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Comparison of Chemical and Biological Control Techniques to Stem Rot Fusarium Spp. On Fig Seedlings (Ficus Carica L.) as an Effort to Substitute Agrochemical Inputs in Environmentally Friendly Control

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Abstract: Figs have many benefits to treat various health problems, so it is necessary to breed vegetatively so that the production of figs can increase in the future. Fig nurseries have problems with the success of seedlings caused by stem rot disease due to the attack of pathogen Fusarium spp. This study aims to determine the ability of chemical and biological control techniques in suppressing the intensity of stem rot disease caused by pathogen Fusarium spp., as well as looking for substitution of agrochemical inputs for environmentally friendly disease control. The research was conducted at greenhouse faculty of agriculture, Batik Islamic University of Surakarta, from September 15, 2020 to December 23, 2020. The study used a Complete Randomized Design (RAL), with 6 types of control technique treatments, consisting of control, biological Trichoderma spp., biological Gliocladium spp., biological Corynebacterium spp., biological PGPR, and chemical Mankozeb, which was repeated 3 times and 3 times subrepannant. Observation consists of the parameters of the incubation period of the disease, the incidence of the disease, and the severity of the disease. The results showed that the treatment of biological control techniques was able to reduce the intensity of disease attacks with the best results obtained in trichoderma spp biological control agents (APH). which is able to delay the incubation period of the disease up to 48.89hsi, reduce the incidence of the disease by 88.89%, and reduce the severity of the disease by up to 97.78% because it has antagonism abilities in the form of competition mechanisms, mycoparasites, and antibiosis. Ability APH Trichoderma spp. can be an alternative solution to substitute agrochemical inputs in disease control that is more environmentally friendly and sustainable and can maintain natural balance in agroecosystems.

Keywords: Biological Control Technique; Chemical Control Technique; Ficus Carica L; Fusarium Spp; Stem Root

Introduction

Figs are commonly known by the name of tin fruit, and this fruit has many benefits so dubbed as the fruit of heaven. Figs are an important source of calcium, iron, fiber, and phosphorus, which have been used around the world to treat a variety of health problems (Hossain et al., 2020). Fig products are widely used as medicines for the treatment of various diseases because they contain active substances such as flavonoids, tannins and terpenes that are known to have antibacterial and antiviral potential (Shamin-Shazwan et al., 2019).

According to Setianingsih (2020), figs have the potential to strengthen the immune system, so as to prevent the attack of new coronavirus (2019-nCoV) causes COVID-19. Figs can be consumed as a form of COVID-19 prevention, because they contain active compounds that can strengthen the immune system and can reduce risk factors such as diabetes and cancer.

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Based on this, figs can be a very promising fruit in the future, so it is necessary to do nurseries so that the yield of figs can increase from before. This is done to support the global action plan in the SDG's (Sustainable Development Goals) 2030 agenda. According to BPS, (2014) one of sdg's 2030 objectives is to realize food security and improved nutrition in order to improve the health and well-being of the community.

Breeding fig plants can be done in a generative or vegetative way, but it is highly recommended to use vegetative breeding techniques, because according to Duaja et al. (2020), vegetative breeding plants will bear fruit faster so that production can increase faster than generative nurseries (Paradjiković et al., 2019).

Observations and interviews that researchers conducted on fig seed farmers in Jakarta, Bekasi, Semarang, Karanganyar, and Bandung have the same problem of failure in the breeding process caused by the attack of stem rot disease. The isolation of pathogens carried out by Jahén-Rivera et al. (2020) states, that the pathogen Fusarium spp. is one of the causes of the attack of the disease (Herlina et al., 2021).

There has been no research on stem rot disease control techniques in the fig seedlings. Usually, farmers use chemical control techniques in the form of synthetic fungicide application Mankozeb, but it is dangerous for the environment and humans. According to Sopialena (2018) and Sunarno (2012), more environmentally friendly integrated disease control efforts can use biological control techniques by utilizing the potential of biological control agent microorganisms (APH). This research was conducted to look for substitution of agrochemical inputs that are more environmentally friendly.

