Original Research Article

YIELD OF SEVERAL LOCAL UPLAND RICE LINES

ABSTRACT

Climate change brought on by global warming affects agricultural production, notably rice crops, and results in harsh weather. Because it is becoming harder to utilize the area of paddy fields, one effort that can be made to boost the national food supply is by improving and expanding the upland rice farming area. This study aimed to analyze and ascertain the upland rice lines in the area's production potential. The study was carried out on agricultural land in Tamarenja Village (Dusun Kalama), Central Sulawesi Province, about 200 meters above sea level, with latitudes of 00o26'51.5" South Latitude and 119o49'50.6" East Longitude. They began in August 2022 and continued through February 2023. Fifteen strains or varieties of upland rice were used in the study's Randomized Block Design (RBD), which was repeated three times to create 45 trial plots. These strains or varieties included Untad I, Untad II, Untad III, Untad V, Uva Buya, Kalendeng, Pulu Tau Leru, Jahara, Buncaili, Delima, Dongan, Konta Island, Tako, and Situ Bagendit. Plant height, leaf length, tiller number, productive tiller number, panicle length, number of grains/panicles, harvest age, the weight of 1000 grains, and production were among the variables recorded. The findings demonstrated that the Tako, Dongan, Pulu Tau Leru, Uva Buya, and Kalendeng strains produced better yields compared to the control variety.

Keywords: yields, upland rice, lines, superior varieties

1. INTRODUCTION

According to (Jiang et al., 2020), rice is a food that is necessary for most of the world's population. According to projections fromVilla et al. (2012), the world's population will increase to 8 billion people by 2030. As a result, when the human population reaches 8 billion, rice output will need to grow by up to 40% (Akbar et al., 2021). extreme weather events like excessive heat, heavy rain, and drought are brought on by climate change and result in global warming (Wu et al., 2015). Furthermore, the amount of productive agricultural land has decreased due to the conversion of agricultural land to non-agricultural property. One of Indonesia's challenges is converting agricultural land to non-agricultural land, making it impossible for rice production in 2030 to meet the demands of Indonesians (Sukardi, 2022).

One of the efforts that may be made to grow country wide meals manufacturing **is** used to grow and increase the rice cultivation area. Currently, the area of rice cropland is shrinking due to land conversion, making it difficult to obtain fertile land. Due to land conversion, most of the fertile rice fields in Java are difficult to predict. Therefore, using marginal/dry land outside Java is a good alternative. These marginal lands are more suitable for developing upland rice to meet the community's needs (Sujarwo et al., 2022). The development of upland rice cultivation is an alternative to increasing national rice production, so the strategy that can be implemented is to utilize idle land and use varieties that are adaptive to the upland environment (Magness et al., 2022).

The agronomic properties of upland rice can be improved using various plant breeding methods. One element that may be carried out is to perform crosses among germplasm which can supply new advanced upland rice varieties (Malemba et al., 2017). The first step to producing superior varieties is to explore and characterize upland rice germplasm. Budi et al. (2018) have characterized and rejuvenated red upland rice in North Sumatra and obtained 12 accessions with yields ranging from 1 to 3 tons ha^{-1}. Research results Taridala et al. (2019) showed that upland rice production ranged from 2.3 to 2.6 tonnes ha-1. Afa et al. (2022) evaluated 18 upland rice cultivars from Southeast Sulawesi and found grain production ranging from 238.80 to 842.8 gr m^{-2}.

Since 2016, the Faculty of Agriculture, University of Tadulako, has been exploring and characterizing local upland rice cultivars from Central Sulawesi. Furthermore, the mass selection is carried out to obtain hopeful lines that can be developed into new superior varieties or parents in crosses to produce superior varieties with the desired characteristics. The mass selection was carried out to select lines with the criteria of having high and uniform yields. The production potential of the selected lines is unknown, so this study aims to study and determine the yield potential of local upland rice lines.

2. RESEARCH METHODS

2.1. Time and place

The research was conducted on agricultural land in Tamarenja Village (Dusun Kalama) at an altitude of 200 meters above sea level, with a latitude of 00o26'51.5" South Latitude and 119o49'50.6" East Longitude, Sindue District, Donggala Regency, Central Sulawesi. This research will be carried out **from August 2022 to February 2023**.

