# EFFECT OF LOW TEMPERATURE ON UPLAND RICE GERMINATION

**Sri Romaito Dalimunthe[1,2], Lollie Agustina P. Putri [3], T. Chairunnisa[3], Aris Hairmansis[4]**

[1]*Doctoral Program of Agricultural Science, Faculty of Agriculture, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia*
[2]*North Sumatera Assessment Institute for Agricultural Technology, Medan, Indonesia*
[3]*Faculty of Agriculture, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia*
[4]*Indonesian Institute for Rice Research, Jl. 9 Sukamandi-Subang, Indonesia*
Correspondence author: romaito_d@yahoo.com

**ABSTRACT**

Fifteen rice genotypes were used for cold tolerance evaluation at the Thermogradient-bar. Seeds of rice genotypes germinated at ten different temperatures containing low temperature (constant 13°C for 9 days) and control (constant 31°C for 9 days). This study aimed to evaluate quickly for getting the tolerant rice lines on low temperature stress. The study was conducted in April-June 2017 at Biology Laboratory, LIPI. A total of 10 lines of upland rice and 5 checks were used in the testing. Gradient temperature on thermogradient-bar tool were 13, 16, 18, 20, 22, 24, 27, 28, 30 and 31$^{o}$C. Seeds of each genotype tested with 5 replications. The results show that low temperature stress began to look at the temperature of 18 $^{o}$C. The most low-temperature sensitive genotype is the DHP KARO 121 at a temperature <18$^{o}$C. seed germination were lower than the sensitive check, followed by a low percentage of leaves, even though the root length, shoot length, wet weight and dry weight showed almost the same values as the strain tested. *Sigambiri Putih* has better performance during germination under cold temperature (13$^{o}$C) and, in general, it is known that *Sigambiri Putih* genotype is more cold tolerant than other ones.

**Keywords**: Cold Tolerant, Rice Germination, Thermogradient-Bar,

## A. INTRODUCTION

The danger of low temperature has become a main problem on the growth and the development of rice in high land. This danger has big effects on vegetative and generative growth of rice. The effects of low temperature on vegetative phase include germination, the growth of seed plant and root growth (Lee, 2001; Dashtmian *et al.*, 2013). According to Cruz and Milach (2000), the symptom of rice damage due to low temperature is the lateness and the slowness of germination percentage. On vegetative phase, the leaves become yellow, the plants grow shorter and the number of the small plants decreases.

Some varieties of local rice on high land such as *Sigambiri Putih, Sigambiri Merah, Mayas and Selasih* are known to be tolerant to low temperature (Yunani *et al.*, 2014, Yusuf 2014), Pulu' Mandoti, Pinjan dan Lambau (Limbongan *et al.* 2009) *Silewah, Pratao, Progal, dan Lengkuwang* (Daradjat *et al.* 2009). The weaknesses of these local varieties are long age and low production. For this, a program to promote local variety as the main donor which is tolerant to low temperature is needed.

The toleration of rice towards low temperature is an important character which needs special attention for plant breeding in high land. During this variety assembling, tolerate screening on low temperature is quite difficult and takes time. It also requires high budget facilities and a lot of cycles to learn the agronomy and physiology character and also the quality if the plants (Zhao *et al*., 2007).

According to Cruz and Milach (2000), germination phase is one of the critical moments on rice towards low temperature. Therefore the selection on low temperature can be done during this moment in order to use thermogradient bar. Thermogradient bar is an equipment for screening at temperature of 2˚C until 45˚C (Lestari and Rohaeni, 2015; Rohaeni et al. 2016). So, this tool is usable for selecting strains on certain temperature fast and effectively in order to see the power of breed until certain age.

The purpose of this research is to evaluate the tolerance of cold of rice strains on germination phase under controlled temperature.

## B. MATERIALS AND METHODS

Fifteen rice strains which are tolerant to low temperature are evaluated in Biology Central Research Laboratory (LIPI), Cibinong, Bogor. The research was conducted from April until June 2017.

The test was done using Thermogradient Bar. Low temperature screening method followed a method from Rohaeni et al 2016. The indicator used to see tolerance on low temperature is growth power percentage under 18˚C.

These are the lists of genotypes used for low temperature screening on vegetative phase (Table 1). There are 15 genotypes include 5 checks such as *Sigambiri Putih* and *Sigambiri Merah* (Tolerant checks), *Ciherang* and *Mekongga* (Sensitive checks) and Situbagendit

Tabel 1. Genotipe padi untuk uji toleransi terhadap suhu rendah

| No | Genotype | Information |
|---|---|---|
| 1 | DHP. KARO 103 | |
| 2 | DHP. KARO 106 | |
| 3 | DHP. KARO 108 | |
| 4 | DHP. KARO 114 | |
| 5 | DHP. KARO 119 | |
| 6 | DHP. KARO 120 | |
| 7 | DHP. KARO 121 | |
| 8 | DHP. KARO 122 | |
| 9 | DHP. KARO 124 | |
| 10 | DHP. KARO 125 | |
| 11 | Situbagendit | |
| 12 | Sigambiri Merah | Tolerant check |
| 13 | CIHERANG | Sensitive check |
| 14 | Sigambiri Putih | Tolerant check |
| 15 | Mekongga | Sensitive check |

The test was done by using five replications. There were 5 sample plants. This number is associated with the size of each temperature column on the equipment (10x15 cm). The replication is different in time. The research was conducted in 9 days after planting. The used temperature gradient was related to the degree according to room separation. There were 10 rooms used for this planting. The formed temperature gradients were shown on Table 2.