Method

The research was conducted at the Greenhouse faculty of agriculture, Batik Islamic University of Surakarta, from September 15, 2020 to December 23, 2020. Tools used include: branch cuttings, buckets, mini shovels, ropes, 12x12 polybags, knives, paranets, sterile filter paper, measuring cups, petri cups, glass test tubes, and measuring instruments. Materials used include: fig stems, organic fertilizer kohe cow, sawdust wood, soil, raw husks, alcohol, isolate Fusarium spp., sterile water, dextrose potatoes, chlorroks, and disease control materials (mentioned in the design).

The research was conducted in vivo experimental test which was prepared on a non-factorial basis using a Complete RandomIzed Design (RAL) with 6 types of treatments consisting of: M0 (control or without control), M1 (biological control technique of APH mushroom "Trichoderma spp."), M2 (biological control technique of cend APHawan "Gliocladium spp."), M3 (biological control technique of APH bacteria "Coryebacterium spp."), M4 (biological control technique of APH bacteria "PGPR"), and A5 (chemical control technique of synthetic fungicide "Mankozeb") , which is repeated 3 times and 3 times the sub-repeat.

The implementation of research consists of isolation and breeding of pathogen Fusarium spp., vegetative fig breeding, and application of disease control techniques. Isolate pathogen Fusarium spp. obtained from Watusambang Ara Garden (Karanganyar) by means of isolation of sick fig rods then reproduced in the Laboratory of Pest and Disease Observation Palur (Sukoharjo). The trick is to cut the diseased part of the stem, soak it in a solution of chlorine, then wash it thoroughly with sterile water and dry it on sterile filter paper, then incubate the fragments on the media so that the potatoes dextrose until the hyphae grows. Then separate again to get a pure culture, and place the culture in a petri dish until harvesting, then the spores are put in a glass test tube.

Nursery preparation is done by taking fig seedling material with vegetative techniques of stem cuttings, how to cut the trunk using branch cuttings on a 5-year-old fig tree in The Ara Tulakan Garden (Karanganyar), then cut again with a size of 15 cm each trunk, then cut the ends at an angle of 45o. After the seedlings of figs from the stem cuttings are ready, then the nursery can then be done. The nursery was conducted at the Greenhouse faculty of Agriculture, Islamic University of Batik (Surakarta) which has been given the shade of paranet. Seedlings to be planted are infested with pathogen Fusarium spp. and inoculation of control materials by immersion. Seedlings are planted in polybags with a mixture of cow's kohe fertilizer, sawdust, raw husks, and soil (ratio 1:2:2:1). The treatment of control technique application is done by watering the seedlings with control materials M0, M1, M2, M3, M4, M5 according to the recommended dose every 1 week of leaking.

Observation parameters include: incubation period of disease (hsi), incidence of disease (%), and severity of disease (%). The incidence of disease is calculated using the Formula 1. The severity of the disease is calculated using the Formula 2.

The score score for each disease severity category is determined based on the following symptoms:
0 = Healthy plants (not symptomatic)
1 = The stem has fine threads (hyphae) in white
2 = The stem part is white and begins to appear black
3 = The black stem part is slightly rotten and appears orange hyphae
4 = The stem rots and the epidermis skin is removed
5 = Dead plants

The observation data was conducted statistical tests using F test at the level of 5% and 1%, and continued with Duncan test at the level of 5% when there are real differences or differences are very real.

$$F = \frac{n}{N} 100\% \quad (1)$$

Description:
F = Incidence of disease (%)
n = Number of fig plant seedlings affected and dead
N = Number of fig plant seedlings observed

$$I = \frac{\Sigma(n.v)}{(N.Z)} 100\% \quad (2)$$

Description:
I = Severity of the disease (%)
n = number of fig seedlings with a certain score
N = total number of fig seedlings observed
v = scale value of disease severity
Z = highest score

Result and Discussion

The results showed that the treatment of control techniques can suppress the incubation period of the disease (figure 1), the incidence of disease (figure 2), and the severity of the disease (figure 3) in the seedlings of figs (*Ficus carica* L).

