maize stalk and root rot [6,7]. *F. moniliforme* and the closely related *F. moniliforme* var. *subglutinans* are responsible for the disease. As a result, which can contaminate feed and food and decrease ear weight, grain quality and mycotoxins. Most inbred lines of maize are sensitive to *F. moniliforme*, but greater sensitivity occurs in high lysine, brown midrib, corn and sweet corn [8,9]. Ateeq et al. [10] surveyed eight areas in central Punjab province of Pakistan, namely Sialkot, Narowal, Gujranwala, Hafizabad, Sheikhupura, Lahore, Okara and Sahiwal; and five districts in southern Punjab, to assess the distribution of corn stalk rot. The survey area showed a 100% prevalence. The incidence rate varies from 41% to 51% in different regions. Sialkot and Sahiwal had the highest disease severity ranging from 17.4% in Hafizabad to 30.2% in Sahiwal. Different species of Fusarium namely *F. vericeiliodes* (Sacc.) Nirenberg, *F. oxysporum* Snyder & Hansen, *F. proliferatum* Nirenberg ex Gerlach & Nirenberg, *F. moniliforme* J. Sheld., *F. bullatum* Sherb., *F. thapsinum* Klittich, Leslie, Nelson & Marasas, *F. incarnatum* (Desm.) Sacc. and *F. acchari* (Butler & Khan) gams were found associated with maize plants infected with a stalk rot disease. Musmade et al. [11] investigated *in-vitro* evaluation of fungicides for controlling the growth of the pathogen and reported that Copper oxychloride was the most effective on the growth of *Fusarium moniliforme*, and the inhibition rate of fungi was 100%, the second was carbendazim (0.1%), thiram (0.2%) and thiophanate methyl (0.1%). The inhibition rates were 86.67%, 79.52% and 71.90%, respectively.

The maize is being attacked by seasonal pests and diseases, including long smut, grain smut, red rot, root rot. Among them, the stalk rot of maize caused by *Fusarium moniliforme* is very important. Keeping in view the huge loss caused by the stalk rot of maize, the present study was conducted to achieve the objectives; survey and sampling of infected plants showing typical symptoms of stalk rot of maize, to evaluate the efficacy of selected fungicides against the disease in field conditions and to evaluate the effect of different fungicides on plant growth and yield parameters.

2. MATERIALS AND METHODS

2.1 Survey and sampling

During Rabi 2019-2020 season survey and sampling of disease specimens were conducted, plants showing typical symptoms of stalk rot were carried out from different maize fields of Tando Allahyar and Hyderabad districts. Four different locations from each district and 5-10 maize plants from each field were randomly selected for disease assessment. The collected specimens were brought to the laboratory of the Department of Plant Pathology, Sindh Agriculture University, Tandojam.

2.2 Isolation of the disease-causing organism

The infected stem showed typical symptoms of stem rot examined under a stereoscopic microscope. Three 5 mm diseased stalks were taken from 5 cm, 10 cm, and 15 cm from the first internode to support the roots as described by Scauflaire *et al.* [7]. Disinfect the surface with 2% sodium hypochlorite for 2 min, and rinse with sterilized water. The pieces were drained and placed on a potato glucose agar modified with streptomycin sulfate (130 µgml-1) to inhibit bacterial growth [12]. The culture was kept at 25°C for two days. The hyphal tip of the fungus was transferred to PDA and grew at 25°C for 2 days. The conidia were isolated by a single spore separation method and cultured at 25°C for 10 days. All fungal isolates were stored in 50% glycerol (contains trace amounts of lactophenol as preservative) until examination [13]. The isolated fungi were identified according to their morphological characteristics as described by Booth [14,] Leslie & Summerell [15].

2.3 Evaluation of different fungicides

For this purpose, six different fungicides were used namely Scoure, Plyrem, Topguard, Ridomil, Fenatac M and Cobox with three different doses *i.e.*, (50 ppm, 100 ppm and 200 ppm). All the experiment was

designed as in (RCBD) with three replications. Disease incidence was scored by using a 0-5 scale described by Bennett & Klich [16].

