Grain yield and yield attributes response of four upland rice (*Oryza sativa* L.) promising lines to shade stress

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Abstract. The purpose of this research was to investigate a response of four promising lines of upland rice (*Oryza sativa* L.) on low-light environments. The study was carried out at the Agronomy Field Laboratory, Faculty of Agriculture, Halu Oleo University Kendari and arranged on split plot design on two factors. The different shade level placed as the main plot and different promising lines as subplot. The observed variables were number of productive tillers, panicle length, the number of unfilled grains and grain yield (t ha⁻¹). The results indicate that both the shade levels and upland rice promising lines affected the grain yield and yield attributes. The shade levels tend to decrease grain yield and increase unfilled grain. The GS12-1 lines recorded as a better promising line, especially for the panicle length and grain yield (t. ha⁻¹).

1. Introduction

Rice (*Oryza sativa* L.) considered the most important staple food, and it supplies more than half of the world’s food requirement. Rice contributes a nutritionally significant amount of thiamine, riboflavin, niacin, and zinc to the diet (Food and Agriculture Organization [1-4]). The promising program is by developing upland rice to increase rice production, included increase quality and viability of seed [5-11], breeding program [12-19], development hybrid rice [20-21], and increase local food consumption [22].

The development of upland rice as an intercropping plant often faces various obstacles, exceptionally low light intensity [23-24]. The larger the staple crop, the wider the level of the canopy so that upland rice gets relatively low light intensity. The light deficit in upland rice plants disrupts metabolic processes, which has implications for the decreased rate of photosynthesis and carbohydrate synthesis. The fastest influence of shading stress is the decrease in carbohydrate content [25].

One of the strategies for plants in the light competition was through the development of shade tolerance. Plant development of its ability to increase utilizing light efficiently [26]. Shade tolerance associated with many factors, including photosynthesis level, pigment biosynthesis process, and traits of morphological and physiological [26-28]. Indeed, even numerous examinations have been done to assess the shade consequences for crops [19, 29-30], but still a little information available on the effects of shade treatments on grain yield and yield attributes of upland rice lines. Yet at the same time somewhat data accessible on the impacts of shade on grain yield and yield characteristics of upland rice.
lines. Subsequently, the point of this examination was to break down the reaction of grain yield and yield qualities of four promising lines of upland rice to conceal pressure.

2. Materials and methods

The study was carried out in Agronomy Laboratory, Faculty of Agriculture, Halu Oleo University Kendari, during the growing season in 2018. The experiment was conducted with four shade levels (0, 20, 40 and 60 per cent) and four promising lines of upland rice (GS11-1 (G1), GS12-1 (G2), GS44-2 (G3), GS16-1(G4) developed from the cross between paddy rice and local upland rice, and one local upland rice as a check variety. Shade was imposed by using shade nets of appropriate shade levels. The experiment was arranged in split plot design. The shade levels placed as the main plot and the different of upland rice lines placed as sub plots. The number of replications was three. The parameter observed was the total grains yield, panicle length, grains number per panicle, filled grains number, unfilled grains number per panicle, and 1000-grain weight. Data analysed using analysis of variance and further test using Duncan Multiple Range Test (DMRT).

3. Results and discussion

3.1. Number of productive tiller and panicle length

The results showed that the interaction between shade levels and upland promising lines have highly significant effect on yield attributes like productive tillers number, panicle length, unfilled grains per panicle, and filled grains per panicle. In general, number of productive tiller and panicle length tend to decrease with the higher shade levels. The highest average number of productive tillers was recorded on G4 lines (Table 1), while the highest panicle length was obtained on G1 lines (Table 2).

| Rice lines | Shade levels |
|------------|--------------|
|            | N0 | N1 | N2 | N3 |
| G1         | 8.00 a | 6.42 a | 5.83 b | 5.42 b |
|            | p  | pq | pq | q  |
| G2         | 8.92 a | 7.08 a | 7.00 a | 5.75 ab |
|            | p  | pq | pq | q  |
| G3         | 8.08 a | 7.83 a | 6.58 ab | 5.50 ab |
|            | p  | pq | pq | q  |
| G4         | 8.83 a | 7.70 a | 7.08 a | 717 a |
|            | p  | p  | p  | P  |
| G5         | 5.08 b | 1.83 b | 1.92 c | 2.83 c |
|            | p  | q  | q  | q  |

Note: The numbers followed by similar letters in the similar column (p, q, r) and the similar same row (a, b, c) are not significantly different at DMRT 0.05

Based on ANOVA result that the effect of interaction between shade levels and upland rice promising lines obtained highly significant on the number of unfilled grains. It found that the highest number of unfilled grains was recorded on the G4 (GS44-2) lines with 60% shade level (Figure 1).
Figure 1. Unfilled grains number per panicle on various shade levels