The results of the print test variety of test F incubation period of the disease has a value of Fcalc. 70.14. Based on the test results, it is known that Fcalc (70.14) > Ftable 5% (3.11) and Ftable 1% (5.06). Statistically, if Fcalc > Ftable then the treatment given has a real effect (>Ftable 5%) or very real (>Ftable 1%). This suggests that the treatment of control techniques has a very real effect on the incubation period of the disease (Ftable 5% < Fcalc. > Ftable 1%), thus the hypothesis has been answered (H0 rejected and H1 accepted). The next statistical test used Duncan's test tool at 5% to determine which control technique produced the best value in suppressing the incubation period of the disease. Duncan's test results are presented in Figure 1.

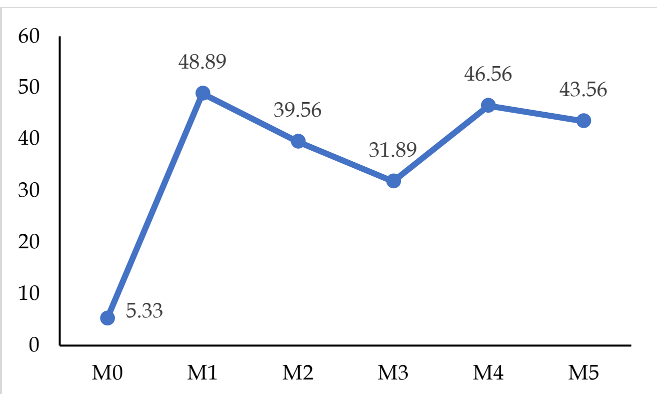

Figure 1. Graph of the influence of control techniques on the incubation period of disease

The results of the print test variety of test F incubation period of the disease has a value of Fcalc. 70.14. Based on the test results, it is known that Fcalc (70.14) > Ftable 5% (3.11) and Ftable 1% (5.06). Statistically, if Fcalc > Ftable then the treatment given has a real effect (>Ftable 5%) or very real (>Ftable 1%). This suggests that the treatment of control techniques has a very real effect on the incubation period of the disease (Ftable 5% < Fcalc. > Ftable 1%), thus the hypothesis has been answered (H0 rejected and H1 accepted). The next statistical test used Duncan's test tool at 5% to determine which control technique produced the best value in suppressing the incubation period of the disease. Duncan's test results are presented in Figure 1.

Based on Figure 1, Duncan's test results at the level of 5% above showed differences in notation (a, b, c, d) that showed a significant difference in influence between the treatment of control techniques (M0, M1, M2, M3, M4, M5) to the incubation period of the disease.

Duncan's test results showed that: (1) M0 treatment or control differed markedly from M1, M4, M5, M2, and M3; (2) Treatment of M1 or biological control techniques of Trichoderma spp. different real with M2, M3, and M0, but different not real with M4 and M5; (3) Treatment of M2 or biological control techniques of Gliocladium spp. different real with M1, M4, M3 and M0, but different not real with M5; (4) Treatment of M3 or biological control techniques of Corynebacterium spp. significantly different from M1, M4, M5, M2, and M0; (5) The treatment of M4 or PGPR biological control techniques differs markedly from M2, M3, and M0, but differs unreally with M1 and M5; and (6) The treatment of M5 or Mankozeb chemical control techniques differs markedly with M3 and M0, but differs not markedly with M1,M4, and M2.

Duncan's test results at 5% level showed that the incubation period of the disease with the highest value was obtained in the treatment of M1 (Trichoderma spp.) which is 48.89 hsi or began to appear symptoms of the disease on the 48th day after the infestation, while the incubation period of the disease with the lowest value obtained in the treatment M0 (Control) is 5.33 hsi or began to appear symptoms of the disease on the 5th day after infestation. The higher the value, the better the treatment gives the best results against the suppression of the incubation period of the disease.

