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The Effect of Smoking Treatment on Infection Level, Dormancy, and Physiological Quality of Shallot Seed

Wariyanti[1]✉, Leopold O. Nelwan[2], Sutrisno[2]

[1]Departement of Postharvest Tecnology, IPB University, Bogor, INDONESIA
[2]Department of Mechanical and Biosystem Engineering, IPB University, Bogor, INDONESIA

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✉Corresponding Author:
wariyanti119@gmail.com

ABSTRACT

Plant-derived smokes has antimicrobial activity and have been reported to have the ability to promote germination for various kinds of plant seeds. The purpose of this study was to analyze the effect of coconut shell burning smoke against the level of fungal infection, dormancy, and the physiological quality of shallot seed bulb. The research design used was a factorial randomized block design. The first factor is the smoking time (t), with 3 levels of treatments (t1 = 40 minutes, t2 = 80 minutes, t3 = 120 minutes) and the second factor is the temperatures of the biomass reactor (T), with 2 treatments (T1 = 200 ± 50 oC and T2 = 300 ± 50 °C). The smoking process using the pyrolysis-external heating method was carried out without affecting the moisture content of the seeds. The smoking with reactor temperature of 300 oC and duration of 40 minutes gave the same effect as the treatment of the highest temperature and duration, two of these treatments gave the highest antimicrobial effect and dormancy compared to other treatments. The smoking with 300 oC reactor temperature and 40 minutes duration gave an average dormancy of 96.3±10.1 (DAH) and 50.7±1.8 % infection.

1. INTRODUCTION

Shallots are one of the important horticultural commodities in Indonesia. Shallots have a high economic value in terms of fulfilling national consumption, farmers' income sources, and their potential as a foreign exchange revenue (Theresia *et al.*, 2016). Freshly harvested shallot bulbs are generally dormant, so they must be stored for one to five months before they can be replanted. To avoid damage to seeds during storage, shallot farmers must dry them until the base of the leaves is dry. However, drying alone is not enough, rot during storage is still common, especially during the rainy season. Pathogenic fungi that cause tuber seed rot are very likely to be fungi carried from the land to the post-harvest process. *Fusarium oxysporum* is the most important fungal pathogen in shallot cultivation. The attack of this pathogen causes damage (rot) at the base of the tuber and is reported to cause a decrease in yield of 50% to 100% (Saputri *et al.*, 2019; Wiyatiningsih *et*

al., 2009). Further postharvest handling aimed at controlling tuber-borne pathogens needs to be carried out.

Smoking is a method of preservation that has long been used by humans. Smoke from burning wood has superior antimicrobial activity (Braithwaite *et al*., 2008). The biomass combustion process produces smoke containing various components of the carbonyl compound group (formaldehyde, aldehyde, and alcohol), phenolics, acids, hydrocarbons, and terpenes (Erkmen & Bozoglu, 2016). Smoke evocation can be done by direct combustion or pyrolysis. Pyrolysis is a thermal decomposition process of a material with limited air. Pyrolysis can be carried out by direct heating and indirect heating. The pyrolysis process with indirect heating produces more yields than direct heating, this is because in direct heating flamable gases such as methane, ammonia, hydrogen and other compounds dissolved in the gas burn a lot (Fatimah, 2011; Ridhuan & Irawan, 2020). The heating temperature (pyrolysis) of biomass can affect the chemical components produced, where according to research conducted by Rizal *et al*., (2020) coconut shell pyrolysis at a temperature of 200^{o}C produces 16 components of chemical compounds, a temperature of 250^{o}C produces 30 components of chemical compounds, the temperature of 250^{o}C produces 30 components of chemical compounds, and 300^{o}C produces 48 components of chemical compounds. Coconut shell is an abundant and easy source of biomass.

