Reduction of inorganic fertilizers and application of antagonistic agents to the growth and severity of local gogo blast disease

M Taufik\(^1\), Gusnawaty\(^1\), D N Yusuf\(^2\), M Botek\(^1\), Rahayu\(^1\) and Sainul\(^3\)

\(^1\)Department of Plant Protection, Faculty of Agriculture, Halu Oleo University, Kendari, 93132 Southeast Sulawesi, Indonesia
\(^2\)Department of Soil Science, Faculty of Agriculture, Halu Oleo University, Kendari, 93132 Southeast Sulawesi, Indonesia
\(^3\)Staf Badan Penelitian dan Pengembangan Daerah Kab. Konawe Selatan Southeast Sulawesi, Indonesia

Email: taufik24@yahoo.com

Abstract. Gogo rice is a potential food alternative to support national food self-sufficiency. But its productivity is still low compared to its production potential. The use of inorganic fertilizers that have not been optimal and infection with blast disease (Pyricularia oryzae) is the main obstacle in increasing the productivity of upland rice. This study aims to evaluate the application of inorganic fertilizers and antagonistic fungi to reduce the severity of blast disease.

The design of the experiment uses a separate plot design. The main plot is inorganic fertilizer, and subplots are antagonistic agents Trichoderma asperellum and Paecilomyces sp. (EP\(^1\)). The results showed that the combination of P\(_2\)C\(_1\) and P\(_2\)C\(_2\) was 50% inorganic fertilizer application (P\(_2\)), T. asperellum (C\(_1\)), and Paecilomyces sp. (EP\(_1\)), produced some tillers that were not significantly different from the recommendation of 100% fertilization, namely 28.27 tillers and 31.27 tillers. There is no difference in the weight of 1000 upland rice seeds combined application of 75% inorganic fertilizer and antagonistic agent (P\(_3\)C\(_1\)) with 100% inorganic fertilizer application and 75% antagonistic agent (P\(_3\)C\(_1\)), but the application of endophytic fungi can increase the weight of 1000 grains of rice also able to inhibit blast infection up to 12 MST with disease severity still below 6%. Reduction of inorganic fertilizer up to 50% can be made by combining the use of antagonistic fungi, both T. asperellum and Paecilomyces sp. (EP\(_1\)).

1. Introduction
Rice is the staple food consumed by most Indonesians with high per capita consumption compared to neighboring countries [1]. Lately, the need for rice is expected to continue to increase from year to year, which is resolved by an increasing population [2]. The national food source of rice is still relying on lowland rice; on the other hand, paddy fields face the threat of conversion from time. Therefore dry land can be a resource for rice development, especially upland rice. Southeast Sulawesi has land or fields 141,731.5 Ha [3].

The potential of the land has not been optimized for the development of upland rice. Besides that, the cultivation system is still conventional and is reflected by the productivity, which is still low.
Southeast Sulawesi upland rice production in 2015 amounted to 14,512 tons with a harvest area of 5,377 ha, of which productivity was 2.70 tons ha\(^{-1}\). The productivity of upland rice in Southeast Sulawesi is lower than the national productivity of 3.34 tons ha\(^{-1}\) [3].

The low productivity of upland rice is influenced by the maintenance of plants that only depend on natural soil fertility, and fertilizer inputs are very low. It might be caused by farmers' ignorance of the importance of fertilizing or the difficulty of getting inorganic fertilizer. Another factor is the pathogenic disorder of the fungi *Pyricularia oryzae*. While it has been proven that the regulation of inorganic fertilizers, especially urea, has an essential effect on the growth of upland rice. Its resistance increases when infected with pathogens, including pathogens that cause blast disease [4].