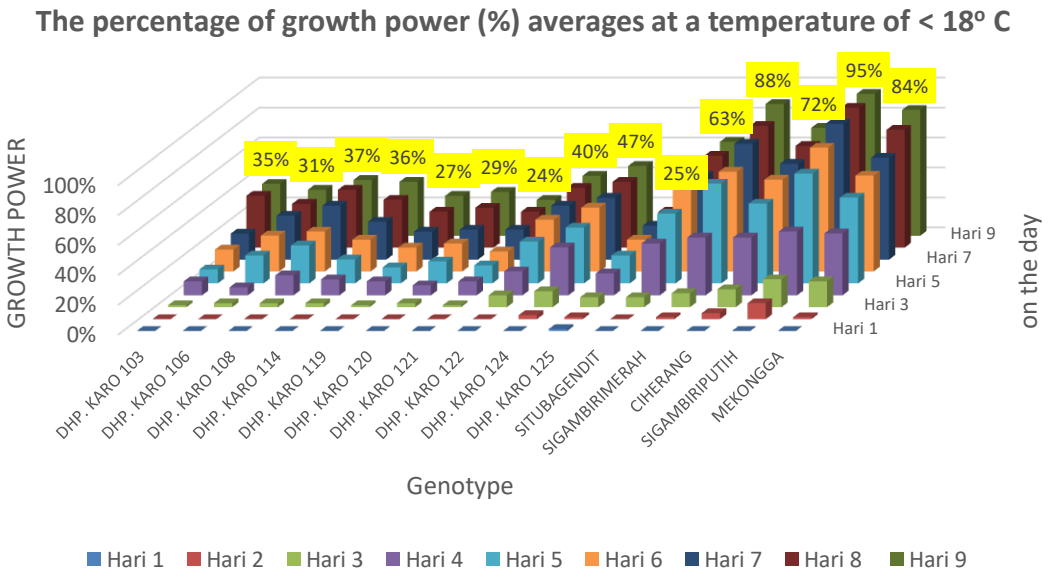
Table 2. Temperature gradients formed on Gradient bar

| Kode | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Suhu ($^{o}$C) | 31 | 30 | 28 | 27 | 24 | 22 | 20 | 18 | 16 | 13 |

The observation included optimum germination, critical temperature on low temperature danger, germination power, the number of leaves, the length of shoots, the number normal shoots, wet weight and dry weight.

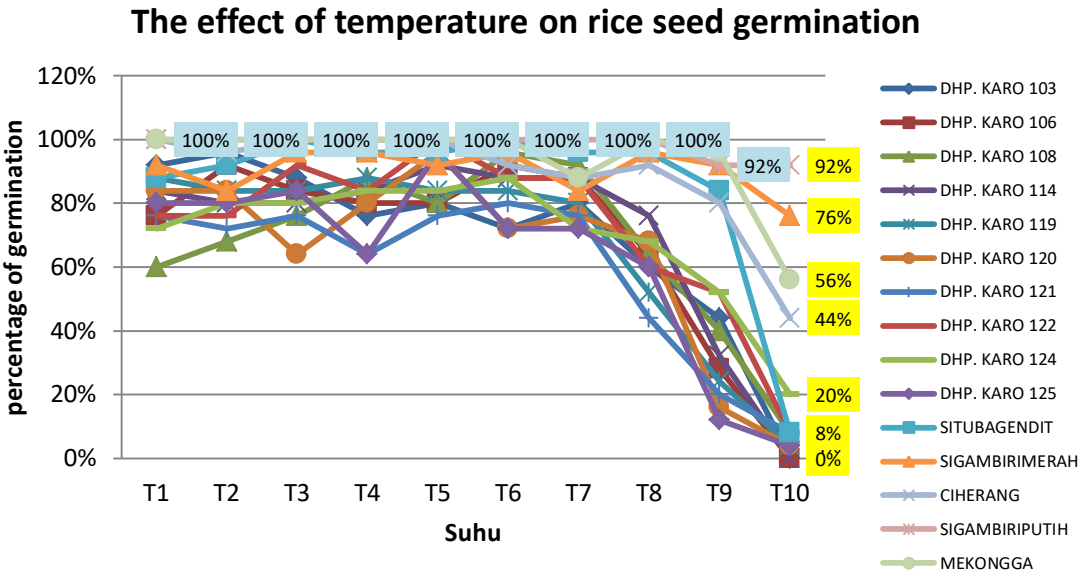
## C. RESULTS AND DISCUSSION

Quick test result on low temperature tolerance shows that there are varieties at all genotypes. The research result shows that DHP Karo 124 is the most tolerant strains on vegetative phase compared to other strains with average power plants on cold temperature (13˚C, 16˚C and 18˚C) was 47%. However, on this lines, power plant average is lower compared to sensitivity checks (*Situbagendit, Mekongga and Ciherang*). The power plant of *Situbagendit* at lower than 18˚C was 63%, meanwhile *Sigambiri putih* got 95%. The most intolerant genotype on low temperature was DHP Karo 121 with the strength only 24%.