Nugroho and Aisyah (2013) used liquid smoke to suppress seed-borne fungal infection, but the use of direct smoke (aerosol) from the biomass heating process for this purpose has never been reported. Although the direct smoking method has disadvantages because it can pollute the air, this method also has advantages. Aerosol smoke could easily reach the crevices of the seeds. If the direct smoking could significantly suppress seed-borne fungal infection, control of fungus and seed-borne pathogens could be applied in instore drying or in storage. Apart from being an antimicrobial effect, smoke has an indication that it can affect the physiological quality of seeds, biomass burning smoke has been shown to shorten the dormancy period and support the germination of various types of plant seeds, but in some cases smoke can also inhibit seed germination (Jefferson *et al*., 2014). Research on the effect of aerosol smoke from burning plant leaves and stems on wheat seeds was carried out by (Iqbal *et al*., 2016), based on research conducted, it was found that the smoke from burning plants can stimulate the germination of wheat seeds. Shayanfar *et al*. (2020) stated that smoke from burning tree branches can free secondary dormancy of *Brassica napus* L. seeds. Sparg *et al*. (2006), stated that the smoke from burning plants had a significant vigor-stimulating effect, but an increase in the exposure time of aerosol smoke resulted in a decrease in germination. The smoke evocation method that has been carried out so far is by direct heating method (combustion) where this method produces less yield, because in direct heating method flamable gases such as methane, ammonia, hydrogen and other compounds dissolved in the gas are burned (Ridhuan & Irawan, 2020). Therefore, in this study, smoke evocation was carried out using the pyrolysis external heating method.

To be able to take advantage of the potential of smoke, this research was conducted to analyze the effect of coconut shell smoke on shallot bulb seeds. The purpose of this study was to design a smoking process using the pyrolysis-external heating method and to analyze the effect of differences in temperature variations and duration of smoking on the level of fungal pathogenic infection, dormancy, and the physiological quality of shallot bulb seeds.

2. MATERIALS AND METHODS

Research on the effect of coconut shell smoke treatment on the level of fungal infection, dormancy, and the physiological quality of shallot bulb seeds was carried out from February 2021 to December 2021 and was carried out at:

1. Renewable Energy Laboratory, Department of Mechanical and Biosystem Engineering, IPB.
2. Plant Biology Laboratory, Center for Biological Resources Research and Biotechnology, IPB.
3. Greenhouse, Department of Soil Science, IPB.

2.1. Materials and Equipment

The sample used was dried shallot, Thai variety from farmers in Nganjuk Regency. The materials used in this study were coconut shell, LPG, Potato Dextrose Agar (PDA), aquadest, alcohol 70%, plastic wrap, and soil (which was sterilized). The tools used in this study were smoking apparatus, laminar, bunsen, object glass, cover glass, compound microscope, petri dish, 10x9 cm poly bag, oven, digital scale, and autoclave.

2.2. Metode

The research design used was a factorial Randomized Block Design and added one control treatment. The first factor is the temperature of the biomass reactor (T), with 2 treatment levels, namely T1 = 200 ± 50 ^{o}C and T2 = 300 ± 50 ^{o}C. The second factor is the duration of smoking (t), with 3 levels of treatment, namely, t1 = 40 min, t2 = 80 min, t3 = 120 min The control sample (without treatment) was separated from the factorial structure to avoid damaging the orthogonal properties of the designed structure. Incorporating control samples into the factorial structure will cause bias, this is because the control samples (without treatment) are not crossed or combined with other treatments (reactor temperature and smoking duration). So in this study, there were 3 variables, namely control, reactor temperature and duration. Therefore there are 2x3+1 or 7 treatment variations. In each treatment, the samples were separated into three different groups (shelves) in the smoking chamber, namely the upper, middle, and lower shelves. Each treatment and control used 2 kg of shallot bulbs, so a total of 42 kg of shallots were required. To find out whether the treatment had a significant effect, a variance analysis was carried out, and to determine the difference in the effect of each treatment, a DMRT (Duncan Multiple Range Test) analysis was performed with a level of = 0.05.

2.2.1. Pyrolysis Process

The smoking unit consists of 5 main components, namely the smoking chamber, blower, smoke channel, smoke generator, and temperature measuring and displaying components. The coconut shell used for each treatment was 10 kg. The design of the smoking device can be seen in Figure 1. Smoke is obtained by pyrolysis of dry coconut shells in a reactor with temperatures of 200 ± 50 ^{o}C and 300 ± 50 ^{o}C. The reactor temperature was measured using a type K thermocouple placed inside the reactor. The heat source used for the pyrolysis process comes from a high pressure gas stove. Temperature regulation in the reactor is done by adjusting the gas output from the stove. To maintain seed viability, the temperature of the smoke passing through the sample (curing room temperature) was controlled so that it did not exceed 40 ^{o}C. According to Huda (2007) drying up to a temperature of 45 ^{o}C does not affect the

germination of shallot bulb seeds. The temperature adjustment in the smoking chamber is done by adjusting the blower valve opening. In this study, one smoke generator was used and the treatments were carried out alternately.