2.2. Research design

This research was arranged using a randomized block design (RAK) with 15 strains/varieties of upland rice as treatments, namely K1=Untad I, K2=Untad II, K3=Untad III, K4=Untad V, K5=Untad V, K6=Uva Buya, K7=Kalendeng, K8=Pulu Tau Leru, K9=Jahara, K10=Buncaili, K11=Delima, K12=Dongan, K13=Pulu Konta, K14=Tako, and K15=Situ Bagendit which is a superior variety of upland rice, repeated three times to obtain 45 experimental plots.

2.3. Research implementation

Soil processing is done by cleaning the soil from weed residue, hoeing and leveling. Next, make beds with a size of 2 x 2 m; the height of the beds is 30 cm, as many as 45 plots. The distance between beds is 60 cm. After that, planting was carried out using the Tableau system (Direct Seed Planting) in a hammer way; each planting hole was filled with five seeds with a depth of 2 cm and a spacing of 30 x 30 cm. At the age of 21 days after planting, thinning is done to 1-2 seeds/planting hole. Fertilization uses pearl NPK fertilizer with a dose of 300 kg ha-1 each or the equivalent of 120 plots-1, given by stabbing between plants. Maintenance includes weeding and controlling pests and diseases if there are attack symptoms. Harvesting is done when the rice grains have matured; changes in the color of the rice grains and loss of chlorophyll in the leaves mark the morphology.

2.4. Observed variables

Variables observed included plant height, leaf length, number of tillers, number of productive tillers, panicle length, number of grain/panicles, harvest age, the weight of 1000 grains, and grain yield.

2.5. Data analysis

The data that has been collected was analyzed using analysis of variance; the results of the analysis of diversity showed a real or very significant effect followed by the Least Significant

Difference (LSD) test at the 5% level by comparing the superior varieties as controls with the strains used in the study.

3. RESULTS AND DISCUSSION

Test results smallest significant difference of 5% indicated that all the lines used had higher plant height than the control (situ bagendit). The Tako line had a higher average plant height compared to the other lines, while the Situ Bagendit variety had the lowest average plant height compared to the other lines (Table 1). Farmers expect their plants to be about 100-120 cm tall because short plants have stability and ease of harvesting advantages. On the other hand, tall plants have weakness, instability and difficulty in harvesting. Plant height is influenced by genetic factors and environmental conditions where plants grow (Weng et al., 2014). Crop production can increase if the environment grows according to the plant's needs. Variations in environmental conditions from one place to another and the special needs of plants for the environment cause variations in plant growth (Wu et al., 2015).

The results of the 5% LSD test showed that all the lines used had leaf lengths with a greater value than the control. The Untad III line had a higher average leaf length compared to the other lines, while the Situ Bagendit variety had a lower average leaf length compared to the other lines (Table 1). The length of the leaves greatly affects the process of photosynthesis, respiration and transpiration in plants. Photosynthesis can produce carbohydrates and oxygen (O_2) by using natural CO_2, water, and sunlight. The carbohydrates produced will be used by plants for their survival (Soni et al., 2016). Plants with long leaves can increase the water evaporation process from plant tissues (transpiration), which is higher than plants with short leaves. This is caused by the number of stomata on long leaves, which is more than on short leaves. As a result, plants with long leaves wither faster and require more water (Abas et al., 2020).

The situ bandit variety has the highest number of tillers compared to the lines used. Delima is a line with the fewest tillers compared to other lines (Table 1). The difference in the number of tillers caused by genetic factors from each genotype which has special genetic characteristics and characteristics is one of the factors that causes the diversity of plant appearance(Walli et al., 2022). This is also caused by genotype adaptation to the environment in producing offspring. The maximum number of tillers will be achieved if the plant has good genetic traits and an environment that supports plant growth and development. According to Kamarani et al. (2021), the number of rice plant tillers is determined by genetic influences and environmental factors such as sunlight intensity. It was further stated that the Situ Bagendit variety had the same number of tillers as the Ciherang, Kabir and Upland rice varieties from Malaysia. In addition, differences in plant growth are also influenced by gene factors owned by these genotypes, in addition to influencing environmental factors (Chen et al., 2014).