The treatment of control techniques against the suppression period of incubation of the disease with the best value obtained in the treatment of biological control techniques Trichoderma spp. with an incubation period of 48.89 hsi, then the next best treatment in sequence includes: pgpr biological control technique (46.56 hsi), chemical control technique Mankozeb (43.56 hsi), biological control technique Gliocladium spp. (39.56

hsi), corynebacterium spp biological control technique. (31.89 hsi), and without control or control (5.33 hsi).

Biological control techniques by utilizing microorganisms used in treatments such as Trichoderma spp., Gliocladium spp., Corynebacterium spp., and PGPR were shown to suppress the incubation period of the disease because these microorganisms have antagonism capabilities to pathogenic microorganisms, including fusarium spp pathogens.

This is in line with Rifai et al. (2020) statement that if bacteria or mushrooms have the ability to inhibit the growth of pathogens, then it can be said that the bacteria or mushrooms are antagonistic and cause antagonism interactions through several mechanisms. The antagonistic mechanism that usually occurs against pathogens is through the mechanism of competition, parasitism, and antibiotics.

The emphasis of disease incubation period on biological control techniques that have proven effective in slowing the incubation of pathogens, it is suspected that the antagonistic microorganisms used in this study have a superior mechanism of competition than pathogenic microorganisms. This is in line with Prabowo et al. (2006) statement that the emphasis on the incubation period of disease is due to competition between antagonistic microorganisms and pathogenic microorganisms in the form of competition for survival and nutrient struggle in the growing media, thus requiring a longer penetration time to infect plant tissues for pathogens. Djafaruddin (2000) statement supports this, that one of the important factors of antagonistic microorganisms in the control of pathogenic microorganisms is the high rate of growth of antagonists capable of competing with pathogens in the same space.

Trichoderma spp., Gliocladium spp., Corynebacterium spp., and PGPR are antagonistic microorganisms dubbed as biological control agents (APH) because they have antagonism capabilities in the form of superior competition mechanisms, as evidenced by the results of this study which is a slowdown in the incubation period of disease in each type of APH microorganisms used in biological control techniques. APH microorganisms are able to compete with the pathogen Fusarium spp. in contesting space or place of life and also nutrition or food so as to inhibit the growth of fusarium spp colony. although in different efficacy times depending on each type of APH microorganisms used. The results showed that APH microorganisms of the mushroom type Trichoderma spp. in biological control techniques capable of provides the best throttling of chemical control and control techniques.

This is in accordance with the statement of Baker & Cook, (1982), that fungi APH Trichoderma spp. has the ability of antagonism to fight pathogenic fungus Fusarium spp. The APH mushroom has the ability of competitive mechanisms to compete sporadically, so that it can quickly master space and nutrition, and then lead to the population of Trichoderma spp. exploded in the medium, resulting in the growth of pathogen Fusarium spp. Hampered. This makes pathogenic infections slower, thus suppressing the incubation period of the disease. Simbolon (2016) conducted research on the antagonistic abilities of APH Trichoderma spp mushrooms. against Fusarium disease in tomato plants, and the results showed that the application of Trichoderma spp. can also effectively suppress the incubation period of fusarium withering disease that often attacks tomatoes.

The suppression of the incubation period due to the implications of control techniques applied in this study, shows that biological control techniques proved effectively able to suppress the incubation period of disease compared to chemical control techniques, so that it can be used as a substitution of agrochemical inputs in suppressing the intensity of disease, especially to suppress the incubation period of disease in an effort to control environmentally friendly integrated diseases that do not cause new problems in environmental health and human health and ecology.

