Growth and productivity responses to the utilization of superior rice varieties and bio-silica application in rainfed land

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Abstract. This research aimed to understand response of growth and rice productivity to the utilization of superior rice varieties and the application of biosilica fertilizer on rainfed land at different planting season. The study employed split plot design with three superior varieties of rice as main plot treatment and biosilica application as sub-plot. The growth and rice productivity were observed during dry season and rainy season. The utilization of superior rice varieties was only affected on number of total grains, 1000 grains weight and productivity at dry season meanwhile it affected the variables observed at rainy season. Application of biosilica fertilizer did not affect plant height, number of empty and total grains at dry season meanwhile it affected the variables observed at rainy season. Rice productivities were significantly different in both factors. Result showed that most of variables values obtained with biosilica application were higher. Biosilica fertilizer was able to increase productivity up to 1.08 tons/ha from 6.48 tons/ha to 7.56 tons/ha at dry season and up to 1.92 tons/ha from 8.7 tons/ha to 10.62 ton/ha at rainy season. This result indicated that utilization of superior rice varieties and biosilica fertilizer is recommended to increase rice productivity on rainfed land.

1. Introduction
Rice is the of staple food for more than 90% of Indonesian citizen. Effort to enhance rice productivity is required in accordance with the increase in Indonesia’s population up to 1.3 % per year with on average 139 kg/head/year of rice consumption [1,2]. Rice productivity is influenced by many factors such as land quality and availability of superior rice varieties. Agriculture land and plant varieties are production factors which should be managed in order to improve the sustainable productivity. Rainfed land plays important role to meet food requirement particularly rice in national level. Rainfed land were located in Java, Sumatera, Kalimantan, Sulawesi, Nusa Tenggara and Bali up to 3.71 million ha [3]. Rainfed land in Bali Province was not declared clearly in the publication of Provinsi Bali dalam Angka [4]. Nevertheless, the land use changes from irrigated rice land to the nonagricultural sector lead to the damage of many irrigation canals; hence, irrigated rice land was not able to obtain water from irrigation canals and the farmers relied on rain to irrigate their land.
As the sub-optimal land, rainfed land faced many issues namely soil fertility (low levels of Nitrogen and Kalium total, medium levels of Phosphorus and Cation Exchange Capacity availability), climate change, drought and the fast growth of weed [5]. When extreme drought happened (El-Nino phenomenon) in 2015, it caused drought in Selemadeg Timur District, Tabanan Regency, Bali Province where up to 800 ha rice land from the total of 3032 ha was affected [6].

Beside of the climate change issue, the land use changes to the nonagricultural sector also occurred in Tabanan Regency. Data from Dinas Pertanian Tanaman Pangan Kabupaten Tabanan showed that rainfed land was decreased with an average of 185.25 ha/year or 0.82% since 2010 to 2015. The decrease of rainfed land in 2014 to 2015 reached up to 248 ha [4]. Other issue faced by Tabanan Regency was the decrease of rice productivity in line with the decreasing of cultivation area. The largest of cultivation area decreasing in Bali Province was contributed by Tabanan Regency which reached 4518 ha (12.25%) in 2015. It was caused by the delayed of cultivation in Jembrana, Tabanan, Gianyar and Buleleng Regency due to the reparation of irrigation canals and prolonged dry season because of El-Nino [4].

Many efforts had been done by the government to solve the issues of rice sufficiency including import. To ensure food security in Indonesia, the government always put a lot of effort to enhance rice productivity such as introduction of agriculture modern technology and utilization of superior rice varieties high productivity. The great contribution of superior rice varieties role in increasing of rice productivity in national level could be seen from the achievement of the rice self-sufficiency in 1984 [7]. Aside from their high productivity, the growth of superior rice varieties tends to equal therefore it can be harvested simultaneously with better quality [8]. The role of superior rice varieties in enhancing rice productivity could reach up to 75% when integrated with irrigation technology and fertilization [9].