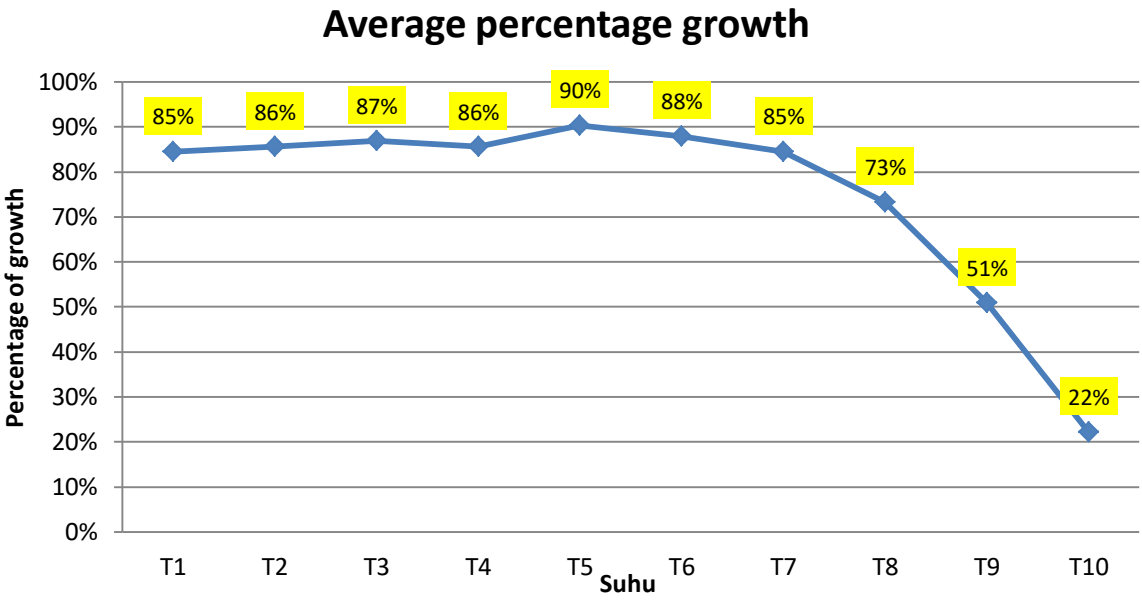

Picture 1. The graph of the percentage of growth power (%) averages at a temperature of <18$^{0}$C

Germination strength/power diagram (Picture 2) shows that there was a spread power plant patterns from different temperature from 15 rice genotypes. But the trend was almost similar for all types. From power plant germination of all genotypes, it is seen that *Sigambiri Putih* shows the highest result at all temperature. Picture 2 shows that the degradation of germination power for all types happened on T6 (the temperature of 22˚C), and on T10 (temperature of 13˚C) it can be seen that dying level is very high, contrasted to *Sigambiri Merah* and *Sigambiri Putih* which have high germination power even though the temperature was low (13˚C).




Picture 2: The germination strength of 15 rice genotypes at different temperature

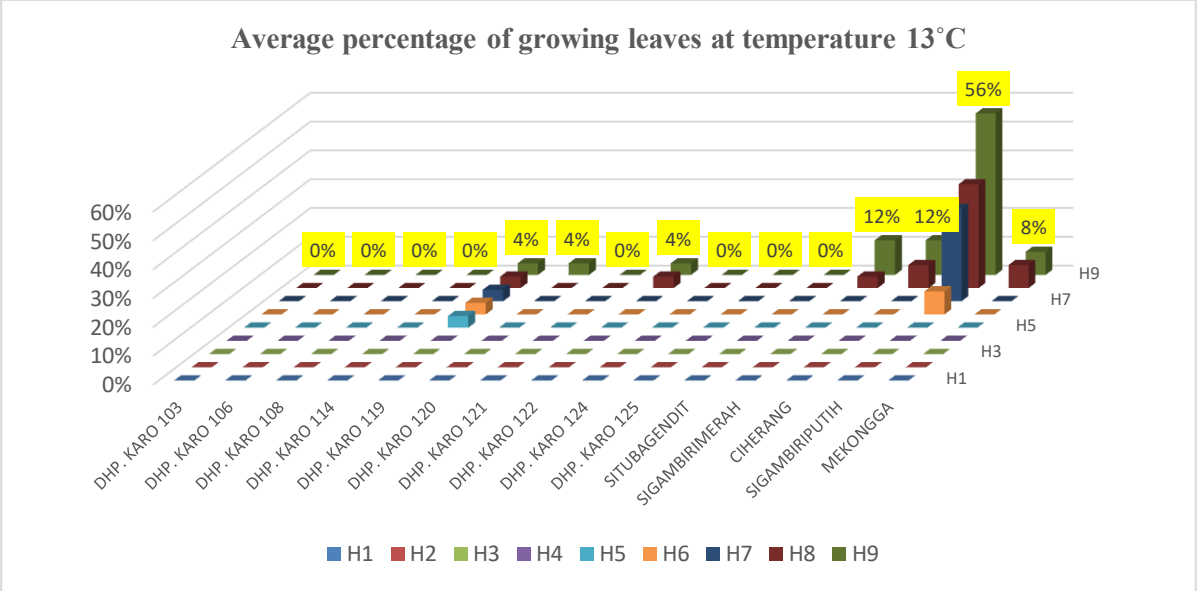
A seed is considered to have high power plant when it has germination power of 80%. Based on this, the maximum temperature of rice breeding is 22˚C - 28˚C, meanwhile the stress on low temperature is able to be seen from 18˚C. This result is supported by the research of Dashtmian et al (2013) that showed the degradation of germination power happened on temperature less than 13˚C. On that research, it was known that the most sensitive genotype on low temperature only has power plant of 35%. Therefore, the selection for rice breeding is done at 18˚C.