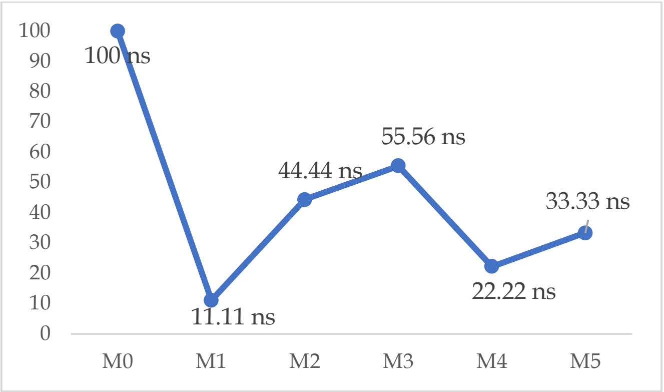

Figure 2. Graph of the influence of control techniques on disease occurrence

The test results of the F test variety of disease occurrence have a value of Fcalc. 2.45. Based on the test results it is known that Fcalc (2.45) < Ftable 5% (3.11) and Ftable 1% (5.06). if Fcalc < Ftable then the treatment given has no real effect (ns). This indicates that the treatment of control techniques has no real effect on the incidence of disease (Ftable 5% > Fcalc. < Ftable 1%), thus H0 is accepted and H1 is rejected, so subsequent tests cannot be continued.

Based on Figure 2, the F test results that show the difference is not real because in all control treatments (be it control, biological, even chemical) there are symptoms of stem rot fusarium spp. although the incubation period is different as well as the frequency of the number of stricken seedlings. Attack of stem rot disease on fig seedlings caused by pathogenic fungus Fusarium spp. it can be seen from the appearance of symptoms on the stem of the disease in the form of patches of mycelium yarn (hyphae) white which indicates that there has been colonization of pathogens with the formation of many spores in the tissues of plants formed in the host plant or fig seedlings (F. carica L.) which then makes the fig stem turn black due to the death of plant cells due to the pathogenic infection. If a colony of pathogens forms a large amount of sporodocium, then the mycelium will change from white to orange, so that the affected stem will lose a lot of fluid until the epidermis escapes, then the plant dies.

However, the frequency of the number of seedlings affected by the symptoms of the disease can be seen the difference in all treatment control techniques in figure 2 above. In detail, the results of the study of the influence of control techniques on the incidence of disease in each treatment include: on control or without control of disease attacks against 100% of the seed population, biological control of Trichoderma spp. 11.10%; biological control of Gliocladium spp. 44.44%; biological control of Corynebacterium spp. 55.56%; biological control of PGPR 22.22%; and chemical control mankozeb 33.33%. The incidence of the disease in Nisa (2018) is also influenced by the speed of infecting the pathogen Fusarium spp. into the tissues of plants.

The results showed that biological control techniques are able to suppress the speed of pathogenic infection Fusarium spp. so that pathogens experience incubation slowing that implies a difference in the percentage of disease occurrence in each type of APH treatment used in biological control techniques, with the best results obtained in APH Trichoderma spp mushrooms. which is able to reduce the incidence of disease up to 88.89%, because the occurrence of the disease is only 11.10%.

The reason why Trichoderma spp. give the best results because according to Oka (1995) Trichoderma spp. is an APH mushroom that has the ability of antagonism which if the antagonist is inoculated into the planting medium or soil will cause an increase in the number of antagonistic populations in the planting medium or soil. Through the mechanism of competition or competition causes inhibition and decrease in the number of pathogens because the antagonist further invades the pathogen by entangling the pathogen hyphae through the mechanism of mycoparasites, so that it can paralyze the pathogen which then leads to a decrease in the ability of the pathogenic infection to the host plant. Suanda (2017) states that the mechanism of mycoparasitism of the antagonist mushroom Trichoderma spp. it is by making helical coils on the pathogenic hyphae Fusarium spp. and form a hook-like structure. The antagonist hyphae attach and wraps into the pathogenic hyphae, and then degrades part of the pathogenic cell wall, allowing the antagonist to penetrate the pathogen's cell wall due to lilies, and then the pathogen will die.