The use of antagonistic fungi can protect host plants from various pathogenic infections. Botek [5] reports that the introduction of antagonistic microbes such as *mycorrhizae*, *trichoderma*, and *rhizobacteria* can reduce the use of inorganic fertilizers by 25% and increase the production of upland rice. Furthermore, Taufik et al. [6] reported that upland rice fed with the fungi *Trichoderma sp.* other microbial funds significantly increased upland rice production by more than 5 tons/ha even though the inorganic fertilizer was reduced by 25%. Therefore, the study aims to evaluate the ability of antagonistic fungi to increase the growth and resistance of upland rice to blast even though the fertilizer dosage is reduced.

2. Methods

The study was conducted in Lamomea Village, Konda, South Konawe, Southeast Sulawesi, the Plant Protection Laboratory, and the Soil Science Laboratory of the Faculty of Agriculture, Halu Oleo University, Kendari. Start from May to October 2018. The materials used were local upland rice seeds, Ungoruno cultivar, organic fertilizer (cow manure), urea fertilizer, SP36 fertilizer, KCl fertilizer, dolomite, antagonistic agents, namely *Trichoderma asperellum* and *Paecilomyces sp.* EP\(_{11}\) isolates. The tools used are hand tractor, hoe, meter, raffia, sample ring, label paper, scales, and writing stationery.

The study was designed using Randomized Block Design (RBD) in a factorial pattern with two factors. The first factor is fertilization, namely:

- \(P_0\) = No inorganic fertilizer
- \(P_1\) = Fertilization with inorganic fertilizer 25\% of the recommendation
- \(P_2\) = Fertilization with inorganic fertilizer 50\% of the recommendation
- \(P_3\) = Fertilization with inorganic fertilizer 75\% of recommendations
- \(P_4\) = Fertilization with inorganic fertilizer 100\% according to recommendations

The second factor is the use of antagonistic fungi, namely:

- \(C_0\) = Without antagonistic mushroom application
- \(C_1\) = *Trichoderma asperellum* application.
- \(C_2\) = Application of *Paecilomyces sp.* (EP\(_{11}\))

The treatment issued as many as 15 combinations. Each settlement was repeated three times so that it took 45 trial units.

2.1. Antagonistic fungal preparation

*T. asperellum* fungus was propagated on glutinous rice media for ten days before use. Application of *T. asperellum* is carried out in conjunction with planting upland rice seeds at a rate of 10 g per planting hole. Endophytic fungi *Paecilomyces sp.* (EP\(_{11}\)) was grown on PDA (*Potato Dextrose Agar*) media for one week, then suspended in sterile *aquades* with 1 × 108 CFU spore density. Furthermore, the seeds to be used are soaked in the suspension for 5 minutes.

2.2. Land preparation and planting

The experimental land measuring 3 m × 1.5 m and given lime is equivalent to 2 tons/ha, cow dung is equal to 5 tons per hectare given before planting. Doses of fertilizer are given equivalent to 225 kg ha\(^{-1}\) Urea, 125 kg ha\(^{-1}\) SP36, 45 g plot\(-1\), or 100 kg ha\(^{-1}\) KCl. Planting is done straightforwardly with a
distance between each planting hole that is 30 × 25 cm, the hole that has been made then filled with 5-7 rice seeds per planting hole. Maintenance includes replacing, cleaning weeds and pest control.

Plant growth variables were carried out only on sample plants of 7 clumps for each treatment and group. Observations include:

a. Number of tillers, counting the number of tillers that grow
b. A number of panicles, calculated by the number of panicles produced by plants per family.
c. The number of panicle heads, derived from 3 panicle samples per family.
d. Weight of 1000 grains, carried out by weighing the weight of 1000 grains of grain at 14% water content (obtained by drying for three days).