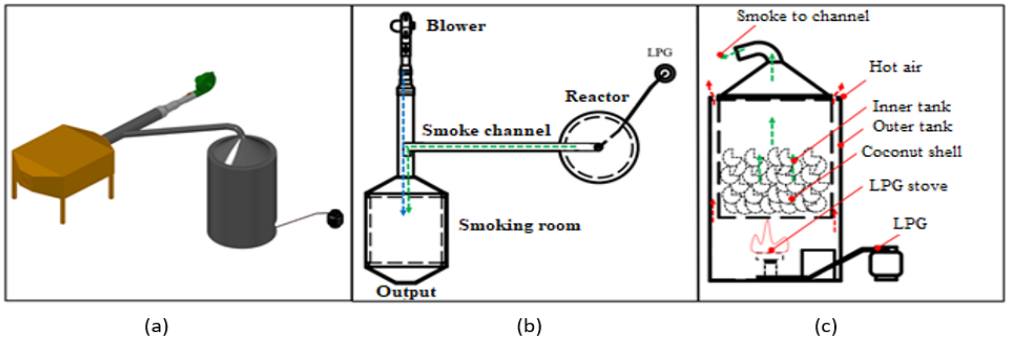

Figure 1. Smoke generator and smoke movement scheme (a) smoke generator apparatus, (b) top view generator apparatus and (c) reactor

2.2.2. Pathogenic Fungal Infection Rate

The effect of variations in temperature treatment and duration of smoking on the infection rate of fungal pathogens was determined using the agar plate method. Incubation was done by placing one tuber sample each into a PDA dish. Each replication treatment used 10 samples, so that for each test used 10 × 7 × 3 samples or 210 samples. The test for the level of infection by pathogenic fungi was carried out in five stages starting from October 20 to December 26, 2021, this was done to increase the accuracy of the test by involving more samples. The total sample used for the calculation of the infection rate was 1050 tuber samples. Incubation of samples in the cup was carried out at room temperature with alternating dark and light conditions for 5 × 24 hours (Pusat Karantina Tumbuhan, 2007). After incubation, the infection rate was calculated for each treatment and control replication, by percentage of the number of samples infected with the fungus *Fusarium* spp. and *Aspergillus niger* from the total sample. The morphological identification of the fungus was carried out using the identification keys of Leslie and Summerell (2006) and Pitt & Hocking (2009).

2.2.3. Dormancy and Physiological Quality of Seed

Seed dormancy test was carried out after the tuber seeds were 57 days after harvest (DAP). The test was carried out in the Cikabayan greenhouse of the Department of Soil Science. The test was carried out by planting tubers in polybags measuring 10 cm × 9 cm. The soil used was previously sterilized in an autoclave for 45 minutes. Watering and observations were carried out every day until all tubers sprouted. Physiological quality testing can be carried out after the tuber dormancy period ends, therefore physiological quality testing of seeds is carried out after the dormancy test. The physiological quality of shallot seeds in this study was determined by calculating the Germination Power (DB), Vigor, and Maximum Growth Potential (PTM) of the seeds, where the calculation equations can be seen in Equation (1) through Equation (3).

$$DB = (\sum BKN\ I + BKN\ II)/(\sum B) \times 100\% \quad (1)$$

$$Vigor = (\sum BKN\ I)/(\sum B) \times 100\% \quad (2)$$

$$PTM = (\sum BKN + \sum BKA)/(\sum B) \times 100\% \quad (3)$$

where DB is the germination rate (%), ΣBKN I is the total seeds that germinate normally in first period, ΣBKN II is the total seeds that germinate normally in the second period,

ΣB is the total seeds germinated, ΣBKA is the total seeds that germinate abnormally. Each replication treatment used 20 tuber samples. Watering and observations were carried out every day until all tuber samples sprouted (If'all & Idris, 2016; Priyantono *et al*., 2013).