1. **Plant height**: 5-10 healthy and diseased plants were selected, and the plant height was recorded in cm.
2. **Root length (cm)**: Root length was measured by root area meter and the average value was calculated.
3. **Root weight (g)**: The root weights of 5 healthy and diseased plants were calculated in grams.
4. **Leaves plant^{-1}:** In each treatment, the number of leaves of marker plant^{-1} was counted and the average value was calculated at maturity.
5. **Biological yield (t acre^{-1}):** The biological yield (ton acre^{-1}) was calculated by the following formula:

$$\text{Biological yield} = \frac{\text{biological yield plot}^{-1} \text{ of given treatment (ton)}}{(\text{t acre}^{-1})\ \text{Plot area } (\text{m}^2)} \times 10000\ \text{m}^2$$

2.4 Statistical analysis

Statistical analysis of the student 'version of Statistics' version 1.0, using computer software to analyze the difference between 5% treatment mean difference on LSD and 5% treatment mean.

3. RESULTS AND DISCUSSIONS

3.1 Evaluation of the different fungicides effect on plant growth parameters

Effect of different fungicides on plant height (cm): Data in Figure 1 indicated significant (P≤0.05) differences regarding the plant height. The overall maximum plant height was observed in plants treated with Ridomil (132.50 cm), followed by Scoure (117.50 cm), Topguard (108.20 cm), Cobox (101.70 cm) while plant height produced by Plyrem was (95.50 cm) and Fenatac M (83.10 cm). However, the overall minimum plant height (61.50 cm) was observed in control plants (where no fungicide was applied).

Plants reached maximum height (132.50 cm) when treated with Ridomil at 200 ppm followed by that of 100 ppm (129.30) and 50 ppm (115.10 cm) concentrations followed by plants treated with Score at 200 ppm (117.50 cm), 100 ppm (115.20), 50 ppm (113.60), and Topguard at 200 ppm (108.20), 100 ppm (107.30) and 50 ppm (105.20 cm). Cobox at 200 ppm (101.70), 100ppm (101.10), 50 ppm (99.30 cm), Plyrem at 200 ppm (95.50), 100 ppm (93.60), 50 ppm (91.30 cm) and Fenatac M at 200 ppm (83.10), 100 ppm (81.50) and 50 ppm (79.90 cm). However, the minimum plant height was observed in Control that is 61.50 cm.

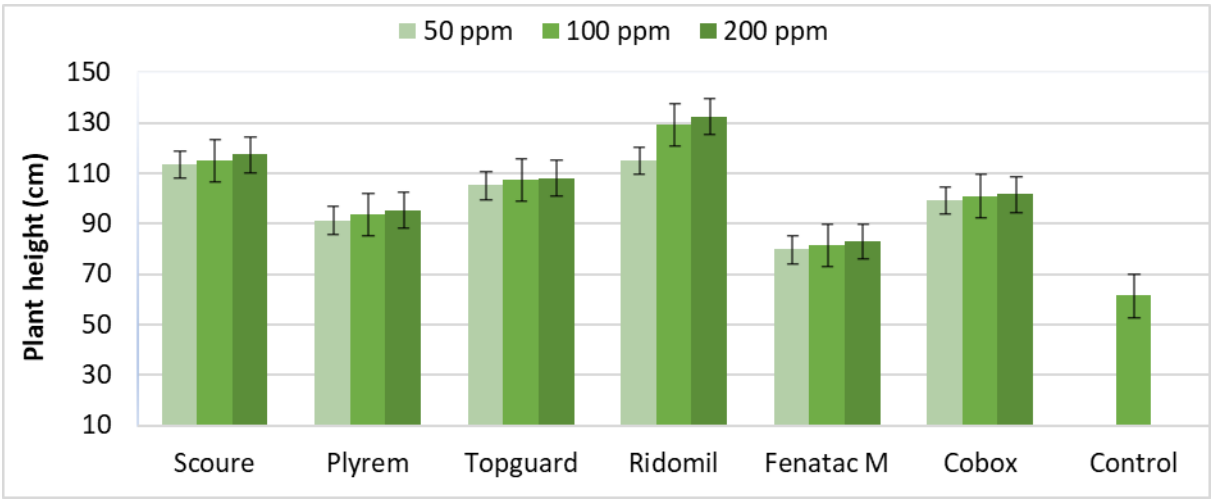

Fig. 1. Effect of different fungicides on plant height (cm) against stalk rot of maize caused by *Fusarium moniliforme*

Effect of different fungicides on root length (cm): Data in (Figure 2) root length (cm) of maize by using different fungicides and their doses shows that the overall maximum root length was observed in plants treated with Ridomil (22.30 cm), followed by Scoure (18.60 cm), Topguard (16.10 cm), Cobox (13.10 cm) while root length produced by Plyrem was (11.00 cm) and Fenatac M (9.70 cm). However, the overall minimum root length (5.80 cm) was observed in control plants (where no fungicide was applied).

