Utilization of local aromatic rice Endophytic fungi to promote the growth and yield of rice plant in drought stress conditions

S Syamsia1, M Kadir2, A Idham1 and N Noerfitryani1

1 Faculty of Agriculture, Makassar Muhammadiyah University, Jl. Sultan Alauddin No. 259 Makassar 90221, Indonesia
2 State Agriculture Polytechnic of Pangkajene and Islands, Jl. Poros Makassar-Parepare km 83 Mandalle Pangkep 90655, Indonesia

E-mail: syamsiatayibe@unismuh.ac.id

Abstract. Drought is one of the major constraints in rice production in the rainfed areas. Water shortages due to long drought are the main problem causing the decline in rice productivity. One effort that can be done to overcome the drought is the use of endophytic fungi. This study aimed to determine the effect of the application of local aromatic rice endophytic fungi on growth and production of rice in limited water conditions. This study was arranged in a Randomized Block Design with four treatments of field inundation combined with the fungi. Treatment were consisted of four levels: inundation with water level of 5 cm, inundation with water level of 1 cm, inundation with water level of 1 cm + endophytic fungi, and inundation with water level of 1 cm + endophytic fungi. Rice seedlings were planted using Legowo 4 : 1 with the distance within rows of 25 cm x 25 cm and the distance between rows of 50 cm. The results show that the application of endophytic fungi produced plant height, tiller number, root length, root weight, number of filled grains and production per hectare were higher and significantly different from the treatment without application of endophytic fungi. This shows that endophytic fungi promote the growth and production of rice in limited water conditions.

1. Introduction

Rice is an important crop in Indonesia because it is a major source of carbohydrates for almost all Indonesian people. The need for rice each year has increased in terms of both quantity and quality. The upper-middle consumers nowadays want fluffier rice with a fragrant aroma. Rice has a fragrant aroma like papyrus known as aromatic rice.

South Sulawesi Indonesia in particular has always been known as a producer of aromatic rice. One type of aromatic rice that is quite popular is Pulu Mandoti of Enrekang. Some local aromatic rice varieties developed in Indonesia is Rojolele, Mentikwangi, Pandan Wangi developed in Central Java. Varieties of aromatic local from South Sulawesi is quite a famous aroma fragrance is aromatic rice origin Enrekang like Pulu Mandoti, Pare Salle, Pare Pulu lotong, Parea Pinjan, Pare Pallan, Pare Solo, Pare Mansur, Pare Kamida and the Lambau which grow in the plains high. Other areas in South Sulawesi as aromatic rice-producing areas are Tana toraja, Gowa and Maros regency.

Drought is a major obstacle in the production in rainfed lowland rice. Lack of water due to the long dry that often occurs lately is a major problem that causes a decrease in rice productivity [1]. One effort that can be done to overcome the drought is through the use of endophytic fungi. Petrini (1991) [2]; Fisher and Petrini (1992) [3] define endophytes to include all organisms that live in plant
tissue during the plant cycle period and colonize plant tissue without causing symptoms of disease in host plants. The colonization of endophytic fungi in host plants contributes to plant genotype in adapting to biotic and abiotic stress conditions [4-6].

The presence of endophytic fungi that are abundant and its ability to produce hormones, increase P uptake in plants, produce siderofore, and other metabolites cause the endophytic fungi to have the potential to be developed to increase the growth and production of plants experiencing drought stress. This may be done as an effort to overcome climate change due to global warming. This study aimed to determine the effect of the application of endophytic fungi on the growth and production of rice planted in rain-fed rice fields in the dry season.

2. Methodology

2.1. Rejuvenation of endophytic fungus.
Endophytic fungi obtained in the study year earlier rejuvenated on PDA, endophytic been aged 7 days on PDA were transferred to medium rice. A total of 100 grams of rice included in the heat-resistant plastic and then sterilized twice for 20 minutes at 121 °C with a 24 hour time interval. Rice media was inoculated with five pieces of the fungi. Isolated colonies that had grown on the media were mashed become rice flour fungi powder using a blender.

2.2. Seedling preparation and experimental design.
Prior to sowing, rice seeds were covered with flour with endophytic fungi formulation using a ratio of 1: 10: 1 g of endophytic fungi powder formulations to 10 grams of rice seeds. The seeds were sown in a nursery and after rice seeds was 14 days after transplanting, the seedlings were transferred to the fields and planted using the system of Legowo 4 : 1 with a spacing of 25 cm x 25 cm. Research was set using a randomized block design with four treatments, inundation (G0), drought (G1), inundation+ fungal endophyte (G2), drought + fungal endophyte (G3).