The severity of the disease is calculated using the following formula:

\[ KP = \frac{\sum n_i (v_i)}{(N \times Z)} \times 100 \]  

Information:

- **KP** = Disease severity (%)
- \( n_i \) = The number of leaves in each attack category
- \( v_i \) = Numeric value of each attack category
- \( Z \) = The highest numerical value of the attack category
- \( N \) = Number of leaves observed

The numerical value of the attack category is 0 = no attack, 1 = leaf area attacked less than 1%, 3 = leaf area attacked 1-5%, 5 = leaf area attacked 6-25%, 7 = leaf area attacked 26-50% , and 9 = leaf area attacked by 51-100% (Silitonga et al., 2003). Data from observations of the vegetative phase, generative phase, and evaluation of upland rice disease resistance were analyzed using variance analysis and Duncan's Multiple Range Test (UJBD) method for treatment that significantly affected the 95% confidence level.

3. Results and discussion

3.1. Total tillers

Application of *T. asperellum* (C1) with inorganic fertilizer 100% (P4) produced the highest number of upland rice tillers at the age of 12 MST which was not significantly different from fertilization with inorganic fertilizer 75% of the recommendation (P3) and fertilization with inorganic fertilizer 50% of recommendations (P2) but substantially different from inorganic fertilization 25% of recommendations (P1) and without inorganic fertilization (P0). Application of *T. asperellum* (C1) and *Paecilomyces sp.* (C2) with 50% inorganic fertilizer (P2) produced some tillers that were not significantly different from the application of inorganic fertilizers 100 and 75%, 12.76 and 13, 29 tillers with 13.33 and 13.43 at 12 MST (table 1).

| Fertilization | Antagonistic fungus | UJBD 0.05 |
|---------------|---------------------|-----------|
| \( P_0 \)     | S                   |           |
| \( P_1 \)     | R                   |           |
| \( P_2 \)     | Q                   |           |
| \( P_3 \)     | P                   |           |

**Tabel 1.** The effect of the interaction of the use of inorganic fertilizers and antagonistic fungi on the number of saplings of upland rice plants at the age of 12 MST.
3.2. Number of panicles

Application of 100% inorganic fertilizer produced the highest number of panicles that were not significantly different with fertilization of 75% of recommendations (P3) and fertilization of 50% of recommendations (P2) but significantly different from fertilization of 25% of recommendations (P1) and without inorganic fertilization (P0) as follows 10.52 panicles, 9.78 panicles, 9.33 panicles, 8.81 panicles, and 6.79 panicles while the application of T. asperellum (C1) produced the highest number of panicles, namely 9.56 panicles, Paecilomyces sp (EP11) 9.10 panicles while without biological agents produced the lowest panicle counts of 8.49 panicles (Table 2).

Table 2. Independent effects of the use of inorganic fertilizers and antagonistic fungi on the number of upland rice panicles.

| Fertilization | Antagonistic fungus | Average | UJBD 0.05 |
|---------------|---------------------|---------|------------|
|               | C0                  | C1      | C2         |             |
| P0            | 6.33                | 7.02    | 7.00       | 6.79 p      | 2 = 1.13   |
| P1            | 8.48                | 9.29    | 8.67       | 8.81 q      | 3 = 1.19   |
| P2            | 8.57                | 9.95    | 9.48       | 9.33 p q    | 4 = 1.22   |
| P3            | 9.05                | 10.43   | 9.86       | 9.78 p q    | 5 = 1.25   |
| P4            | 10.00               | 11.10   | 10.48      | 10.52 p     |             |
| Average       | 8.49 b              | 9.56 a  | 9.10 ab    |             |
| UJBD 0.05     | 2 = 0.88            | 3 = 0.92|            |             |

3.3. Number of heads

The application of inorganic fertilizer 100% produced the highest number of panes that were not significantly different from P3 and P2. But significantly different from fertilization of 25% of recommendations (P1) and P0 with a total of 275.23 ears, 264.71 ears, 235.72 ears, 204.26 ears, and 165.10 ears. T. asperellum application. (C1) gives the best number of per panicle responses on independent effects that are not significantly different from the application of Paecilomyces sp (EP11). (C2) substantially different from without the application of endophytic fungi (C0) with the number of heads is 241.69 ears, 238.07 ears, and 207.26 ears (Table 4).
Table 3. Independent effects of the use of inorganic fertilizers and antagonist fungi on the number of upland rice seedlings.