The result shows that maximum root length (22.30 cm) was noted under Ridomil when plants were treated at 200 ppm, at 100 ppm (21.90) and at 50 ppm (21.50 cm) followed by Scoure at 200 ppm (18.60), at 100 ppm (18.30) and at 50 ppm (17.50), Topguard at 200 ppm (16.10), at 100 ppm (15.80) and at 50 ppm (15.70 cm), Cobox at 200 ppm (13.10), at 100 ppm (13.00) and at 50 ppm (12.10 cm). Whereas Plyrem and Fenatac M showed the least effective response. However, the minimum root length (5.80 cm) was observed under control. The response shows that Ridomil performed better than other fungicides.

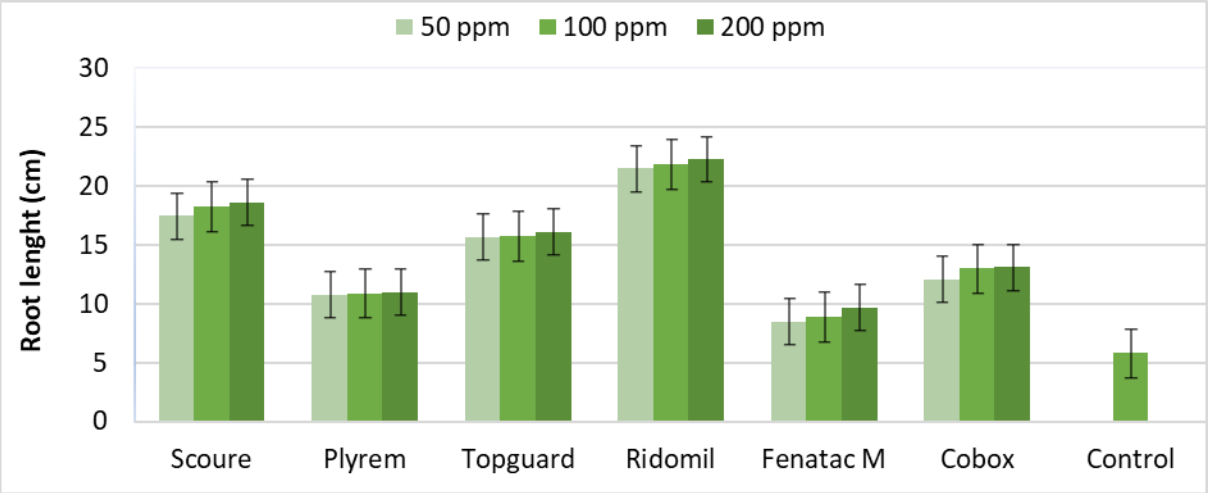

Fig. 2. Effect of different fungicides on root length against stalk rot of maize caused by *Fusarium moniliforme*

Effect of different fungicides on root weight (g): Data in (Figure 3) shows the root weight (g) of maize after using different fungicides with different doses and the overall maximum root weight was observed in plants treated with Ridomil (82.60 g), followed by Scoure (77.50 g), Topguard (71.50 g), Cobox (67.70 g) while root weight produced by Plyrem was (59.90 g) and Fenatac M (52.70 g). However, the overall minimum root weight (43.93 g) was observed in control plants (where no fungicide was applied).

The result shows that maximum root weight was found (82.60 g) when treated with Ridomil at 200 ppm, at 100 ppm (82.10) and at 50 ppm (80.30 g) concentrations followed by plants treated with Score at 200 ppm (77.50 g), at 100 ppm (75.60), at 50 ppm (73.70g), Topguard at 200 ppm (71.50 g), at 100 ppm (69.40), at 50 ppm (67.70g) Cobox at 200 ppm (67.7 g), at 100 ppm (63.90), at 50 ppm (63.40g) Plyrem at 200ppm (59.90 g), at 100 ppm (57.80), at 50 ppm (57.70g) and Fenatac M at 200 ppm (52.70 g), at 100 ppm (52.60), at 50 ppm (49.30g). However, the minimum root weight was observed in Control that is 43.93 g. The response shows that Ridomil performed better than other fungicides.