3. RESULTS AND DISCUSSION

3.1. Smoking Treatment

Based on the temperature recording obtained, the highest temperature recorded in the smoking chamber was 38.6 °C. Controlling the temperature inside the reactor encountered a few obstacles, the temperature inside the reactor had a tendency to continue to increase after passing through a temperature of 300 °C and a heating time of 100 minutes, this caused the upper deviation of the reactor treatment temperature to be quite large. Since the thermocouple is only placed at one point i.e. on top of the biomass pile, the temperature distribution inside the reactor is unknown. A continuous and difficult to control temperature increase is thought to occur because the bottom of the biomass pile has a much higher temperature than the top. The exothermic reaction from the bottom of the biomass pile significantly delivers and transfers heat to the top of the pile (Gafur *et al*., 2021). Although there was a fairly large temperature deviation, the deviation was still in an acceptable range, the highest temperature recorded for the 300 °C reactor temperature treatment was 351.3 °C with a standard deviation of 11.51. For the 200 °C treatment, the highest temperature recorded was 220 °C with a standard deviation of 6.68. The graph of the smoking temperature recording can be seen in Figure 2.

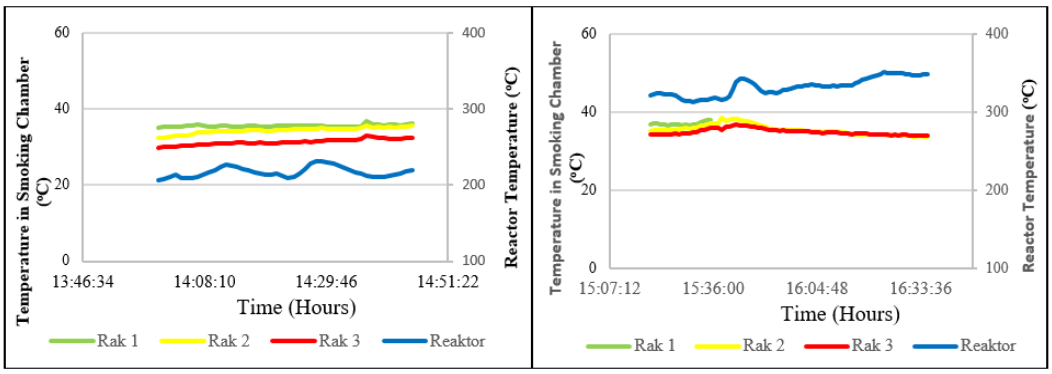

Figure 2. Example of temperature recording in smoking chamber (Shelves 1, 2, 3) and reactor for pyrolysis temperature treatment of 200±50 °C, 40 minutes (left) and temperature of 300±50 °C, 80 minutes (right)

Table 1. Moisture content of samples in each treatment

Treatment (°C|minute)		Control	200 |40	200| 80	200| 120	300| 40	300| 80	300| 120
Moisture Content (%)	1	84.2	83.5	82.9	83.8	81.4	83.0	82.4
	2	82.1	82	83.1	81.9	82.3	85.7	82.7
	3	83.2	81.9	82.2	81.6	81.7	81.7	83.2
Average		83.2±1.0	82.5 ±0.9	82.7± 0.4	82.4± 1.1	81.8± 0.4	83.5± 2.02	82.7±0. 4

The water content of the sample after treatment can be seen in Table 1. The highest average water content was owned by the 200 ^{o}C, 40 minute treatment sample and the lowest water content average was owned by the 300 ^{o}C, 40 minute treatment sample. Analysis of variance performed showed that the smoking treatment did not affect the moisture content of the sample. It was to be expected that the difference in infection rates of the samples was due to the anti-microbial effect of the smoke, and not to variations in water content. The results of the analysis of the variance of the effect of treatment on water content can be seen in Table 2.