| Fertilization | Antagonistic fungus | Average | UJBD 0.05 |
|---------------|---------------------|---------|-----------|
|               | C₀                  | C₁      | C₂        |           |
| P₀            | 149.18              | 175.41  | 170.70    | 165.10    |
| P₁            | 163.63              | 226.13  | 223.02    | 204.26    |
| P₂            | 214.84              | 246.07  | 246.25    | 235.72    |
| P₃            | 243.61              | 279.28  | 271.26    | 264.71    |
| P₄            | 265.01              | 281.57  | 279.11    | 275.23    |
| Average       | 207.26 b            | 241.69 a| 238.07 b  |           |

3.3.1. 1000 grains. There is no difference in weight of 1000 grains of upland rice combined with 75% inorganic fertilizer application and antagonist agent (P₁C₁) with 100% inorganic fertilizer application and 75% antagonist agent (P₄C₁). The weight of the 1000 highest ears that are not significantly different from the application of Paecilomyces sp (EP₁₁). (C₂) which were also significantly different from controls without antagonist agents (C₀) with an average weight of 1000 grains were 31.27 g, 31.27 g, and 27.80 g (table 5).

Table 4. Effect of interaction of the use of inorganic fertilizers and antagonistic fungi on the weight of 1000 upland rice seeds.

| Fertilization | Antagonistic fungus | UJBD 0.05 |
|---------------|---------------------|-----------|
|               | C₀                  | C₁      | C₂        |
| P₀            | 23.77               | b       | 25.23     | 25.20 a   |
| P₁            | 25.10               | a       | 26.87     | 26.43 a   |
| P₂            | 28.13               | A       | 28.27     | 27.67 a   |
| P₃            | 28.33               | A       | 29.37     | 29.37 a   |
| P₄            | 27.80               | B       | 31.27     | 31.27 a   |

Description of the symbol below on table 1

3.4. The severity of blast disease
The combination of 100% inorganic fertilization and T asperellum sp. (P₄C₁) gave the lowest blast disease severity response with the average severity of blast disease at the age of 12, 14, 16, and 18 MST was 0.04, 6.75, 11.94 and 24.58%.

Table 5. Average severity of upland rice (P. oryzae) rice.

| Treatment | The severity of Disease in Age (%) |
|-----------|-----------------------------------|
|           | 12 MST | 14 MST | 16 MST | 18 MST |
| P₀C₀      | 8.94   | 22.88  | 41.67  | 51.69  |
| P₀C₁      | 8.94   | 20.76  | 30.94  | 41.05  |
Field observations indicate there is an interaction between fertilization (P) and antagonistic agent (C) on several observational variables. This interaction illustrates that the dose of inorganic fertilizer fertilization can be reduced, but the growth variable has no significant effect, such as the number of tillers. Application of \textit{T. asperellum} provides the best response to the growth of upland rice and can reduce the use of inorganic fertilizers 50% to 75% of the recommendations. These results are the same as those reported by Taufik et al. (2016) that the introduction of antagonistic microbes, including \textit{Trichoderma sp.}, can reduce inorganic fertilizers up to 50% on the growth of upland rice in the Bakala cultivar. Therefore the dose of inorganic fertilizer can be reduced, but the application of antagonistic fungi (\textit{T. asperellum} and \textit{Paecilomyces sp} (EP11)) is needed to stimulate the growth of upland rice possible by producing phytohormone. Hajieghrari et al. (2010) reported that the corn seedlings were given \textit{Trichoderma T.} isolates able to spur plant growth and were able to increase the root length and shoots of corn seeds and increase stomata productivity. \textit{Trichoderma} is also able to produce phytohormones such as ethylene, auxin, and plays a role in interconnecting plant development [7].