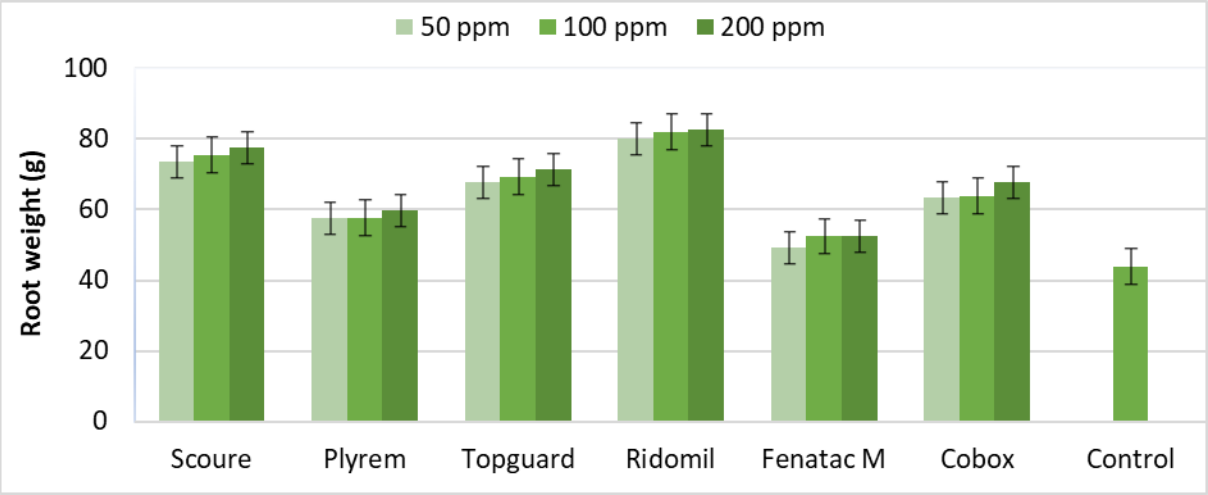

Fig. 3. Effect of different fungicides on root weight against stalk rot of maize caused by *Fusarium moniliforme*

***Effect of different fungicides on leaves plant*$^{-1}$**: Data in (Figure 4) shows the effect of different fungicides with different dosages on the leaves plant^{-1} of maize the overall maximum leaves plant^{-1} was found in plants treated with Ridomil (22.00), followed by Scoure (20.00), Topguard (19.00), Cobox (17.10) while leaves plant^{-1} produced by Plyrem was (15.00) and Fenatac M (13.00). However, the overall minimum leaves plant^{-1} (10.00) was observed in control plants (where no fungicide was applied).

The result shows that maximum leaves plant^{-1} was found (22.00) when treated with Ridomil at 200 ppm and at 100 ppm whereas at 50 ppm (21.00) followed by plants treated with Score at 200 ppm (20.00), at 100 ppm (19.25), 50 ppm (19.00), Topguard at 200ppm (19.00), at 100 (18.00), at 50 ppm (16.85), Cobox at 200 ppm (17.10), at 100 ppm (16.00), at 50 ppm (15.45), Plyrem at 200 ppm (15.00), at 100 (14.00), at 50 ppm (13.33), and Fenatac M at 200 ppm (14.00), at 100 (13.00) and 50 ppm (12.20). However, the minimum leaves plant^{-1} was observed in Control that is 10.00. The response shows that Ridomil performed better than other fungicides.