2.3. Measurement of seedling growth characteristics and biomass production.
Observation parameter were plant height (cm), number of tillers (stem), shoot dry weight (g), root dry weight (g), number of grains per panicle (grains), weight of 100 seeds (g).

2.4. Analysis of pigments.
The concentration of chlorophyll a, chlorophyll b, the amount of chlorophyll and carotenoid of rice leaves were conducted randomly. Total chlorophyll and carotenoids were determined using a spectrophotometer.

2.5. Statistical analysis.
Data were analyzed using ANOVA to determine the effect of Endophytic fungi applications and drought stress in rice plants. If the variance in the level of α = 0.05 is a significant effect, analysis was continued by Duncan (DMRT) test.

3. Results and discussion
Statistical analysis show that the application of endophytic fungi on rice seedlings significantly affected plant height, number of tillers, crown weight, root weight, and root length (Figure 1). The application of endophytic fungi resulted in the highest average of plant height, number of tillers, crown weight, root weight, root length and root volume and significantly different from treatment without endophytic fungi.

The results of this study are in line with research of Subowo [7], that the addition of mushroom biological fertilizer can increase the growth of rice plants. At 0.5% salinity can increase plant height 67%, tiller number 91%, biomass (straw) dry weight 186% and root dry weight 188%. According to Arora et al. and Shula et al. [8-9], the application of Trichoderma strains in plants increases roots
length, which help in increasing the water acquisition at deeper layer of soil, hence increasing plant’s ability to resist abiotic stresses (drought, salt, etc.) and uptake of nutrients.

![Graphs showing plant height, number of tillers, crown weight, root weight for treatments G1, G2, G3, G4](image)

**Figure 1.** Plant height, number of tillers, crown weight, root-weight. G1 = inundation with water level of 5 cm; G2 = inundation with water level of 1 cm; G3 = inundation with water level of 5 cm + endophytic fungi; G4 = inundation with water level of 1 cm + endophytic fungi.

This study shows that the 5 cm (G1) water height treatment was not significantly different from the 1 cm (G2) water height treatment, but the G2 treatment resulted in an average grain content lower than the G1 treatment, whereas the weight of 100 seeds showed significantly different results between treatments of G1 and G2. This shows that in limited water conditions a decline in rice yield. According to [10-11], grain yield under stress environment is the primary trait for selection in breeding for drought tolerance. Drought effect on seed yield is due to the relation with duration of watering from flowering until physiological maturity.

The application of endophytic fungi show that the number of filled grains and weight of 100 was significantly different from the treatment without the application of endophytic fungi (Figure 2). This shows that the application of endophytic fungi can increase rice yield compared to without the application of endophytic fungi. Similar results were reported by Morse et al. [12], infecting *Neotyphodium* endophyte in Arizona fescue (*Festuca arizonica* Vasey).
Figure 2. Number of grain per panicle and weight of 100 seeds. G1 = inundation with water level of 5 cm; G2 = inundation with water level of 1 cm; G3 = inundation with water level of 5 cm + endophytic fungi; G4 = inundation with water level of 1 cm + endophytic fungi.

The content of chlorophyll a, chlorophyll b and total chlorophyll in the treatment of 1 cm (G1) and 5 cm (G2) water height show the same results, but the application of endophytic fungi show higher than without the application of endophytic fungi (Figure 3). According to Farooq et al. [13], Shukla et al. [9], decreased chlorophyll content in plants experiencing drought stress are typical symptoms of oxidative stress and may be a result of photo pigment oxidation and chlorophyll degradation. Photosynthetic pigments are important to plants mainly for harvesting light and production of reducing powers.

Figure 3. The content of chlorophyll a, chlorophyll b and total chlorophyll.

Content of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid decrease in crops suffer from lack of water, but the treatment of endophytic fungi can improve drought treatment plant chlorophyll content (Figure 3 and 4). According to Singh and Reddy [14]; Sudrajat et al. [15], the change in chlorophyll and carotenoids contents has been used to evaluate the influence of environmental stress on plant growth, and earlier study proved that chlorophyll contents usually decreased under drought condition.
Figure 4. The levels of carotenoids of rice in drought and inundation treatment and application of endophytic fungi.

4. Conclusions

1) Application of endophytic fungi in the treatment of surface height of 1 cm in the dry season can increase the growth and production of rice and provide higher average yield compared to the application of endophytic fungus applications and 5 cm water height.

2) The application of endophytic fungi can increase the content of chrolophyll a, chlorophyll b and total chlorophyll.

Acknowledgment

Thanks to the Directorate-General of Research and Higher Education of the Ministry of Research, Technology and Higher Education which has funded these activities through Products Research Applied Research Scheme.

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