Picture 3: Average power of germination of rice at different temperatures

At the temperature of 31˚C, the strength of rice breeding is considered normal for all genotypes. The average percentage for growing is 85%. Then, this percentage decreases to 22%, 13%

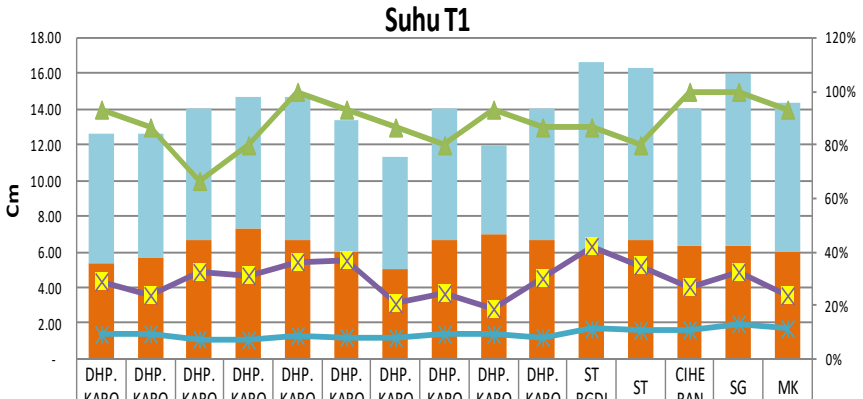
at temperature of 13˚C and this percentage gets bigger relates to the environment temperature at 28˚C, stabilized at this level before going to 30˚C with percentage of growing 23.82˚C. Different temperature causes some changes on others things such as the number of normal breeds, the period of germination and the sprouts vigour. The rice sprouts will grow slower at low temperature, while on higher heat the sprouts will not grow branches. It is common to see the branches become dry.




Picture 4: Average percentage of growing leaves at temperature 13˚C

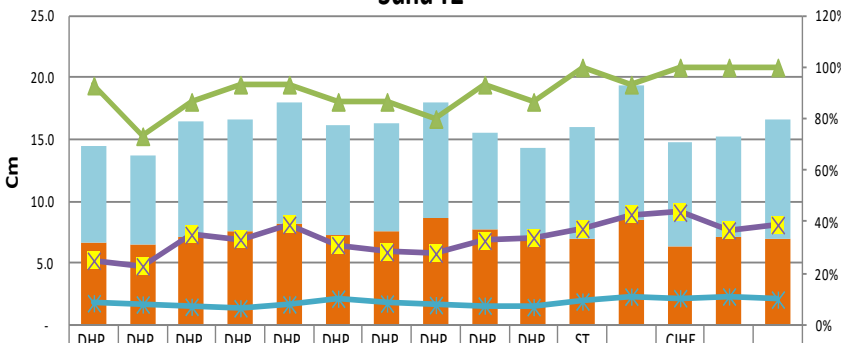
The result of Jena and Jeung research (2004) cultivars which have endurance towards low temperature can be identified on critical degree of rice which is 19˚C. During vegetative phase, temperature lower than 15˚C will affect the leaves chlorosis, the number of breeding reduces and the time for blowing will be delayed. Zhao *et al.* (2009) also reported that the effect of the danger of this low temperature varies for all genotypes.

At low degree (13˚C), *Sigambiri Putih* (Tolerant checked) has growing leaves percentage of 56%, while *Sigambiri Merah* and *Ciherang* towards high land has balance growing leaves with 13˚C which are 12%. Visual research also shows that both varieties have the same good performance at same temperature gradients. Therefore, it is suspected that *Ciherang* critical points on low temperature happened at generative phase only. So, further research in site for generative phase is needed. The ideal site for the research is over 900 above the sea level with environment average temperature less than 18 ˚C.




| | DHP. KARO 103 | DHP. KARO 106 | DHP. KARO 108 | DHP. KARO 114 | DHP. KARO 119 | DHP. KARO 120 | DHP. KARO 121 | DHP. KARO 122 | DHP. KARO 124 | DHP. KARO 125 | ST BGDI T | ST MRH | CIHE RAN G | SG PTH | MK GGA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 7.33 | 7.00 | 7.33 | 7.33 | 8.00 | 7.33 | 6.33 | 7.33 | 5.00 | 7.33 | 10.67 | 9.67 | 7.67 | 9.67 | 8.33 |
| Panjang Akar (cm) | 5.33 | 5.67 | 6.67 | 7.33 | 6.67 | 6.00 | 5.00 | 6.67 | 7.00 | 6.67 | 6.00 | 6.67 | 6.33 | 6.33 | 6.00 |
| Jlh. Kec. Normal (%) | 93% | 87% | 67% | 80% | 100% | 93% | 87% | 80% | 93% | 87% | 87% | 80% | 100% | 100% | 93% |
| bobot basah (gr) | 0.29 | 0.24 | 0.33 | 0.31 | 0.36 | 0.37 | 0.21 | 0.24 | 0.19 | 0.30 | 0.42 | 0.35 | 0.27 | 0.33 | 0.24 |
| bobot kering (gr) | 0.09 | 0.09 | 0.08 | 0.07 | 0.09 | 0.08 | 0.08 | 0.09 | 0.09 | 0.08 | 0.11 | 0.11 | 0.11 | 0.13 | 0.11 |