Lovelyana (2018) conducted research on sugar cane seedlings inoculated with APH Trichoderma spp. and the results prove that this method of biological control can reduce the incidence of diseases in sugar cane.

The test results of the test F severity of the disease has a value of Fcalc. 46.25. Based on the test results, it is known that Fcalc (46.25) > Ftable 5% (3.11) and Ftable 1% (5.06). Statistically, if Fcalc > Ftable then the treatment given has a real effect (>Ftable 5%) or very real (>Ftable 1%). This suggests that the treatment of control techniques has a very noticeable effect on the severity of the disease (Ftable 5% < Fcalc. > Ftable 1%), thus the hypothesis has been answered (H0 rejected and H1 accepted). Further statistical tests used Duncan's 5% test tool to determine which control techniques produced the best value in suppressing disease severity. Duncan's test results are presented in Figure 3.

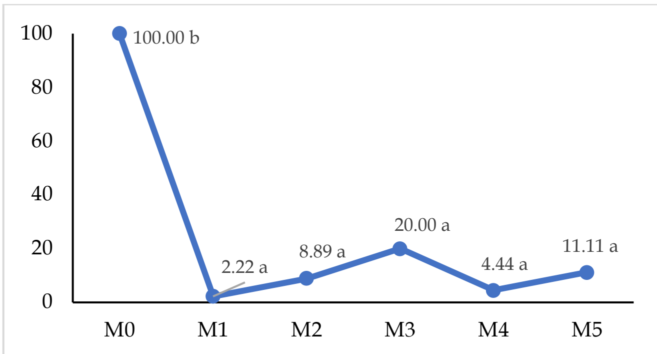

Figure 3. Graph of the influence of control techniques on the severity of the disease

Based on Figure 3, Duncan's test results at the level of 5% above showed differences in notation (a, b) that showed a significant difference in influence between the treatment of control techniques (M0, M1, M2, M3, M4, M5) to the severity of the disease.

Duncan's test results showed that: (1) M0 Treatment treatment or control differed markedly from M3, M5, M2, M4 and M1; (2) Treatment of P1 or biological control techniques of Trichoderma spp. real different from M0, but not real different from M3, M5, M2, and M4; (3) Treatment of P2 or biological control techniques of Gliocladium spp. real different from M0, but not real difference with M3, M5, M4, and M1; (4) Treatment of M3 or biological control techniques of Corynebacterium spp. real different from M0, but different not real with M5, M2, M4, and M1; (5) The treatment of M4 or PGPR biological control techniques differs markedly from M0, but differs markedly from M3, M5, M2, and M1; (6) The treatment of M5 or Mankozeb chemical control techniques differs markedly from M0, but differs markedly from M3, M2, M4, and M1.

Duncan's test results at 5% showed that the lowest percentage of disease severity obtained in P1 treatment (Trichoderma spp.) was 2.22%, while the highest percentage of disease severity obtained in P0 treatment (Control) was 100%. The lower the value, the better the treatment given to the best results against the suppression of the severity of the disease.

Treatment of control techniques against the suppression of disease severity with the best percentage obtained in the treatment of biological control techniques *Trichoderma* spp. (2.22%), meaning it is able to reduce the severity of the disease by 97.78%. The next best treatment in a row included: PGPR biological control technique (4.44%) or suppress the severity up to 95.56%, biological control technique *Gliocladium* spp. (8.89%) or reduce the severity to 91.11%, Chemical Control Techniques Mankozeb (11.11%) or suppress the severity of up to 88.89%, corynebacterium spp biological control technique. (20%) or reduce the severity by up to 80%, and control (100%) or without emphasis on severity due to pressing 0%.

The results of pulungan et al. (2014) also showed that the severity of disease in rubber plant nurseries due to white root fungal pathogens produced the highest severity of control treatment (83.33%), and the lowest severity in biological control treatment of APH antagonist *Trichoderma* spp. (5,5%).