Table 2. ANOVA of the effect of smoking treatment on water content

SK	DF	JK	KT	F-hit	F 0.05	F 0.01	Notasi
Treatment	(Tt+1)-1 = 6	5.362	0.894	0.975	3.000	4.821	ns
Control	Tt-(T-1)-(t-1)-(T-1)(t-1)=1	0.853	0.853	0.930	4.750	9.330	ns
Temperatur(T)	(T-1)=1	0.074	0.074	0.080	4.750	9.330	ns
Duration (t)	(t-1)=2	2.818	1.409	1.536	3.890	6.927	ns
T*t	(T-1)(t-1)=2	1.618	0.809	0.882	3.890	6.927	ns
Block	(r-1)=2	2.873	1.437	1.566	3.890	6.927	ns
Error	(Tt)(r-1)=12	5.362	0.894	0.975	3.000	4.821	ns
Total	r(ab+1)-1=20	0.853	0.853	0.930	4.750	9.330	ns

3.2. Infection Rate

The calculation of the infection rate was carried out after incubation, by percentage of the number of samples infected with the fungus *Fusarium* spp. and *Aspergillus niger* from the total incubation sample *Fusarium* spp. and *Aspergillus niger* were the most common fungal pathogens in incubation. Incubation of shallot bulb samples can be seen in Figure 3.

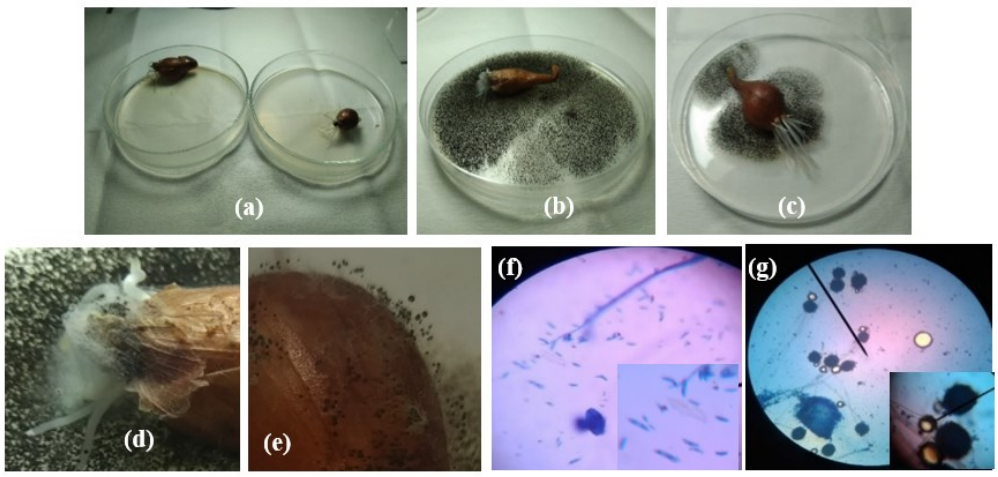

Figure 3. Incubation of samples on PDA media in plates: (a) shallots without fungus, (b) shallots with Fusarium spp., (c) shallots with fungus and *Aspergillus niger*, (d) macroscopic structure of the fungus *Fusarium* spp., (e) macroscopic structure of the fungus *Aspergillus niger*, (f) microscopic structure of the fungus *Fusarium* spp., and (g) microscopic structure of the fungus *Aspergillus niger*

Data on the effect of smoke on the level of fungal infection can be seen in Table 3. Analysis of variance was carried out to determine the significance of the treatment given to the percentage of infection in the sample of shallot bulbs. Based on the analysis of variance, it was found that the temperature treatment and smoking duration each had a very significant effect on the percentage of infection of shallot bulb seeds, but the interaction between treatments had no significant effect. Analysis of the variance of the effect of smoke treatment on the level of infection can be seen in Table 4. Further test of DMRT was carried out to test the differences between each treatment. DMRT further test results can be seen in Table 3.