## Suhu T2

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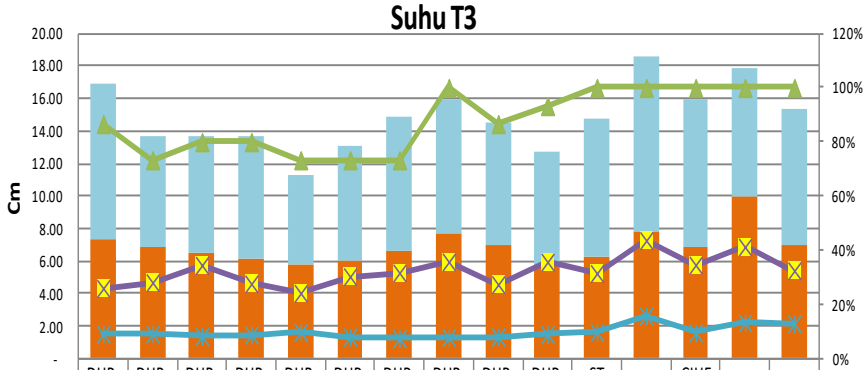
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 7.8 | 7.3 | 9.3 | 9.1 | 9.8 | 8.8 | 8.8 | 9.3 | 7.8 | 7.3 | 8.9 | 10.9 | 8.4 | 8.2 | 9.6 |
| Panjang Akar (cm) | 6.6 | 6.4 | 7.2 | 7.6 | 8.2 | 7.3 | 7.5 | 8.7 | 7.8 | 6.9 | 7.0 | 8.4 | 6.3 | 7.1 | 7.0 |
| Jlh. Kec. Normal (%) | 93% | 73% | 87% | 93% | 93% | 87% | 87% | 80% | 93% | 87% | 100% | 93% | 100% | 100% | 100% |
| bobot basah (gr) | 0.25 | 0.23 | 0.35 | 0.33 | 0.39 | 0.31 | 0.28 | 0.28 | 0.33 | 0.34 | 0.37 | 0.43 | 0.44 | 0.37 | 0.39 |
| bobot kering (gr) | 0.09 | 0.08 | 0.07 | 0.07 | 0.08 | 0.10 | 0.08 | 0.08 | 0.08 | 0.07 | 0.09 | 0.11 | 0.11 | 0.11 | 0.10 |

## Suhu T3

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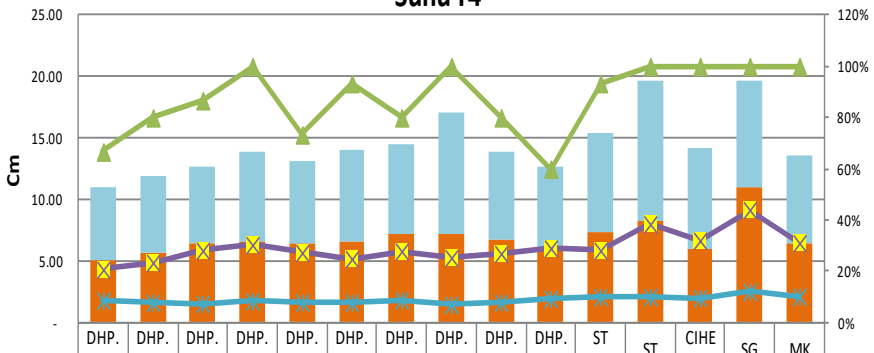
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 9.46 | 6.81 | 7.08 | 7.52 | 5.44 | 6.96 | 8.21 | 8.33 | 7.56 | 6.96 | 8.48 | 10.73 | 9.10 | 7.79 | 8.40 |
| Panjang Akar (cm) | 7.40 | 6.85 | 6.54 | 6.15 | 5.79 | 6.06 | 6.63 | 7.67 | 6.94 | 5.73 | 6.25 | 7.85 | 6.83 | 10.02 | 7.00 |
| Jlh. Kec. Normal (%) | 87% | 73% | 80% | 80% | 73% | 73% | 73% | 100% | 87% | 93% | 100% | 100% | 100% | 100% | 100% |
| bobot basah (gr) | 0.26 | 0.28 | 0.35 | 0.28 | 0.24 | 0.30 | 0.32 | 0.36 | 0.27 | 0.36 | 0.32 | 0.44 | 0.35 | 0.41 | 0.33 |
| bobot kering (gr) | 0.09 | 0.09 | 0.08 | 0.09 | 0.10 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.10 | 0.16 | 0.10 | 0.13 | 0.13 |