Table 1. Average value of plant height, leaf length, number of tillers, number of productive tillers, panicle length and number of grain per panicle of local upland rice lines

Treatment	Plant height (cm)	Leaf length (cm)	Numer of tiller	Number of productive tillers	Panicle length (cm)	Grain per panicle (gabah)
Untad I	136,67 *	57,92 *	2,83*	2,58 *	27,33 *	134,17 *
Untad II	144,17 *	57,00 *	3,33 *	3,08 *	29,75 *	118,58 *

Untad III	144,42 *	67,50 *	3,58 *	3,50 *	30,58 *	148,83 *
Untad IV	147,08 *	55,42 *	3,08 *	2,83 *	30,75 *	139,58 *
Untad V	130,25 *	48,00 *	3,08 *	2,92 *	22,17 ns	208,58 *
Uva Buya	144,17 *	57,08 *	3,67 *	3,67 *	30,92 *	161,83 *
Kalendeng	142,83 *	66,58 *	4,08 *	4,00 ns	33,75 *	150,17 *
Pulu Tau Leru	120,25 *	51,75 *	2,92 *	2,75 *	24,25 ns	252,25 *
Jahara	148,00 *	56,58 *	2,83 *	2,75 *	31,75 *	174,67 *
Buncaili	144,75 *	57,00 *	3,58 *	3,25 *	28,08 *	170,42 *
Delima	132,08 *	56,17 *	2,75 *	2,75 *	24,42 ns	142,92 *
Dongan	155,42 *	63,17 *	4,61 *	4,17 ns	31,25 *	181,33 *
Pulu Konta	151,42 *	53,00 *	2,42 *	2,42 *	30,23 *	185,17 *
Tako	175,80 *	57,80 *	4,67 *	4,33 ns	30,00 *	242,67 *
Situ Bagendit	71,22	32,03	5,94	4,42	21,50	88,38
LSD 5%	19.60	8.28	0.56	0,50	3,39	26.95

*Information: ns = not significantly different; *= significantly different from the control treatment*

Kalendeng, Dongan and Tako were lined with the same number of productive tillers as the control. In addition, the other lines had fewer tillers than the Situ Bagendit variety as a control. The ability to produce productive tillers is influenced by the genetic characteristics of the variety and the environmental conditions in which they grow. In addition, the ability of tillers is one of the important characteristics of high-yielding varieties. The number of tillers positively correlates with plant productivity and fertility; different varieties show different numbers of offspring (Yang and Kim, 2016). According to Nurhasanah et al. (2017) the number of productive tillers is a very important yield trait because the final yield is primarily a function of the number of panicles containing tillers per unit area.

The results showed that the panicle length of the evaluated lines ranged from 22.17 to 33.75 cm. The results of the least significant difference test of 5% indicated that Untad V, Pulu Tau Leru, and Pomegranate lines had panicle lengths that were not different from the control. The other lines had different panicle lengths compared to the control. Panicle length, representing panicle architecture, is one of the important yield-related properties. It is categorized as a quantitative trait controlled by multiple genes (Liu et al., 2011; Xiao-yun et al., 2015). It has a highly variable phenotype and is greatly influenced by environmental conditions. High panicle length phenotypic variation was observed among rice species and within rice subspecies. Generally, the indica subspecies have longer panicles than the japonica. According to Shi-min et al. (2014), considerable genetic variation in panicle length may occur within the subspecies, also observed in this study. Genetic factors can influence differences in grain shape between strains. High grain density can provide significant (Xiao-yun et al., 2015)benefits in developing new rice varieties. Panicle length can also be used to determine increased production, especially if followed by an increase in the number of grains per panicle. Lines that have the longest panicles and a greater number of grains per panicle tend to have the potential to be developed and produce higher production (Akbar et al., 2021).

Table 2. Average values of harvesting age, weight of 1000 grain and grain production of local upland rice lines

Treatment	Harvesting age (days)	weight of 1000 grain (g)	grain production (ton ha^{-1})
Untad I	127,00 *	30,50 *	1,18 ns
Untad II	124,67 *	35,43 *	1,46 ns
Untad III	127,00 *	30,73 *	1,79 *
Untad IV	132,00 *	33,20 *	1,47 ns
Untad V	140,00 *	27,47 *	1,86 *
Uva Buya	136,67 *	30,53 *	2,02 *
Kalendeng	127,00 *	31,20 *	2,09 *
Pulu Tau Leru	135,00 *	33,33 *	2,55 *
Jahara	140,00 *	32,53 *	1,76 *
Buncaili	140,00 *	27,07 *	1,65 *
Delima	142,00 *	29,80 *	1,26 ns
Dongan	112,00 *	32,03 *	2,68 *
Pulu Konta	141,33 *	33,18 *	1,58 *
Tako	126,00 *	24,00 *	2,81 *
Situ Bagendit	121,33	26,40	1,14
LSD 5%	2,57	0,90	0,35

*Information: ns = not significantly different; *= significantly different from the control treatment*