Table 3. Effect of smoking treatment on infection rate

SK	DF	JK	KT	F-hit	F 0.05	F 0.01	Notation
Treatment	(Tt+1)-1 = 6	3722.5	620.4	35.6	3.0	4.8	**
Control	Tt-(T-1)-(t-1)-(T-1)(t-1) = 1	3170.0	3170.0	182.1	4.8	9.3	**
Temp (T)	(T-1)=1	174.2	174.2	10.0	4.8	9.3	**
Duration (t)	(t-1)=2	264.1	132.1	7.6	3.9	6.9	**
T*t	(T-1)(t-1)=2	114.1	57.1	3.3	3.9	6.9	tn
Block	(r-1)=2	76.4	38.2	2.2	3.9	6.9	tn
Error	(Tt)(r-1)=12	208.9	17.4				
Total	r(ab+1)-1=20	4007.8					

Table 4. ANOVA treatment on the level of infection

Treatment(°C|mnt)		Control	200/40	200/80	200/120	300/40	300/80	300/120
Infection Percentage (%)	**1**	88	64	54	50	51	52	51
	2	89	61	50	51	50	51	31
	3	84	64	50	51	51	51	51
Averages		87±6.5c	63±8.4 b	51.3±4.8a	50.7±4.8a	50.7±1.8 a	51.3±1.8a	44.3±2.3a

The control sample had the highest average percentage of infection compared to the sample treated with smoke. Among samples treated with smoke, the sample with the lowest temperature and duration treatment (200°C, 40 minutes) had the weakest anti-microorganism effect, while the other treatment variations were 200 °C / 80 minutes, 200 °C / 120 minutes, 300 °C / 40 min, 300 °C / 80, and 300 °C / 120 min have the same anti-microorganism effect. Because all five gave the same anti-microorganism effect, the selection of the treatment with the best anti-microorganism effect was based on the treatment with the lowest temperature or the treatment with the shortest duration, namely 200 °C and 80 minutes or 300 °C and 40 minutes. These results are a strong indication that coconut shell smoke treatment can be used to control postharvest carried fungi, which can indirectly suppress rot during storage and minimize the risk of the fungus returning to the field. Smoke treatment with a higher temperature of 300 °C, has the ability to suppress infection better than the lower temperature (200 °C). This can be explained by research conducted by Rizal *et al.* (2020), where the pyrolysis of coconut shell at a temperature of 300 °C produces more variations in chemical compounds than the temperature of 200 °C. Most of the phenol group compounds were found at pyrolysis temperatures above 250 °C. Pyrolysis of coconut shells produces various components of chemical compounds, and acetic acid is

the component of chemical compounds with the highest percentage. Acidic components can inhibit the formation of spores, the growth of bacteria, fungi, and virus activity in foodstuffs (Assidiq *et al*., 2018). In addition to acetic acid, there are many other anti-microbial compounds produced through the pyrolysis of coconut shells, such as compounds of the carboxylic acid group, phenols, and alcohols (Rizal *et al*., 2019). The main organic components of biomass can be classified into three groups, namely cellulose, hemicellulose, and lignin. Differences in the composition of cellulose, hemicellulose, and lignin in the biomass affect variations in the quantity of chemical compounds produced in the pyrolysis process. So that the smoke resulting from pyrolysis with one biomass source can produce different anti-microorganism and dormancy effects on shallot bulb seeds (Kerry & Ledward, 2009; Asmawit *et al*., 2011).

3.3. Dormancy and Physiological Quality

A seed is said to be dormant if the seed is actually alive, but does not germinate even though it is placed in environmental conditions that meet the requirements for ongoing growth (Sutopo, 2004). In this study, the tuber seed samples for each treatment were considered to have passed the dormant period when the leaves appeared to grow on the tuber surface. Seed dormancy testing was carried out when the shallot bulbs were 57 DAP. Data on the effect of smoke treatment on dormancy of the shallot bulb seed samples can be seen in Table 5. Analysis of variance was carried out to determine the significance of the treatment given to seed dormancy. Based on the analysis of variance, it is known that the treatment of the smoking reactor temperature has a very significant effect on the dormancy of the sample, while the treatment of smoking duration has no significant effect on dormancy. Analysis of the variance of the effect of smoke treatment on dormancy can be seen in Table 6. Further test of DMRT was carried out to test the differences between treatments. DMRT further test results can be seen in Table 5.