## Suhu T4

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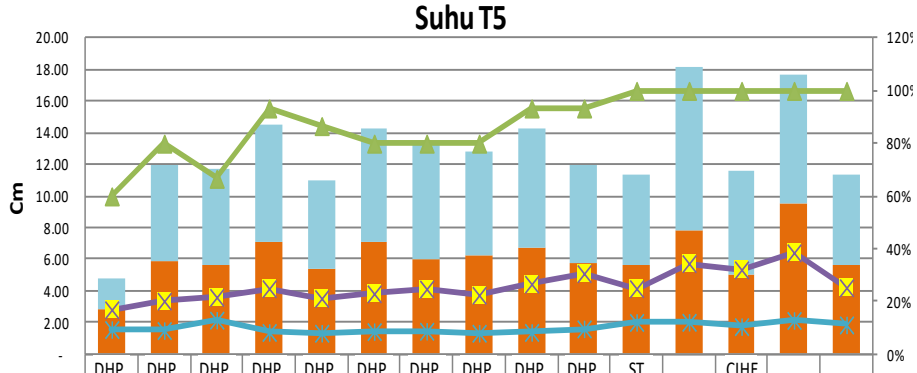
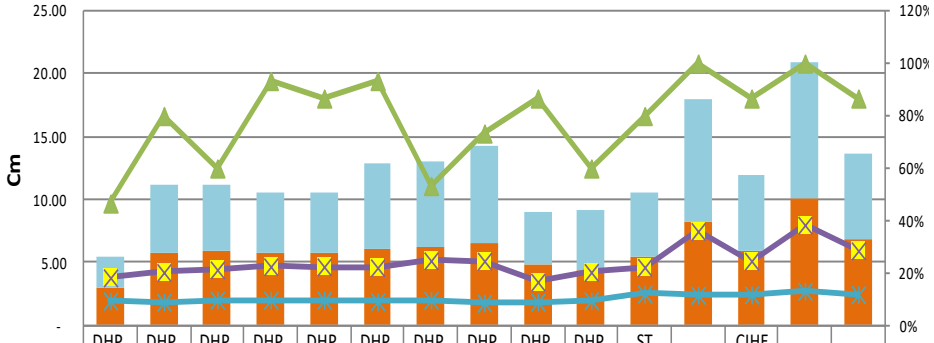
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 5.86 | 6.20 | 6.27 | 7.38 | 6.61 | 7.49 | 7.30 | 9.83 | 7.14 | 6.74 | 8.12 | 11.43 | 8.28 | 8.70 | 7.10 |
| Panjang Akar (cm) | 5.10 | 5.71 | 6.39 | 6.54 | 6.45 | 6.52 | 7.16 | 7.17 | 6.73 | 5.93 | 7.31 | 8.21 | 5.96 | 11.01 | 6.50 |
| Jlh. Kec. Normal (%) | 67% | 80% | 87% | 100% | 73% | 93% | 80% | 100% | 80% | 60% | 93% | 100% | 100% | 100% | 100% |
| bobot basah (gr) | 0.21 | 0.23 | 0.28 | 0.30 | 0.27 | 0.25 | 0.28 | 0.25 | 0.27 | 0.29 | 0.28 | 0.38 | 0.32 | 0.44 | 0.31 |
| bobot kering (gr) | 0.09 | 0.08 | 0.07 | 0.08 | 0.08 | 0.08 | 0.09 | 0.07 | 0.08 | 0.09 | 0.10 | 0.10 | 0.10 | 0.12 | 0.10 |

## Suhu T5




| | DHP. KARO 103 | DHP. KARO 106 | DHP. KARO 108 | DHP. KARO 114 | DHP. KARO 119 | DHP. KARO 120 | DHP. KARO 121 | DHP. KARO 122 | DHP. KARO 124 | DHP. KARO 125 | ST BGDI T | ST MRH | CIHE RAN G | SG PTH | MK GGA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 1.84 | 6.05 | 6.07 | 7.35 | 5.65 | 7.12 | 7.33 | 6.46 | 7.54 | 6.18 | 5.78 | 10.36 | 6.57 | 8.17 | 5.77 |
| Panjang Akar (cm) | 2.90 | 5.93 | 5.60 | 7.13 | 5.36 | 7.13 | 6.04 | 6.29 | 6.68 | 5.73 | 5.58 | 7.80 | 4.99 | 9.50 | 5.63 |
| Jlh. Kec. Normal (%) | 60% | 80% | 67% | 93% | 87% | 80% | 80% | 80% | 93% | 93% | 100% | 100% | 100% | 100% | 100% |
| bobot basah (gr) | 0.17 | 0.20 | 0.22 | 0.25 | 0.21 | 0.23 | 0.25 | 0.23 | 0.27 | 0.31 | 0.25 | 0.35 | 0.32 | 0.39 | 0.25 |
| bobot kering (gr) | 0.10 | 0.09 | 0.13 | 0.08 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.10 | 0.12 | 0.12 | 0.11 | 0.13 | 0.11 |