The grains per panicle of the evaluated lines ranged from 118.58 to 252.25. All evaluated lines had more grain per panicle than the control variety (Situ Bagendit). Situ bandit, as a control variable, had the lowest number of panicle grains (88.38). The amount of grain per panicle is influenced by the environment and the cultivation method (Lu et al., 2022). High temperatures at the flowering stage and young microspores cause a decrease in the number of grains per panicle in rice plants due to grain degeneration and reduced pollen viability (Hu et al., 2021; Park et al., 2021). Genetic elements influence the number of grains per panicle. In addition, environmental conditions also play a role in determining the amount of rice grain because sunny weather can increase photosynthetic activity, namely the process of transforming light energy into food for plants. Photosynthesis results will be stored in the stem and leaf tissues and then transferred to the rice grain when it matures (Huang et al., 2019). The number of filled and empty rice grains is greatly influenced by plant type, soil fertility, pest attack and growth environment (Wijayanyo and Briliawan, 2016). The high number of filled rice grains has a significant effect on yields. The grain weight of rice is affected by the translocation of photosynthetic results into the formed grains, thereby affecting the grain weight of rice. The higher the rate of photosynthesis, the greater the yield of photosynthate, which is translocated into the rice grains and further affects the grain weight of the rice (Rehmani et al., 2014).

The harvesting age of upland rice lines ranged from 112 to 142 days after planting (Table 2). Of the fourteen lines used, only the Dongan line had a faster harvest than the control varieties, while the other lines took longer to harvest than the control varieties. The harvest time of each line depends on the length of the vegetative period; the longer the vegetative period of the plant, the longer the harvest. Vice versa, the shorter the vegetative period, the more mature the harvest age; the harvest age is also influenced by the speed of flowering and genetic and environmental factors where it grows (Semenchuk et al., 2016).

The weight of 1000 grains of all lines differs from the control varieties. *Tako* is a line that weighs 1000 grains with the smallest value compared to the control variety, while the other lines have a higher weight than the check variety. The weight of a thousand grains of every range is prompted using genetic elements and the surroundings in which it grows. Rice grain weight is strongly influenced by conditions after fertilization, such as the number of leaves, availability of sunlight, and weather conditions. These factors will affect the amount of carbohydrates produced from photosynthesis and the shape and size of rice grains (Liu et al., 2014).

Grain yield is a complex quantitative characteristic determined by three main components: the number of panicles, the range of grains in keeping with the panicle, and grain weight (Shi-min, et al., 2014). In addition, the number of grains per panicle is a critical trait in increasing grain yield (Lu et al., 2022). The results showed that lines untad I, untad II, untad IV, and delima yielded the (Xu et al., 2020)same as the control varieties. The other lines have higher yields than the control varieties. The high production of each plant line is influenced by genetic factors and the environment in which it grows. These elements play a vital position in plant increase and production and production. Even though plant genetics is considered superior, if the environment is not supportive, the growth and yield of these plants can decrease (Liu et al., 2014). The most important factors affecting production yield are the number of tillers and panicles formed (Xu et al., 2020).

4. CONCLUSION

Tako lines have a high number of productive tillers, number of panicles per plant and high yields compared to other lines. Dongan is the second highest-yielding line after the tako line, followed by pulu tau Peru, Uva Buya, and Kalendeng.

REFERENCES

Abas, N., Kalair, E., Kalair, A., Hasan, Q. ul, & Khan, N. (2020). Nature inspired artificial photosynthesis technologies for hydrogen production: Barriers and challenges. *International Journal of Hydrogen Energy*, *45*(41), 20787–20799. https://doi.org/10.1016/j.ijhydene.2019.12.010

Afa, L. O., Anas, A. A., Sabaruddin, L., Bahrun, A., Arsana, M. W., Putri, N. P., & Labir, F. (2022). Agronomic Response of Local Upland Rice Cultivars on Growing under Two Cultivation Systems. *Indian Journal of Agricultural Research*, *56*(2), 183–188. https://doi.org/10.18805/IJARe.AF-690

Akbar, M. R., Purwoko, B. S., Dewi, I. S., Suwarno, W. B., Sugiyanta, & Anshori, M. F. (2021). Agronomic and yield selection of doubled haploid lines of rainfed lowland rice in advanced yield trials. *Biodiversitas*, *22*(7), 3006–3012. https://doi.org/10.13057/biodiv/d220754

Budi, R. S., Suliansyah, I., Yusniwati, & Sobrizal. (2018). Characterization and rejuvination of upland red rice in North Sumatra. *International Journal of Scientific and Technology Research*, *7*(2), 1–6.