The data shows that the application of fertilizer at a dose of 50%, the number of panicles, and the number of grains differ significantly. Najata and Sugiyanta 2015 found the use of organic fertilizers and NPK fertilizer dosage reduction up to 50% can increase nutrient availability in the soil. Increase soil microbial population and be able to provide grain/plant yields and grain/ha yield that is not different from the full NPK fertilizer dosage treatment [8]. Both \textit{T. asperellum} and \textit{Paecilomyces sp} isolates EP11 were equally good at triggering these variables. Poulton et al. [9] reported that \textit{Trichoderma sp.} plays a role in decomposing soil organic matter such as N, P, S, and Mg and also helps plants absorb nutrients such as phosphate. The fungi \textit{Paecilomyces formous} LHL10 produced gibberellin phytohormones reaching 32 µg / ml and indole acetic acid (IAA) 1.21 µg / ml. Astriani et al. [10] noted that isolates of \textit{Trichoderma sp.} produce IAA around 2.82 to 67.5 ppm on \textit{Potato Dextrose Broth} (PDB) media without tryptophan enriched. Vasdevan et al. [11] also reported an

| P0C2  | 8.42  | 21.24 | 31.61 | 42.82 |
| P1C0  | 5.84  | 20.37 | 33.30 | 43.16 |
| P1C1  | 5.26  | 19.16 | 28.65 | 40.49 |
| P1C2  | 5.18  | 18.33 | 29.90 | 41.80 |
| P2C0  | 5.18  | 16.82 | 31.61 | 42.43 |
| P2C1  | 0.07  | 14.82 | 25.28 | 33.45 |
| P2C2  | 0.02  | 16.00 | 27.60 | 34.68 |
| P3C0  | 0.05  | 17.20 | 28.28 | 36.66 |
| P3C1  | 0.04  | 8.07  | 15.08 | 27.81 |
| P3C2  | 0.02  | 8.71  | 19.11 | 27.33 |
| P4C0  | 0.04  | 14.67 | 18.86 | 31.32 |
| P4C1  | 0.04  | 6.03  | 11.81 | 24.58 |
| P4C2  | 0.04  | 6.75  | 11.94 | 25.18 |

Description :
MST = Week after planting
P0 = Without inorganic fertilizer
P1 = Inorganic fertilization 25% of recommendations
P2 = Inorganic fertilization 50% of the recommendations
P3 = Inorganic fertilization 75% of the recommendation
P4 = Inorganic fertilization 100% of the recommendations
C0 = Without endophytic fungi
C1 = \textit{Trichoderma sp}. application,
C2 = \textit{Paecilomyces sp} EP11 application.

\textit{Trichoderma} T. isolates able to spur plant growth and were able to increase the root length and shoots of corn seeds and increase stomata productivity. \textit{Trichoderma} is also able to produce phytohormones such as ethylene, auxin, and plays a role in interconnecting plant development [7].
increase in the root length of rice varieties IR 24, IR 50, and Joythi respectively by 47.82, 46.95, and 44.02% after being given antagonistic fungi.

Interaction occurs on the variable number of tillers and 1000 grain weights. This shows that although the fertilizer dosage was lowered, the number of tillers and the weight of 1000 heads increased. The reduction of fertilizer to 50% can still increase the number of tillers. Increasing the number of tillers has the potential to linearly with the increase in upland rice production, especially if each tiller succeeds in producing panicles with a healthy grain. Rusdiansyah and Saleh [12] describes an increase in NPK fertilizer to 75 kg/ha in Nanung cultivars, increasing the number of tillers and, on average, increasing the percentage of grain filling.

The severity of blast disease in upland rice shows that antagonistic fungi can slow the emergence of blast disease even though inorganic fertilizer decreases. The severity of blast disease is still below 6% at the age of 12 MST. Age 12 MST upland rice has begun to form panicles, which indicate the entry of the generative phase. Ardiansyah et al. [13] suggested that secondary metabolites of Trichoderma sp. have an inhibitory power of Pseudomonas solanacearum of 35.98% by in vitro. The same thing was reported [14] that secondary metabolites of Trichoderma sp. potential to reduce the intensity of vascular streak dieback (VSD) in cocoa seedlings by up to 81.8%.