Table 5. Effect of smoking treatment on dormancy

SK	DF	JK	KT	F-hit	F 0.05	F 0.01	Notation
Treatment	(Tt+1)-1 = Tt = 6	214.5	35.7	13.3	3.0	4.8	**
Control	Tt-(T-1)-(t-1)-(T-1)(t-1)=1	103.1	103.1	38.3	4.8	9.3	**
Temp (T)	(T-1)=1	56.9	56.9	21.1	4.8	9.3	**
Duration (t)	(t-1)=2	0.3	0.2	0.1	3.9	6.9	Ns
T*t	(T-1)(t-1)=2	54.1	27.1	10.0	3.9	6.9	Ns
Block	(r-1)=2	2.3	1.2	0.4	3.9	6.9	ns
Error	(Tt)(r-1)=12	32.3	2.7				
Total	r(ab+1)-1=20	249.1					

Table 6. ANOVA of treatment effect on dormancyA

Treatment (°C|mnt)		Control	200|40	200|80	200|120	300|40	300|80	300|120
Dormancy (DAH)	1	86	91	97	90	96	93	95
	2	88	89	93	93	98	92	96
	3	87	90	92	89	95	93	98
Averages		87±8.8 a	90±8.5 b	94±10.9 cd	90.7±11 b	96.3±10.1 d	92.7±11.3 bc	96.3±9.5 d

The first shoots appeared in the control sample (without smoking treatment). The control sample had the shortest average dormancy compared to the treated sample. The dormant period of the control samples started from 68 DAP (11 DAP) to a maximum of 102 DAP (45 DAP). Meanwhile, the longest average dormant period was owned by the sample with a reactor temperature treatment of 300 ^{o}C and a duration of 120 minutes. Samples treated with a smoking reactor temperature of 300 ^{o}C and a duration of 120 minutes had a dormant period ranging from 75 DAP (18 DAP) to 116 DAP (59 DAP). This is most likely due to the effect of the compound TMB (Trimethylbutenolide) which can prolong the dormancy of plant seeds. Lee *et al.* (2021) found that the presence of TMB compounds can cause dormant seeds, dormant and non-germinating seeds in the presence of TMB can continue germination and growth when transferred to TMB-free media. TMB is a compound of the butanolide group, which is produced through the pyrolysis of biomass.

The biomass burning smoke has a dual function in regulating seed germination. The smoke content of the butanolide group, KAR (Karrikin), was identified to support seed germination in many plant species, while another butanolide group, TMB, was identified to function to inhibit seed germination (Gupta *et al.*, 2020). Hrdlička *et al.* (2021) found that the TMB component of smoke was 4.5 and 2.6 higher, respectively, than KAR1 and KAR2. Based on the information above, it can be said that the extension of dormancy experienced by shallot bulb seeds treated with smoke was most likely due to the dominance of the germination inhibitor component (TMB) compared to the germination stimulator component (KAR) in the coconut shell smoke. Determination of the best dormancy effect is based on the need for use and also considering the cheapness of the treatment (lowest temperature or shortest duration). If you want the effect of extending the optimum dormancy period, the best treatment according to the research is a temperature of 300 ^{o}C and a duration of 40 minutes, whereas if you want a minimum dormancy effect, the best treatment according to the study is a temperature of 200 ^{o}C and a duration of 40 minutes.

Physiological quality test was carried out when the tuber seeds were 125 DAP. The physiological quality of shallot bulb seeds was determined by calculating the percentage of germination, vigor, and maximum growth potential of the planted samples. Data on germination, vigor, and maximum growth potential of shallot bulb seed samples can be seen in Table 7. Based on the data obtained, it is known that the control sample (not treated with smoke) has the highest average percentage of germination and vigor compared to the sample that given treatment. While the average percentage of germination and the lowest vigor was owned by the sample with treatment at 300 ^{o}C and a duration of 120 minutes. The maximum growth potential value for all treatment variations is the same, namely 100%. Analysis of variance was carried out to determine the significance of the treatment given to germination, vigor, and maximum growth potential of the sample of shallot bulbs. Based on the analysis of variance, it was found that the treatment temperature and duration of smoking had no significant effect on germination, vigor, and maximum growth potential of the shallot bulb seed samples. Therefore, it can be said that the treatment temperature and duration of smoking did not affect the physiological quality of the shallot bulb seeds, as long as the planting was carried out after the dormancy of the seeds ended. The results of the variance analysis of the effect of smoke treatment on germination and seed vigor can be seen in Table 8 and Table 9.