Chen, D., Neumann, K., Friedel, S., Kilian, B., Chen, M., Altmann, T., & Klukas, C. (2014). Dissecting the phenotypic components of crop plant growthand drought responses based on high-throughput image analysis w open. *Plant Cell*, *26*(12), 4636–4655. https://doi.org/10.1105/tpc.114.129601

Hu, Q., Wang, W., Lu, Q., Huang, J., Peng, S., & Cui, K. (2021). Abnormal anther development leads to lower spikelet fertility in rice (Oryza sativa L.) under high temperature during the panicle initiation stage. *BMC Plant Biology*, *21*(1), 1–17. https://doi.org/10.1186/s12870-021-03209-w

HUANG, M., FAN, L., JIANG, L. geng, YANG, S. ying, ZOU, Y. bin, & Uphoff, N. (2019). Continuous applications of biochar to rice: Effects on grain yield and yield attributes. *Journal of Integrative Agriculture*, *18*(3), 563–570. https://doi.org/10.1016/S2095-3119(18)61993-8

Jiang, N., Yan, J., Liang, Y., Shi, Y., He, Z., Wu, Y., Zeng, Q., Liu, X., & Peng, J. (2020). Resistance Genes and their Interactions with Bacterial Blight/Leaf Streak Pathogens (Xanthomonas oryzae) in Rice (Oryza sativa L.)—an Updated Review. *Rice*, *13*(1). https://doi.org/10.1186/s12284-019-0358-y

Kamarani, Satriawan, H., Nazirah, L., & Ernawita. (2021). The Growth and Production of Several Upland Rice Varieties under Shaded Conditions. *IOP Conference Series: Earth and Environmental Science*, *1012*(1). https://doi.org/10.1088/1755-1315/1012/1/012066

Liu, Q. hua, Wu, X., Chen, B. cong, Ma, J. qing, & Gao, J. (2014). Effects of Low Light on Agronomic and Physiological Characteristics of Rice Including Grain Yield and Quality. *Rice Science*, *21*(5), 243–251. https://doi.org/10.1016/S1672-6308(13)60192-4

Liu, T., Li, L., Zhang, Y., Xu, C., Li, X., & Xing, Y. (2011). Comparison of quantitative trait loci for rice yield, panicle length and spikelet density across three connected populations. *Journal of Genetics*, *90*(2), 377–382. https://doi.org/10.1007/s12041-011-0083-9

Lu, Y., Chuan, M., Wang, H., Chen, R., Tao, T., Zhou, Y., Xu, Y., Li, P., Yao, Y., Xu, C., & Yang, Z. (2022). Genetic and molecular factors in determining grain number per panicle of rice. *Frontiers in Plant Science*, *13*(August), 1–14. https://doi.org/10.3389/fpls.2022.964246

Magness, D. R., Wagener, E., Yurcich, E., Mollnow, R., Granfors, D., & Wilkening, J. L. (2022). A Multi-Scale Blueprint for Building the Decision Context to Implement Climate Change Adaptation on National Wildlife Refuges in the United States. *Earth (Switzerland)*, *3*(1), 136–156. https://doi.org/10.3390/earth3010011

Malemba, G. M., Nzuve, F. M., Kimani, J. M., Olubayo, M. F., & Muthomi, J. W. (2017). Combining Ability for Drought Tolerance in Upland Rice Varieties at Reproductive Stage. *Journal of Agricultural Science*, *9*(3), 138. https://doi.org/10.5539/jas.v9n3p138

Nurhasanah, Sadaruddin, & Sunaryo, W. (2017). Yield-related traits characterization of local upland rice cultivars originated from east and North Kalimantan, Indonesia. *Biodiversitas*, *18*(3), 1165–1172. https://doi.org/10.13057/biodiv/d180339

Park, J. R., Kim, E. G., Jang, Y. H., & Kim, K. M. (2021). Screening and identification of genes affecting grain quality and spikelet fertility during high-temperature treatment in grain filling stage of rice. *BMC Plant Biology*, *21*(1), 1–21. https://doi.org/10.1186/s12870-021-03056-9

Rehmani, M. I. A., Wei, G., Hussain, N., Ding, C., Li, G., Liu, Z., Wang, S., & Ding, Y. (2014). Yield and quality responses of two indica rice hybrids to post-anthesis asymmetric day and night open-field warming in lower reaches of Yangtze River delta. *Field Crops Research*, *156*, 231–241. https://doi.org/10.1016/j.fcr.2013.09.019