One of elements which often ignored in agriculture soil particularly rice land is Silica element (Si). All this time, rice crops relies on Si element availability in nature to meet Si requirement. Rice crops uptake Si element between 100-300 kg/ha when harvested [10]. The loss of Si through harvesting process and leaching without addition of Si lead to decreasing of Si availability in soil. Silica deficiency in rice crops can cause many negative impacts namely susceptible to pest and disease, biotic and abiotic stresses then lead to the decrease of rice quality and productivity. Based on all issues stated, this study aimed to investigate response of growth and rice productivity to the utilization of superior rice varieties namely Inpari 40, Situ Bagendit, Towuti and biosilica application in rainfed land at different planting season.

2. Materials and methods
Research was carried out at rainfed land in Subak Babakan Anyar, Tempek Betenan, Mambang Village, Selemadeg Timur District, Tabanan Regency, Bali Province. Superior rice varieties namely Inpari 40, Situ Bagendit and Towuti were cultivated at rainy season in April to August 2018 and dry season in December 2019 to April 2020.

The age of rice seedling at 16 days were planted 2-3 seeds per hole with 25 cm x 25 cm planting space. Phonska fertilizer was applied at 5-7 Days After Planting (DAP) with 200kg/ha dosage. Urea fertilizer with dosage of 110 kg/ha was given at 3 and 7 Weeks After Planting (WAP) followed by 50 kg/ha of KCl fertilizer. Biosilica fertilizer produced by Hoerundin et al [11] was applied to rice crops at 20-25 days after planting (DAP) and 40-45 DAP by adding 100 liters of water into 1 liter of biosilica fertilizer then it was sprayed to rice crops in the morning and evening. Weeds, pest and disease were controlled based on Integrated Crops Management.

Research was arranged by using split plot design with superior rice varieties namely Inpari 40, Situ Bagendit and Towuti as main plot and silica application as supporting plot (with and without silica). Growth and productivity variables were observed during rainy season and dry season namely number of tiller productive, plant height, length of panicle, number of filled grains per panicle, number of empty grains per panicle, number of grains total, 1000 grains weight and productivity. Collected data were analyzed by using analysis of variance (ANOVA) and post-hoc test with Duncan Multiple Range
Test (DMRT) at 5% level. Observed data variables in this study were done by following these guidelines:

a) plant height (cm): by measuring height from the bottom of the plant to the highest of the panicle when approaching the harvest time in five plant chosen samples.
b) number of productive tillers: all of tillers produce the panicle were counted in five plant chosen samples.
c) panicle length (cm): by measuring length from the bottom of panicle to the top of panicle in five plant samples.
d) number of filled and empty grain: by counting the number of filled and empty grain in five plant samples.
e) 1000 grain weight: by weighing 1000 grains at 14% water content.
f) productivity: the yield was obtained from yield at trial plot after reduced the two outer plant rows (border plant).

Selection of plant samples were done according to Figure 1 disregarding the border plant.

![Figure 1](image)

**Figure 1.** Trial plot of plant samples observed

### 3. Results and discussion

The growth and productivity of rice crops at dry season dan rainy season was better by biosilica fertilization than without biosilica in most of variables (Table 1 and 2). At rainy season, the highest growth was occurred in Inpari 40 (118.1 cm) and significantly different from plant height of Situ Bagendit (109.80 cm), the lowest plant height than others (Table 2). The difference of plant height could be caused by genetic factor of varieties [12, 13]. Syahri and Soemantri [14] stated that plant height could be categorized as growth variable however it cannot determine the productivity. Plant height variable could not be used as indicator in terms of yield potential of rice due to various environmental effects in every location. The plant height of Situ Bagendit obtained was lower than previous study Sujitno et al [15] which were between 110-120 cm and [16] at dry season (Table 1). Only plant height of Inpari 40 was equal to rice varieties description by Puslitbangtan [16] namely ± 101 cm both at rainy season and dry season (Table 1 and 2). The growth of Towutiwas was in accordance with previous publication BB Padi [17] when it cultivated at rainy season (Table 2). In contrast, superior rice varieties used cannot be distinguished by the plant height among each other at dry season (Table 1).