4. Conclusions
The use of inorganic fertilizer can be reduced up to 50%, but the application of the antagonist Trichoderma sp. and Paecilomyces sp., and at the same time, the antagonistic agent was able to suppress the severity of blast disease below 6% at 12 MST.

References
[1] Heriqbaldi U, Purwono R, Haryanto T and Primanthi M R 2017 An Analysis of Technical Efficiency of Rice Production in Indonesia Asian Soc. Sci. 11
[2] Mardianto M F F, Tjahjono E and Rifada M 2019 Statistical modelling for prediction of rice production in Indonesia using semiparametric regression based on three forms of fourier series estimator ARPN J. Eng. Appl. Sci. 14 2763–70
[3] Badan Pusat Statistik 2016 Sulawesi tengah dalam angka (Palu: BPS Provinsi Sulawesi Tengah)
[4] Hasfiah, Taufik, M., Wijayanto T 2012 Uji Daya Hasil dan Ketahanan Padi Gogo Lokal Terhadap Penyakit Blas (Pyricularia oryzae) Pada Berbagai Dosis Pemupukan Berk. Penelit. Agron. 1 26–36
[5] Botek M 2015 Pemanfaatan Mikroba Sebagai Agens Proteksi, Pemicu Pertumbuhan Dan Produksi Padi Gogo Serta Mereduksi Penggunaan Pupuk Anorganik
[6] Taufik M, Wijayanto T, Gusnawaty H S, Nurmas A, Alam S, Santiaji L O and Sarawa Improvement of local upland rice utilizing mixture of microbes: resistance, yield and reduction of chemical fertilizer usage
[7] Hermosa R, Viterbo A, Chet I and Monte E 2012 Plant-beneficial effects of Trichoderma and of its genes Microbiology 158 17–25
[8] Najata E 2015 Pengaruh Reduksi Pupuk NPK dengan Pembenaman Jerami, Aplikasi Pupuk Organik Dan Hayati terhadap Ketersediaan Hara, Populasi Mikroba, dan Hasil Padi Sawah di Indramayu Bul. Agrohorti 3 294–300
[9] Poulton J L, Koide R T and Stephenson A G 2001 Effects of mycorrhizal infection and soil phosphorus availability on in vitro and in vivo pollen performance in Lycopersicon esculentum (Solanaceae) Am. J. Bot. 88 1786–93
[10] Astriani F, Fibiarti B L and Zul D 2014 Seleksi Isolat Jamur dalam Menghasilkan Hormon IAA (Indole Acetic Acid) Asal Tanah Gambut Desa Rimbo Panjang Kabupaten Kampar JOM FMIPA 1
[11] Vasdevan P, Reddy M S, Kavitha S, Velusamy P and Paulraj R S D 2002 Role of Biological Preparation in enhancement of rice seedling growth and grain yield Curr. Sci. 83 1140–3
[12] Rusdiansyah R and Saleh M 2017 Response of two local rice cultivars to different doses of
nitrogen fertilizer in two paddy fields *J. Agric. Sci.* **39** 137–44

[13] Adriansyah A, Arri M, Hamawi M and Ikhwan A 2015 Uji metabolit sekunder Trichoderma sp. sebagai antimikrobia patogen tanaman Pseudomonas solanacearum secara in vitro *J. Sains Agrotech* **2** 19–30

[14] Harni R, Amaria W, Syafaruddin and Mahsunah H 2017 Potensi Metabolit Sekunder Trichoderma spp. Untuk Mengendalikan Penyakit Vascular Streak Dieback (VSD) pada bibit kakao *J. Tanam. Ind. dan Penyegar* **4** 57–66