Table 7. Effect of smoking treatment on physiological quality

Treatment (°C|mnt)		Control	200|40	200|80	200| 120	300|40	300|80	300| 120
DB (%)	1	100	100	95	100	100	100	100
	2	100	100	95	90	100	100	95
	3	100	100	100	100	100	100	90
Averages (%)		100±0	100±0	96.7±2.8	96.7±5.7	100±0	100±0	95±5
Vigor (%)	**1**	100	100	90	100	90	100	100
	2	100	85	95	85	100	90	90
	3	100	100	90	90	95	100	80
Averages (%)		100±0	95±8.6	91.6±2.8	91.6±7.6	95±5.0	96.7±5.7	90±10
PTM (%)	**1**	100	100	100	100	100	100	100
	2	100	100	100	100	100	100	100
	3	100	100	100	100	100	100	100
Averages (%)		100±0	100±0	100±0	100±0	100±0	100±0	100±0

Table 8. ANOVA of treatment effect on physiological quality (germination)

SK	DF	JK	KT	F-hit	F 0.05	F 0.01	Notasi
Treatment	(Tt+1)-1 = 6	83.3	13.9	1.5	3.0	4.8	tn
Control	Tt-(T-1)-(t-1)-(T-1)(t-1)=1	9.7	9.7	1.0	4.8	9.3	tn
Temp (T)	(T-1)=1	1.4	1.4	0.1	4.8	9.3	tn
Duration (t)	(t-1)=2	52.8	26.4	2 .8	3.9	6.9	tn
T*t	(T-1)(t-1)=2	19.4	9.7	1.0	3.9	6.9	tn
Block	(r-1)=2	19.4	9.7	1.0	3.9	6.9	tn
Error	(Tt)(r-1)=12	113.9	9.5				
Total	r(ab+1)-1=20	216.7					

Table 9. ANOVA of the treatment effect on physiological quality (vigor)

SK	DF	JK	KT	F-hit	F 0.05	F 0.01	Notasi
Treatment	(Tt+1)-1 = 6	214.3	35.7	0.9	3.0	4.8	tn
Control	Tt-(T-1)-(t-1)-(T-1)(t-1)=1	114.3	114.3	2.8	4.8	9.3	tn
Temp (T)	(T-1)=1	5.6	5.6	0.1	4.8	9.3	tn
Duration (t)	(t-1)=2	58.3	29.2	0.7	3.9	6.9	tn
T*t	(T-1)(t-1)=2	36.1	18.1	0.4	3.9	6.9	tn
Block	(r-1)=2	108.3	54.2	1.3	3.9	6.9	tn
Error	(Tt)(r-1)=12	491.7	41.0				
Total	r(ab+1)-1=20	814.3					

4. CONCLUSIONS AND RECOMMENDATION

The smoking process using the pyrolysis-external heating method can be carried out without affecting the moisture content of the seeds. The results showed that the pyrolysis temperature and smoking duration were effective in reducing the infection rate of pathogenic fungi. Variations in the treatment of reactor temperature and duration of smoking carried out in this study all had the effect of prolonging the dormant period. Variations in reactor temperature treatment and smoking duration carried out in this study did not affect the physiological quality of shallot bulb seeds (germination vigor and maximum growth potential), with a note, planting was carried out after the dormant period ended. The smoking treatment of shallot bulb seeds can be carried out as needed, if it is desired for longer dormant seeds to extend their shelf life, then the best smoking treatment according to research is a temperature of 300 °C and a duration of 40 minutes, this treatment also provides the best anti-microorganism effect based on research conducted. If a minimum dormant period extension effect is desired, the best smoking treatment based on the research conducted is a temperature of 200 ^{o}C and a duration of 40 minutes, but this treatment has the lowest anti-microorganism effect compared to other treatments. It is possible that the pyrolysis of coconut shells at temperatures below 200 ^{o}C can have an effect on shortening the dormancy of shallot bulb seeds. The quantity and diversity of chemical compounds produced from the pyrolysis process is highly dependent on the source of biomass, temperature, and the duration of the pyrolysis carried out. To find the effect of smoke resulting from pyrolysis of biomass that can be used to shorten seed dormancy, it is necessary to conduct research using other sources of biomass with a wider pyrolysis temperature range (from 100 to 400 ^{o}C).

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