Simbolon (2016) suggests that if the incubation period is fast then the percentage of disease severity in plants will be higher, but if the incubation period is slow or delayed then the percentage of disease severity in plants will also decrease. The delay of the incubation period of the disease leads to a decrease in the severity of the disease.

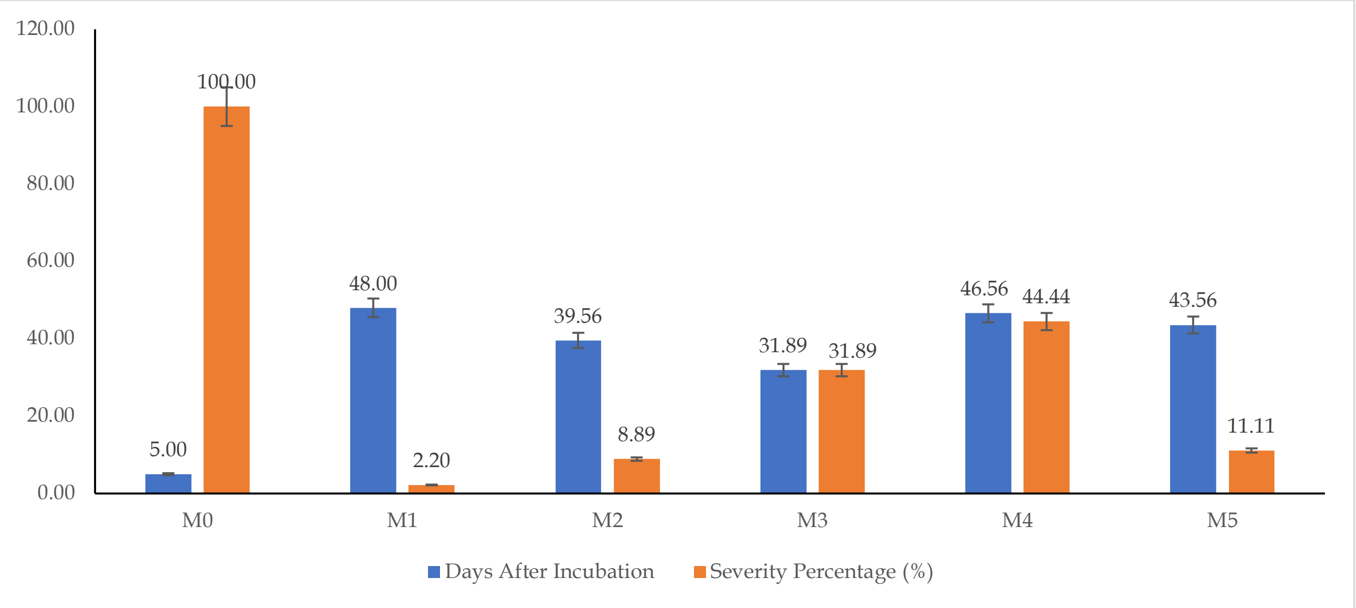

Figure 4. The relationship between the incubation period of the disease and the severity of the disease

Based on Figure 4, it can be concluded that the incubation period of the disease is related to the percentage of severity of the disease. The incubation period of M0 (control or without control) that appears at 5 hsi, is associated with the highest percentage of disease severity, which is 100%. The incubation period of M1 (biological control technique Trichoderma spp.) which appears at 48 days after invesment, is associated with the lowest percentage severity of the disease, which is 2.2%. Similarly, the treatment of M2, M3, M4, and M5, so it can be concluded that biological and chemical control techniques are able to delay the incubation period of the disease, which is then related in reducing the severity of the disease.

Biological control techniques of microorganisms type Trichoderma spp., Gliocladium spp., Corynebacterium spp., and PGPR are able to suppress the severity of the disease better than control (Abdelaziz et al., 2023; Omidvari et al., 2023), not even less good with chemical control techniques Mankozeb.