Semenchuk, P. R., Gillespie, M. A. K., Rumpf, S. B., Baggesen, N., Elberling, B., & Cooper, E. J. (2016). High Arctic plant phenology is determined by snowmelt patterns but duration of phenological periods is fixed: An example of periodicity. *Environmental Research Letters*, *11*(12). https://doi.org/10.1088/1748-9326/11/12/125006

Shi-min, Z., Hou-xiang, K., Qian-qian, L., Zong-xiang, C., Ya-fang, Z., Guo-liang, & C. Hong-qi. (2014). Genome Gwide Association Analysis on Genes Controlling Panicle Traits of Varietiesfrom International Rice Core Collection Bank and Its Breeding Utilization. *Chin J Rice Sci*, *28*(6), 649-658.

Soni, R. A., Sudhakar, K., & Rana, R. S. (2016). Biophotovoltaics and Biohydrogen through artificial photosynthesis: An overview. *International Journal of Environment and Sustainable Development*, *15*(3), 313–325. https://doi.org/10.1504/IJESD.2016.077391

Sujarwo, Putra, A. N., Setyawan, R. A., Teixeira, H. M., & Khumairoh, U. (2022). Forecasting Rice Status for a Food Crisis Early Warning System Based on Satellite Imagery and Cellular Automata in Malang, Indonesia. *Sustainability (Switzerland)*, *14*(15). https://doi.org/10.3390/su14158972

Sukardi, A. S. (2022). *Jurnal REP (Riset Ekonomi Pembangunan) Impact Of Rice Land Function Transfer On Rice Production In The Framework Of Food Security (Case Study In Holy District)*. *7*(1). https://doi.org/10.31002/rep.v7i1.65

Taridala, S. A. A., Abdullah, W. G., Tuwo, M. A., Bafadal, A., Fausayana, I., Salam, I., Wahyuni, S., & Suaib. (2019). Exploration of the potential of upland rice agribusiness development in South Konawe District, Southeast Sulawesi. *IOP Conference Series: Earth and Environmental Science*, *260*(1). https://doi.org/10.1088/1755-1315/260/1/012011

Villa, J. E., Henry, A., Xie, F., & Serraj, R. (2012). Hybrid rice performance in environments of increasing drought severity. *Field Crops Research*, *125*, 14–24. https://doi.org/10.1016/j.fcr.2011.08.009

Walli, M. H., Al-Jubouri, Z., Madumarov, M. M., Margaryta, M., & Aldibe, A. A. A. (2022). Genetic and environment diversity to improve wheat (Triticum spp.) productivity: A review. *Research on Crops*, *23*(2), 295–306. https://doi.org/10.31830/2348-7542.2022.041

Weng, X., Wang, L., Wang, J., Hu, Y., Du, H., Xu, C., Xing, Y., Li, X., Xiao, J., & Zhang, Q. (2014). Grain Number, Plant Height, and Heading Date7 is a central regulator of growth, development, and stress response. *Plant Physiology*, *164*(2), 735–747. https://doi.org/10.1104/pp.113.231308

Wijayanyo, N., & B.P. Briliawan. (2016). Jurnal Sylva Lestari. *Jurnal Sylva Lestari*, *4*(1), 11–20. http://jurnal.fp.unila.ac.id/index.php/JHT/article/view/1064/969

Wu, D., Zhao, X., Liang, S., Zhou, T., Huang, K., Tang, B., & Zhao, W. (2015). Time-lag effects of global vegetation responses to climate change. *Global Change Biology*, *21*(9), 3520–3531. https://doi.org/10.1111/gcb.12945

Xiao-yun, Y. A. O., Qing, L. I., Jin, L. I. U., Shu-kun, J., Sheng-long, Y., Jia-yu, W., & Zheng-jin, X. U. (2015). *Dissection of QTLs for Plant Height and Panicle Length Traits in Rice Under Different Environment*. *48*(3), 407–414. https://doi.org/10.3864/j.issn.0578-1752.2015.03.01

Xu, J., Henry, A., & Sreenivasulu, N. (2020). Rice yield formation under high day and night temperatures—A prerequisite to ensure future food security. *Plant Cell and Environment*, *43*(7), 1595–1608. https://doi.org/10.1111/pce.13748

Yang, Y. Y., & Kim, J. G. (2016). The optimal balance between sexual and asexual reproduction in variable environments: A systematic review. *Journal of Ecology and Environment*, *40*(1). https://doi.org/10.1186/s41610-016-0013-0