Table 2. Effect of interaction between some upland rice promising lines and shade levels on panicle length

| Rice lines | Shade levels | N0  | N1  | N2  | N3  |
|------------|--------------|-----|-----|-----|-----|
| G1         | N0           | 40.35 | a   | 22.36 | b   | 24.70 | a | 25.94 | b |
| G2         | N1           | 27.99 | b   | 26.54 | ab  | 2654  | a | 24.47 | b |
| G3         | N2           | 30.61 | b   | 24.32 | ab  | 24.63 | a | 23.30 | b |
| G4         | N3           | 27.52 | b   | 28.84 | a   | 25.88 | a | 23.08 | b |
| G5         | N0           | 30.60 | b   | 28.88 | a   | 24.82 | a | 28.27 | a |

Note: The numbers followed by similar letters in the similar column (p, q, r) and the similar same row (a, b, c) are not significantly different at DMRT 0.05

3.2. Grains yield (t ha⁻¹)

Analysis of variance result indicates that the interaction effect was found not significantly difference on the grain yield. The genetic differences among upland rice affect the grain yield (Figure 2).

The environmental factors greatly affect plant growth and development. In addition to environmental factors, genetic factors influence plant responses. Tolerant genotypes have relatively high photosynthetic activity capabilities in low light conditions so that they can produce photosynthates that are adequate for vegetative growth of plants [31]. The highest grain yield (t ha⁻¹) obtained in the GS12-1 (G2) lines. The average grain yield of GS12-1 (G2) lines supported by the moderate number of unfilled grains per panicle. Genetic variation among upland rice lines used in this study may lead to the differences in yield of grain yield.
Figure 2. Grain yield of four upland rice promising lines on various shade levels

4. Conclusions
It concluded that both the shade levels and upland rice promising lines had affected the grain yield and yield attributes. The shade levels tend to decrease yield of grain and increase the unfilled grain. The GS12-1 lines recorded as a better promising line, especially for the panicle length and grain yield (t. ha⁻¹).

References
[1] FAOSTAT 2014 Food and Agricultural Commodities Production/Countries by Commodity (Rome: Food and Agriculture Organization of the United Nations Statistics Division)
[2] Adigun J A, Kolo E, Adeyemi O R, Daramola O S, Badmus A A, Ospitan O A 2017 Growth and yield response of upland rice to nitrogen levels and weed control methods Int J Agron Agri Res 11 6 p 92-101
[3] Sadimantara G R, Muhidin and Cahyono E 2014 Genetic analysis on some agro-morphological characters of hybrid progenies from cultivated paddy rice and local upland rice Advanced Studies in Biology 6 1 p 7–18
[4] Sutariati G A K, Arif N, Muhidin, Rakian T C, Mudi L and Nuralam 2017 Persistency and seed breaking dormancy on local upland rice of southeast sulawesi, Indonesia Pakistan Journal of Biological Sciences 20 11 p 563-70
[5] Muhidin, Jusoff K, Syam’un E, Musa Y, Kaimuddin, Meisanti, Sadimantara G R and Baka L R 2013 The development of upland red rice under shade trees World Applied Sciences Journal 24 1 p 23-30
[6] Muhidin, Syam’un E, Kaimuddin, Musa Y, Sadimantara G R, Usman, Leomo S and Rakian T C 2018 The shading effect on the generative character of upland red rice from Southeast Sulawesi, Indonesia IOP Conf Ser: Earth Environ Sci 157 012017
[7] Muhidin, Syam’un E, Kaimuddin, Musa Y, Sadimantara G R, Usman, Leomo S and Rakian TC 2018 The effect of shade on chlorophyll and anthocyanin content of upland red rice IOP Conf Ser: Earth Environ Sci 122 012030
[8] Sutariati G A K, Khaeruni A, Pasolon Y B, Muhidin and Mudi L 2016 The effect of seed bio- invigoration using indigenous rhizobacteria to improve viability and vigor of upland rice (Oryza sativa L.) seeds International Journal PharmTech Research 9 12 p 565-73
[9] Syaiful S A, Syam’un E, Dachlan A, Jusoff K and Haerani N 2013 The effect of inoculating nitrogen fixing bacteria on production of rice World Applied Sciences Journal 26 p 94-9
[10] Sutariati G A K, Bande L O S, Khaeruni A, Muhidin, Mudi L and Savitri R M 2018 The effectiveness of preplant seed bio-invigoration technique using Bacillus sp. CKD061 to improving seed viability and vigor of several local upland rice cultivars of Southeast Sulawesi IOP Conf Ser: Earth Environ Sci 122 012031
[11] Sutariati G A K, Muhidin, Rakian T C, Afa L O, Widanta I M, Mudi L, Sadimantara G R and Leomo S 2018 The effect of integrated application of pre-plant seed bio-invigoration, organic and inorganic fertilizer on the growth and yield of local upland rice *Bioscience Research* **15** 1 p 160-5