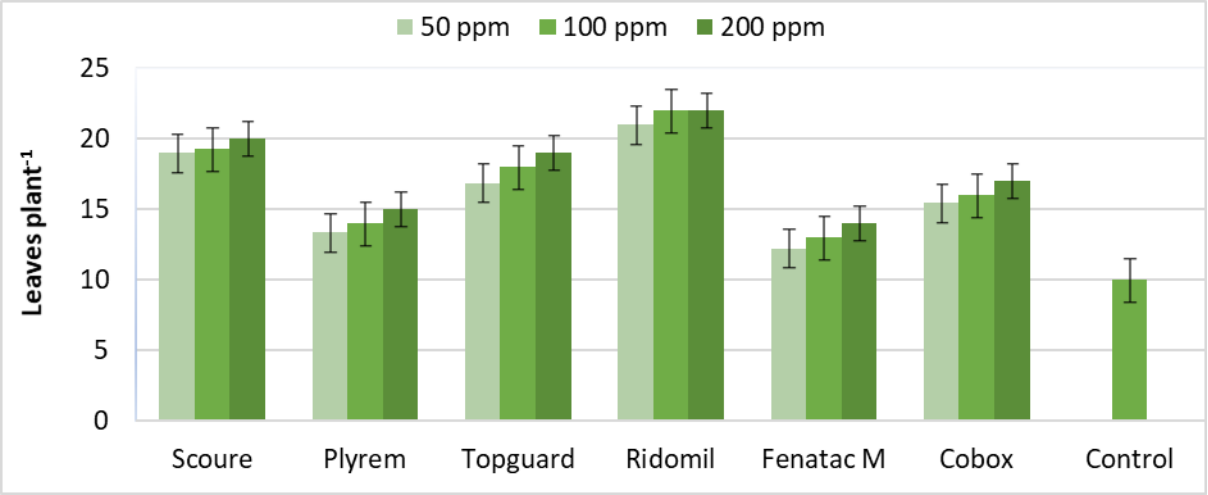

Fig. 4. Effect of different fungicides on leaves plant^{-1} against stalk rot of maize caused by *Fusarium moniliforme*

3.2 Effect of fungicides on yield parameters of maize

Effect of different fungicides grain weight (g): Data in (Figure 5) shows the effect of different fungicides with different dosages on the grain weight of maize, the overall maximum grain weight was found in plants treated with Ridomil (501.10 g), followed by Scoure (479.00 g), Topguard (434.62 g), Cobox (406.30 g) while grain weight produced by Plyrem was (385.70 g) and Fenatac M (352.44g). However, the overall minimum grain weight (312.13) was observed in control plants (where no fungicide was applied).

The result shows that maximum grain weight was found (501.10 and 501.00 g) when treated with Ridomil at 200 ppm and at 100 ppm, whereas at 50 ppm (500.00 g) followed by plants treated with Score at 200 ppm (479.00), at 100 (477.70) and at 50 ppm (475.50), Topguard at 200 ppm (434.62), at 100 (432.75) and at 50 ppm (430.15 g), Cobox at 200 ppm (406.30), at 100 (403.75) and at 50 ppm (401.45 g), Plyrem at 200 ppm (385.70), at 100 (381.58) and at 50 ppm (378.26 g), and Fenatac M at 200 ppm (352.44), at 100 (351.15) and at 50 ppm (349.10 g). However, the minimum grain weight was observed in Control that is 312.13 g. The response shows that Ridomil performed better than other fungicides.

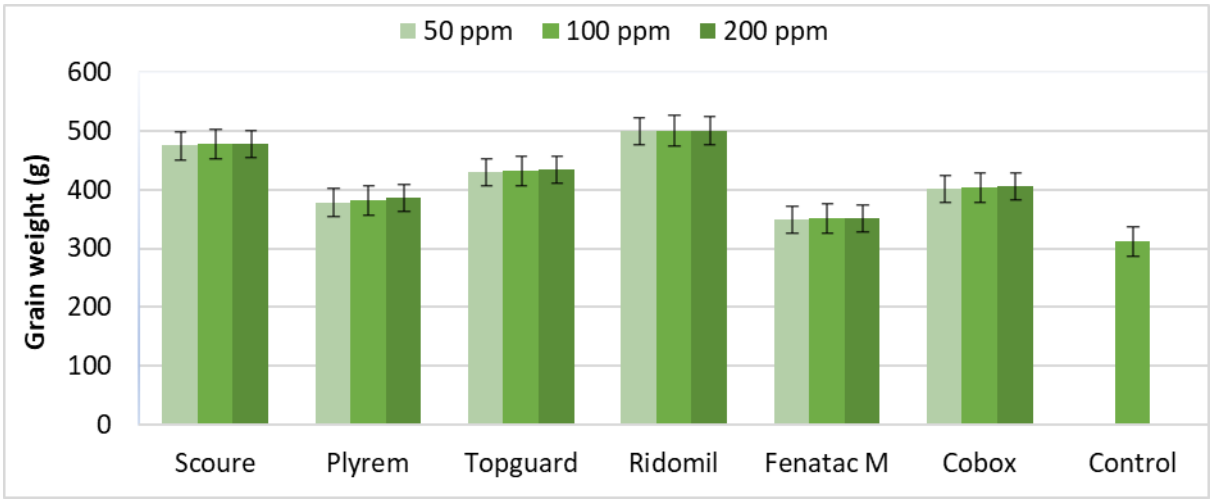

Fig. 5. Effect of different fungicides on grain weight against stalk rot of maize caused by *Fusarium moniliforme*