Number of productive tillers overall was equal among the superior rice varieties both at dry season and rainy season (Table 1 and 2). Situ Bagendit and Towuti produced more productive tillers than other varieties described by previous experiment BB Padi [17] both at dry season and rainy season (Table 1 and 2). Factors influencing tillering in rice was divided into three major groups namely multiple genes contained, environmental factors and biotic factor which functionally contributed to hormonal, genetic control, growth and developmental [12, 18, 19].
Application of biosilica fertilizer was not affecting plant height, number of empty and total grains at dry season (Table 1) meanwhile it was positively affecting the overall variables observed at rainy season (Table 2). Result showed that most of variables value obtained with biosilica application were higher than without biosilica (Table 1 and 2). Biosilica fertilizer able to increase productivity up to 1.08 tons/ha from 6.48 tons/ha to 7.56 tons/ha at dry season and up to 1.92 tons/ha from 8.70 tons/ha to 10.62 tons/ha at rainy season (Table 1 and 2). Si element contained in biosilica fertilizer was beneficial for supporting plant growth under both abiotic and biotic stresses such as salinity, drought,
Fe toxicity, pest and disease [26]. Si element made the leaves and stem plant more upright and reduced the shading in leaves of the canopy downside to better able absorbing solar radiation highly therefore photosynthesis became more efficient. Silicon has also been observed to be used by plants to strengthen their cell walls [27].

### Table 2. The growth and yield of three superior rice varieties at rainy season

| Treatments                | Varieties Factor | Fertilization Factor |
|---------------------------|------------------|----------------------|
|                           | Inpari 40        | Situ Bagendit        |
|                           | 18.54 a          | 16.60 a              |
|                           | 118.1 b          | 109.8 a              |
|                           | 23.65 b          | 27.48 a              |
|                           | 112.2 a          | 110.95 a             |
|                           | 14.15 b          | 8.50 a               |
|                           | 126.35 a         | 119.45 a             |
|                           | 24.18 a          | 30.41 c              |
|                           | 9.85 b           | 9.36 a               |
| Variation Coefficient (%) | 9.33             | 14.6 a               |
|                           | 3.72             | 111.46 a             |
|                           | 8.24             | 25.21 a              |
|                           | 11.10            | 95.43 a              |
|                           | 19.85            | 18.9 b               |
|                           | 22.01            | 114.33 a             |
|                           | 1.10             | 26.64 a              |
|                           | 1.34             | 8.70 a               |
| With Biosilica            | 19.4 b           | 115.73 b             |
|                           | 26.73 b          | 122.93 b             |
|                           | 11.73 a          | 134.66 b             |
|                           | 28.62 b          | 10.62 b              |
| Variation Coefficient (%) | 14.70            | 5.10                 |
|                           | 10.33            | 8.97                 |
|                           | 17.07            | 17.13                |
|                           | 1.95             | 2.31                 |

Noted: Numbers followed by the same letters in same column were not significantly different at DMRT 5%.

Climate change from dry season to rainy season may directly influenced to rice plant growth through the changes in air temperature, evapotranspiration, precipitation and particularly availability of water [28]. Rainy season increased surface water availability, allowing for increased cropped yield [29]. Some phenological growth stages of rice crops were influenced by external factors climate related namely temperature, rainfall intensity and solar radiation. The high daily temperature during the seed maturing phase at dry season causes the maturation phase was faster therefore the time for completing grains was decrease and reduce rice yield at dry season [30]. At rainy season, water availability was more abundant than at dry season up to above surface. These conditions impacted on the growth of weeds became more controllable and increase the available phosphorus element. Anaerobic decomposition of organic material during the rainy season was higher than the dry season [31].

### 4. Conclusion

The utilization of superior rice varieties had only affected the number of total grains, 1000 grains weight and productivity at dry season; meanwhile it was positively affecting most variables observed at rainy season. Application of biosilica fertilizer was not affecting plant height, number of empty and total grains at dry season; meanwhile it had positive effect on overall variables observed at rainy season. Rice productivity was significantly different by both varieties and biosilica factors. Most the growth and productivity variables with biosilica application were higher than without biosilica. Biosilica fertilizer was able to increase the productivity up to 1.08 ton/ha from 6.48 ton/ha to 7.56 ton/ha at dry season and up to 1.92 ton/ha from 8.70 ton/ha to 10.62 ton/ha at rainy season.

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