[12] Kadidaa B, Sadimantara G R, Suaib, Safuan L O and Muhidin 2017 Genetic diversity of local upland rice (*Oryza sativa* L) genotypes based on agronomic traits and yield potential in marginal land of North Buton Indonesia *Asian Journal of Crop Science* **9** 4 p 109-17

[13] Kadidaa B, Sadimantara G R, Suaib, Safuan L O and Muhidin 2017 Genetic diversity of local upland rice (*Oryza sativa* L) genotypes based on agronomic traits and yield potential in marginal land of North Buton Indonesia *Asian Journal of Crop Science* **9** 4 p 109-17

[14] Suliartini N W S, Wijayanto T, Madiki A, Boer D, Muhidin and Tufaila M 2018 Yield potential improvement of upland red rice using gamma irradiation on local upland rice from southeast sulawesi Indonesia *Bioscience Research* **15** 3 p 1673-8

[15] Suliartini N W S, Wijayanto T, Madiki A, Boer D, Muhidin and Juniawan 2018 Relationship of some upland rice genotype after gamma irradiation *IOP Conf Ser: Earth Environ Sci* **122** 012033

[16] Sadimantara G R, Muhidin, Suliartini N W S, Nuraida W, Leomo S and Ginting S 2018 Agronomic and yield characteristics of new superior lines of amphibious rice derived from paddy rice and local upland rice crossbreeding in konawe of indonesia *Bioscience Research* **15** 2 p 893-9

[17] Sadimantara G R, Kadidaa B, Suaib, Safuan L O and Muhidin 2018 Growth performance and yield stability of selected local upland rice genotypes in Buton Utara of Southeast Sulawesi *IOP Conf Ser: Earth Environ Sci* **122** 012094

[18] Sadimantara G R, Nuraida W, Suliartini N W S and Muhidin 2018 Evaluation of some new plant type upland rice (*Oryza sativa* L.) lines derived from cross breeding for the growth and yield characteristics *IOP Conf Ser: Earth Environ Sci* **157** 1 012048

[19] Sadimantara G R, Alawyah T, Suliartini N W S, Febrianti E and Muhidin 2019 Growth performance of two superior line of local upland rice (*Oryza sativa* L.) from SE Sulawesi on the low light intensity *IOP Conf Ser: Earth Environ Sci* **260** 012145

[20] Afa L O, Purwoko B S, Junaedi A, Haridjaja O and Dewi I S 2018 Simulation of hybrid rice tolerance to drought stress on nutrients culture in seedling *Bioscience Research* **15** 1 p 530-9

[21] Afa LO, Purwoko B S, Junaedi A, Haridjaja O and Dewi I S 2018 Screening of hybrid rice tolerance through stimulated condition of drought stress in rainfed lowland *Bioscience Research* **15** 3 p 1630-7

[22] Muhidin, Leomo S, Alam S and Wijayanto T 2016 Comparative studies on different agroecosystem base on soil physicochemical properties to development of sago palm on dryland *International Journal of ChemTech Research* **9** 8 p 511-8

[23] Las I 1982 Efisiensi radiasi surya dan pengaruh naungan fisik terhadap padi gogo (The efficiency of solar radiation and the influence of physical shade on upland rice) *Master Thesis* Institut Pertanian Bogor, Bogor

[24] Khumaida N 2002 Studies on adaptability of soybean and upland rice to shade stress *PhD Thesis* The University of Tokyo, Tokyo

[25] Prasetyo Y T 2003 *Bertanam Padi Gogo Tanpa Olah Tanah [Cultivation of Upland Rice Zero Tillage] (Jakarta: Penebar Swadaya)*

[26] Khan S R, Rose R and Haase D L 2000 Effects of shade on morphology, chlorophyll concentration, and chlorophyll fluorescence of four Pacific Northwest conifer species *New Forest* **19** p 171-86

[27] Jiang Y W, Duncan R R and Carrow R N 2004 Assessment of low light tolerance of seashore paspalum and Bermuda grass *Crop Sci* **44** 8 p 587-94

[28] Kim S J, Yu D J and Kim T C 2011 Growth and photosynthetic characteristics of blueberry (*Vaccinium corymbosum* L. cv. Bluecrop) under various shade levels *Sci Hortic - Amsterdam* **129** p 486-92

[29] Zhao D L, Oosterhuis D 1998 Cotton responses to shade at different growth stages: nonstructural carbohydrate composition *Crop Sci* **38** p 1196-203

[30] Moula G 2009 Effect of shade on yield of rice crops *Pakistan J Agric Res* **22** p 24-7
[31] Sasmita P, Purwoko B S, Sujiprihati S, Hanarida I, Dewi I S and Chozin M A 2006 Growth and production evaluation of shade tolerant doubled haploid lines of upland rice in an intercropping system Bul Agron 34 2 p 79–86

Acknowledgements
The authors extend their gratitude to Rector of Halu Oleo University, the Directorate General of Research, Ministry of Research, Technology and Higher Education Republic of Indonesia, for providing research grant under the Scheme PTUPT in 2019.