Effect of different fungicides biological yield (t acre^{-1}): Data in (Figure 6) shows the effect of different fungicides with different dosages on the biological yield (t acre^{-1}) of maize, the overall maximum biological yield (t acre^{-1}) was found in plants treated with Ridomil at 200 ppm (29.30 t acre^{-1}), 100 ppm (28.60), 50 ppm (27.50) followed by Scoure at 200 ppm(25.70 t acre^{-1}), at 50 ppm (24.50), at 100 ppm (24.20), Topguard at 200 ppm (23.60 t acre^{-1}), at 100 ppm (22.70), at 50 ppm (22.10), Cobox at 200 ppm (22.70 t acre^{-1}), at 100 ppm (21.50), 50 ppm (20.40) while biological yield (t acre^{-1}) produced by Plyrem at 200 ppm was (18.60 t acre^{-1}), at 100 ppm (17.50), 50 ppm (16.50) and Fenatac M at 200 ppm (16.90 t acre^{-1}), at 100 ppm (16.60) and 50 ppm (15.70). However, the overall minimum biological yield (t acre^{-1}) (12.27 t acre^{-1}) was observed in control plants (where no fungicide was applied). The response shows that Ridomil performed better than other fungicides.

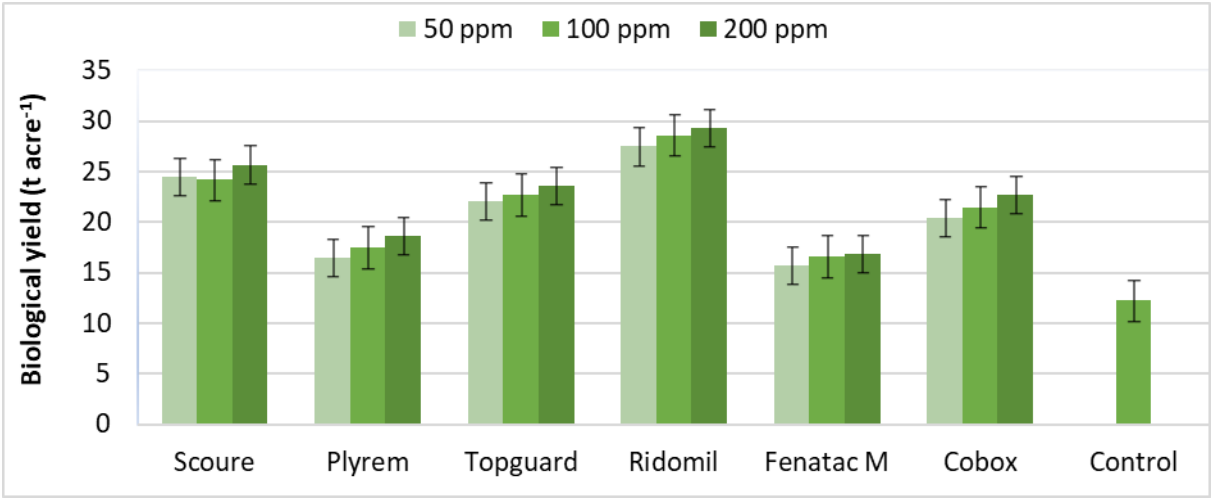

Fig. 6. Effect of different fungicides on biological yield (t acre^{-1}) against stalk rot of maize caused by *Fusarium moniliforme*

Many fungicides were tested by other researchers and found many of them were effective for the stalk rot of Maize. In this study, it was noted that Ridomil fungicide at 200 ppm performed better against stalk rot of maize throughout the experiment and produced the maximum value among all growth and yield parameters of maize crop. Our findings are also in confirmation to those reported by Jagtap et al. [17], who observed that Ridomil exhibited excellent control. To combat *Fusarium moniliforme*, Tagne et al. [18] tested three different seed treatment fungicides on highly infected seedlings. He found that Apron star, Benlate and Marshall significantly increased the germination rate.