## Suhu T6

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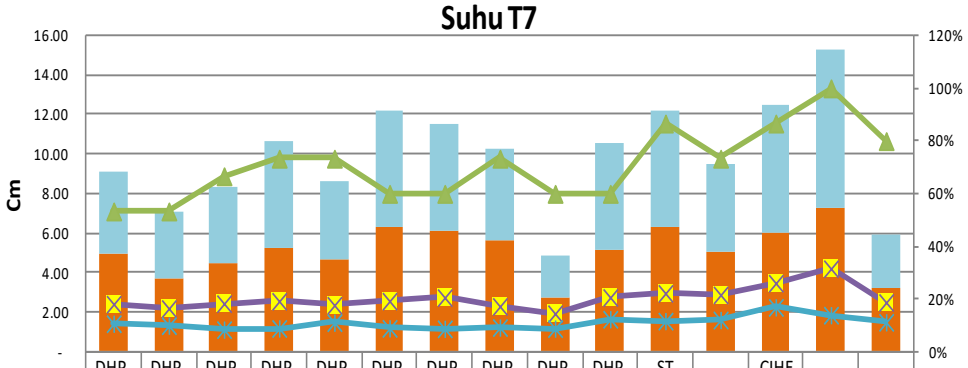
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 2.46 | 5.51 | 5.27 | 4.84 | 4.66 | 6.78 | 6.83 | 7.61 | 4.13 | 4.80 | 5.19 | 9.84 | 5.89 | 10.79 | 6.69 |
| Panjang Akar (cm) | 2.97 | 5.73 | 5.90 | 5.78 | 5.84 | 6.03 | 6.26 | 6.57 | 4.92 | 4.43 | 5.39 | 8.20 | 6.00 | 10.13 | 6.91 |
| Jlh. Kec. Normal (%) | 47% | 80% | 60% | 93% | 87% | 93% | 53% | 73% | 87% | 60% | 80% | 100% | 87% | 100% | 87% |
| bobot basah (gr) | 0.18 | 0.20 | 0.21 | 0.23 | 0.23 | 0.22 | 0.25 | 0.25 | 0.17 | 0.20 | 0.22 | 0.36 | 0.25 | 0.38 | 0.29 |
| bobot kering (gr) | 0.10 | 0.09 | 0.10 | 0.10 | 0.10 | 0.09 | 0.10 | 0.09 | 0.09 | 0.10 | 0.12 | 0.12 | 0.12 | 0.13 | 0.12 |

## Suhu T7

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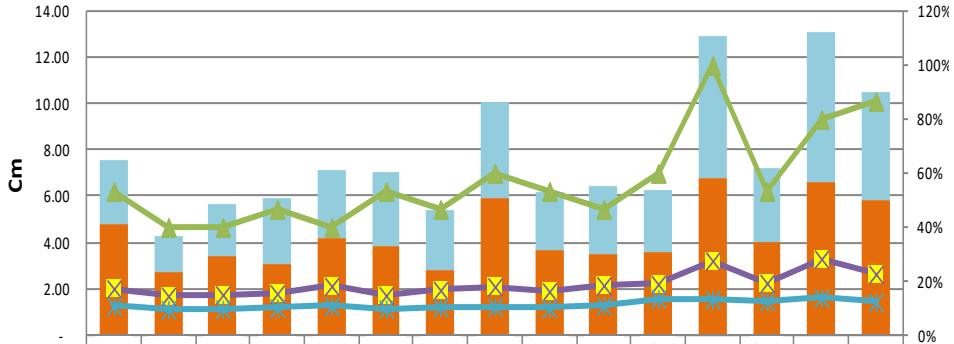
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 4.12 | 3.38 | 3.82 | 5.46 | 3.92 | 5.95 | 5.46 | 4.65 | 2.08 | 5.45 | 5.80 | 4.46 | 6.47 | 7.95 | 2.67 |
| Panjang Akar (cm) | 4.99 | 3.68 | 4.47 | 5.20 | 4.71 | 6.26 | 6.06 | 5.64 | 2.73 | 5.11 | 6.35 | 5.05 | 6.00 | 7.28 | 3.23 |
| Jlh. Kec. Normal (%) | 53% | 53% | 67% | 73% | 73% | 60% | 60% | 73% | 60% | 60% | 87% | 73% | 87% | 100% | 80% |
| bobot basah (gr) | 0.18 | 0.17 | 0.18 | 0.19 | 0.18 | 0.19 | 0.21 | 0.17 | 0.15 | 0.21 | 0.22 | 0.22 | 0.26 | 0.32 | 0.19 |
| bobot kering (gr) | 0.11 | 0.10 | 0.09 | 0.09 | 0.11 | 0.09 | 0.09 | 0.09 | 0.09 | 0.12 | 0.12 | 0.12 | 0.17 | 0.14 | 0.11 |