The results showed that the treatment of biological control techniques of various types of APH microorganisms, was shown to suppress the intensity of the disease because it has the ability of antagonism to pathogens Fusarium spp. causes of stem rot disease in fig seedlings from stem cuttings through various mechanisms. The antagonist mechanism is by competitive, antibotic, and mycoparasitic mechanisms (Gajera et al., 2013; Nusaibah & Musa, 2019), so it is effective in inhibiting the pathogenic growth of Fusarium spp. However, the antagonistic mechanisms of each biological agent will provide different efficacy, and it is influenced by the resulting antibiotic substances, as well as the ability to compete for the speed of growth by each of these biological agents.

Based on the above statement, researchers can conclude that the antagonism ability possessed by APH microorganisms against pathogenic microorganisms Fusarium spp. in biological control techniques is through the mechanism of competition of space and nutrition, where APH is able to grow very quickly and aggressively so that it can control the space and seize all available nutrients, then from the invasion occurred the mechanism of mycoparasitism in the form of hyphae fungi antagonist into the hyphae fungi pathogens, then there is the mechanism of antibiosis APH by removing antibiotic substances in the form of secondary metabolite compounds capable of making lysis and vakoulation of Fusarium spp cells. , so that APH can penetrate and enter into the pathogen hyphae, until finally pathogen Fusarium spp. will slowly die as APH grows in it.

Experiments that researchers conducted on the pathogen Fusarium spp. causes of stem rot disease in fig seedlings, where the results showed that the treatment of biological control techniques of the type APH Trichoderma spp. proven superior to other APH microorganisms, indicating that the antagonism capability of APH Trichoderma spp. it is very effective to reduce the intensity of the disease such as delay in incubation period, suppression of disease occurrence, and suppression of disease severity.

In line with the statement of Ningsih et al. (2016); Venkataramanamma et al. (2022); and Younesi et al. (2021), that Trichoderma spp. grow faster than pathogen Fusarium spp., so as to dominate the competition of space and nutrition. APH Trichoderma spp. it also has the ability to release antibiotic compounds released when wrapped around pathogenic hyphae to thin cell walls. Compounds and enzymes produced by Trichoderma spp. volatile and nonvolatile, which can inhibit the colonization of pathogens against host plants, thus reducing the intensity of the disease.

The control techniques used indicate that the biological control technique of APH Trichoderma spp. able to obtain better results than Mankozeb chemical control techniques in suppressing the intensity of the disease. This proves that agrochemical inputs of synthetic pesticides can be substituted by biological control of biological pesticides type APH Trichoderma spp. more environmentally friendly.

That the long-term use of agrochemical pesticides from the mankozeb synthetic fungicide for disease control will lead to increased disease intensity, decreased diversity of soil microorganisms and decreased crop productivity. This is in accordance with Syamsuddin (2003) view that the use of synthetic fungicides for disease control can have a negative impact on the environment, such as environmental pollution, pathogen resistance, and the death of non-target organisms such as natural enemies and antagonists.

Given the negative impact of the use of agrochemical inputs on the environment, the use of antagonistic biological control agents (APH) can be one of the alternative solutions for disease control as described in this study, that this APH is proven to reduce the intensity of disease and can be used as a biological pesticide. For farmers and all parties involved, the use of biological control techniques from biological pesticides can be used as a substitute to replace chemical agro-crops because it is more environmentally friendly and can maintain the balance of nature.

Sopialena (2018) suggests that the use of biological pesticides for disease control will not have an impact on the environment and humans, so the application is very safe and can maintain the balance of ecosystems.

Conclusion

Biological control techniques are able to suppress the intensity of stem rot disease due to Fusarium spp. with the best results obtained on the treatment of Trichoderma spp. which is able to delay the incubation period of the disease to 48.89 day after invesment, reduce the incidence of the disease by 88.89%, and reduce the severity of the disease by up to 97.78%. Trichoderma spp application. in biological control techniques can be used as substitution of agrochemical inputs in integrated disease control that is more environmentally friendly.

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