3.3 Disease incidence of different maize varieties against stalk rot of Fusarium moniliforme

Six randomly selected varieties of Maize from six different locations of Tando Allahyar and Hyderabad were checked during the survey *i.e.*, Shehenshah at Machi Hotel, Pak-Afgoi at Chambar, Akbari at Chambar, Kargal at Moosa Khatian, Red seed at Khesana Mori and White at Tando Jam. The minimum disease incidence was reordered in Shehenshah (33%), followed by Pak Afgoi (36%), Akbari (41%), Kargil (45%), Red seed (50%). However, the White variety of maize showed the highest disease incidence that is (51%).

Plant diseases are crucial to humans because they damage plants and plant products on which humans depend for food, clothing, furniture and the environment. In Maize (*Zea mays* L.), *Fusarium moniliforme* is the most prevalent fungal pathogen that can cause seedling disease, root rot, stalk rot, ear or kernel rot. Different researchers studied the wide range of diseases caused by *Fusarium moniliforme* in several crops [19-21]. The results from disease incidence indicated that *Fusarium moniliforme* was the most prevalent fungal pathogen and caused stalk rot of maize. However, Shehenshah variety is an average variety from other varieties and better performed against the disease (**Error! Reference source not found.**).

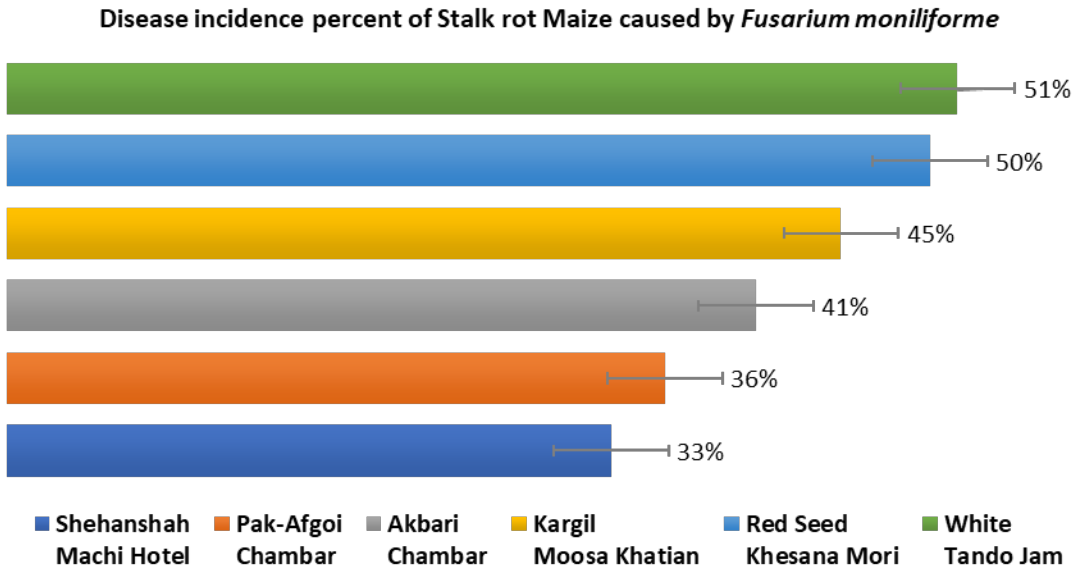

Fig. 7. Disease incidence of different maize varieties in different locations

4. CONCLUSIONS

It is concluded that all tested fungicides showed a significant effect against the stalk rot of maize caused by *Fusarium moniliforme*. It is also noted from the results that Ridomil at 200 ppm performed better throughout the experiment and produced maximum value in all the growth and yield parameters of maize crops. The results from disease incidence show that Shehenshah variety is an average variety from other varieties and better performed against the disease. In the place of disease, effective fungicides should be used to minimize the losses caused by Fusarium stalk rot of maize. Shehenshah variety in maize performs very well in all parameters so it is suggested to the growers that choosing Shehenshah variety for fodder or grain purpose will be beneficial. Metalaxyl-M group of fungicides are very effective against the targeted pathogen, so it is suggested that the timely use of fungicides will improve crop yield.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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