## Suhu T8

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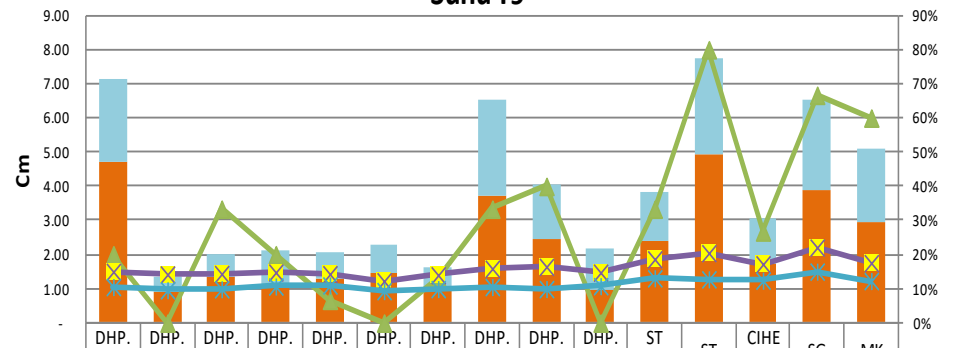
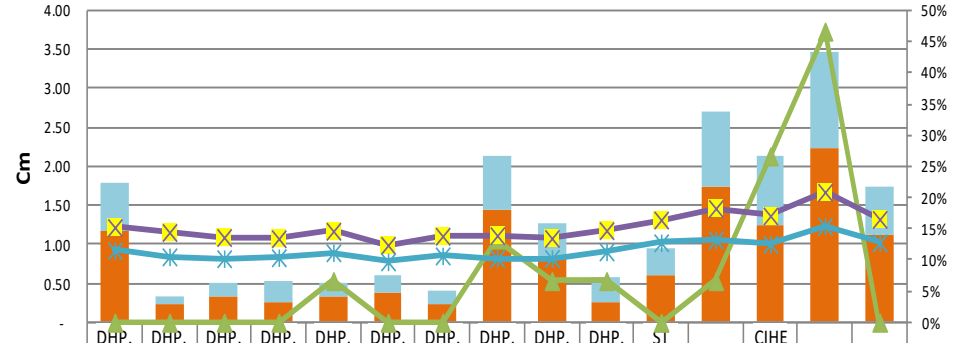
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 2.78 | 1.59 | 2.28 | 2.86 | 2.98 | 3.24 | 2.61 | 4.16 | 2.52 | 2.94 | 2.70 | 6.11 | 3.17 | 6.49 | 4.67 |
| Panjang Akar (cm) | 4.75 | 2.67 | 3.37 | 3.05 | 4.18 | 3.81 | 2.77 | 5.91 | 3.68 | 3.53 | 3.59 | 6.76 | 4.00 | 6.57 | 5.81 |
| Jlh. Kec. Normal (%) | 53% | 40% | 40% | 47% | 40% | 53% | 47% | 60% | 53% | 47% | 60% | 100% | 53% | 80% | 87% |
| bobot basah (gr) | 0.17 | 0.15 | 0.15 | 0.15 | 0.18 | 0.15 | 0.17 | 0.18 | 0.16 | 0.18 | 0.19 | 0.28 | 0.19 | 0.28 | 0.23 |
| bobot kering (gr) | 0.11 | 0.10 | 0.10 | 0.10 | 0.11 | 0.10 | 0.10 | 0.11 | 0.10 | 0.11 | 0.14 | 0.13 | 0.13 | 0.14 | 0.12 |

## Suhu T9




| | DHP. KARO 103 | DHP. KARO 106 | DHP. KARO 108 | DHP. KARO 114 | DHP. KARO 119 | DHP. KARO 120 | DHP. KARO 121 | DHP. KARO 122 | DHP. KARO 124 | DHP. KARO 125 | ST BGDI T | ST MRH | CIHE RAN G | SG PTH | MK GGA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 2.44 | 0.40 | 0.64 | 1.09 | 0.74 | 0.81 | 0.65 | 2.79 | 1.63 | 1.23 | 1.42 | 2.78 | 1.29 | 2.62 | 2.17 |
| Panjang Akar (cm) | 4.69 | 0.92 | 1.34 | 1.01 | 1.29 | 1.45 | 0.94 | 3.73 | 2.42 | 0.96 | 2.40 | 4.94 | 1.75 | 3.89 | 2.95 |
| Jlh. Kec. Normal (%) | 20% | 0% | 33% | 20% | 7% | 0% | 13% | 33% | 40% | 0% | 33% | 80% | 27% | 67% | 60% |
| bobot basah (gr) | 0.15 | 0.14 | 0.14 | 0.15 | 0.14 | 0.12 | 0.14 | 0.16 | 0.16 | 0.15 | 0.19 | 0.20 | 0.17 | 0.22 | 0.18 |
| bobot kering (gr) | 0.11 | 0.10 | 0.10 | 0.11 | 0.11 | 0.09 | 0.10 | 0.11 | 0.10 | 0.11 | 0.13 | 0.13 | 0.12 | 0.15 | 0.12 |

## Suhu T10




| | DHP. KARO 103 | DHP. KARO 106 | DHP. KARO 108 | DHP. KARO 114 | DHP. KARO 119 | DHP. KARO 120 | DHP. KARO 121 | DHP. KARO 122 | DHP. KARO 124 | DHP. KARO 125 | ST BGDI T | ST MRH | CIHE RAN G | SG PTH | MK GGA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panjang Tunas (cm) | 0.61 | 0.10 | 0.16 | 0.27 | 0.19 | 0.20 | 0.16 | 0.70 | 0.41 | 0.31 | 0.36 | 0.97 | 0.90 | 1.26 | 0.62 |
| Panjang Akar (cm) | 1.17 | 0.23 | 0.34 | 0.25 | 0.32 | 0.39 | 0.24 | 1.43 | 0.86 | 0.26 | 0.60 | 1.74 | 1.24 | 2.22 | 1.11 |
| Jlh. Kec. Normal (%) | 0% | 0% | 0% | 0% | 7% | 0% | 0% | 13% | 7% | 7% | 0% | 7% | 27% | 47% | 0% |
| bobot basah (gr) | 0.15 | 0.14 | 0.14 | 0.13 | 0.15 | 0.12 | 0.14 | 0.14 | 0.14 | 0.15 | 0.16 | 0.18 | 0.17 | 0.21 | 0.17 |
| bobot kering (gr) | 0.12 | 0.11 | 0.10 | 0.10 | 0.11 | 0.10 | 0.11 | 0.10 | 0.10 | 0.11 | 0.13 | 0.13 | 0.13 | 0.15 | 0.13 |

## CONCLUSION

The danger of low temperature is visible at the temperature of 18˚C. DHP Karo 121 strain is the most sensitive genotype at lower than 18˚C which is in fact different from the strength check of *Sigambiri Putih.* DHP Karo 124 is the most tolerant genotype on vegetative phase compared to other strains with average power plant at cold temperature of (13, 16, and 18 $^0$C) at 47%.

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