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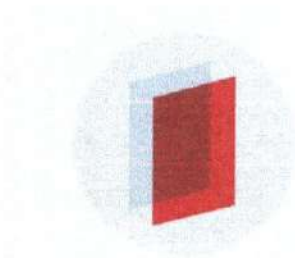
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Harvest index and yield components of aerobic rice (*Oryza sativa*) under effect of water, varieties and seed priming

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Abstract. This research was conducted to investigate harvest index and yield components of aerobic rice (*Oryza sativa*) under effect of water, varieties and seed priming in the tropical region. The experiment was set in split-split plot design. The treatments were priming seed with poly ethylene glycol (PEG), treated (P₁) and untreated (P₀) as sub-sub-plot. Three aerobic rice cultivars as sub-plot consisted of Inpago 8, new potential one (V₁), IR64, susceptible aerobic rice cultivar (V₂) and Situbagendit, a normal aerobic rice cultivar (V₃) as sub-plot, three irrigation intervals namely irrigated every 5 days (W₁), irrigated every 10 days (W₂) and irrigated every 15 days (W₃) set as main plot. Yield components and harvest index parameters were calculated. Results indicated significant and insignificant difference, in spite these, there was no significant difference the date of W₁ and primed seed revealed the highest data compared with W₂, W₃ and non-primed seed. High harvest index revealed by W₁V₁P₀ was 0.827 and the smallest by W₁V₃P₁. Grain yield ranging between 4.49-1.60 ton ha⁻¹ and straw about 15.39-5.33 ton ha⁻¹ depend upon aerobic rice cultivars and water availability. More research about aerobic rice technology need to face water problem in the future.

1. Introduction

Harvest index is defined as the economical yield (grain yield) of the crop expressed as a decimal fraction of the total biological yield, but the clearly meant total aboveground dry matter production. Otherwise, harvest index define as a ratio between economical yield and biological yield [1]. There are many biotic and abiotic factors play role to increase and decrease different value of harvest index. These factors include type of varieties, plant population density, time and method of planting, fertilization dose especially nitrogen fertilization, soil water contents, water stress, temperature, sun radiation, season of cultivation short dry season and long wet season [2].

Hydro and osmo-priming recently playing an advancing technology practiced by farmer to cultivate crops under drought and salinity conditions. Furthermore, Poly ethylene glycol (PEG) is a substance like growth regulators which have ability to adapt seed and plant through seed priming technology to improve its response to be tolerance against water scarcity, drought and salinity condition. Otherwise, many researchers reported that PEG has famous role to accelerate crops establishment and crop



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flowering and increase the germination behaviors and habituate seed and plant for best growth when suffer from water scarcity, drought and salinity condition. Furthermore, the positive beneficial effects of seed priming have been conducted for many field crops such as aerobic rice [3, 4]. However, the negative results indicated that seed priming decreased germination percentage in barley and corn [5] and reduced rate of seedling emergence and plants per unit area in sunflower [6].

Aerobic rice technology is a new technology of cultivating rice in the world to facing the problem of water scarcity. A scientist have modified aerobic rice through the advantage of "improved upland rice" that cultural practice under aerobic rice technology will lead to save 50% of irrigation water, less methane gas emission, reducing production costs, and finally Aerobic rice practices gives great hope to farmers who do not have access to enough water to grow flooded lowland rice [7, 8].

Aerobic rice technology using alternative irrigation system wetting and drying is best practices which helping farmers cultivated rice especially under water scarcity condition thus, understanding the ability of soil water holding capacity and duration of soil water contents between field (FC) capacity and wilting point (WP) which is varied according to soil properties (clay, sand, loam and silt) and abiotic condition that relate with water loss mechanisms such as evaporation, transpiration and evapotranspiration will guide farmers to water scheduling and irrigation management furthermore. Many researchers recorded that the differentiation in growth, Harvest index and yield of crops especially rice depend upon soil water contents. This research investigated the harvest index and yield components of aerobic rice (*Oryza sativa*) under effect of water, varieties and seed priming.

2. Methodology

2.1. Research location

The research was conducted at Indonesian Center for Cereal Crops, in Bajeng, Limbung district, Gowa regency, South Sulawesi province. It is located -5.14 latitude and 119.42 longitudes and it is situated at elevation and altitude of 8 meters above sea level. The soil is Sand Clay Loam with pH about 5.7. The climate also characterized by long hot and wet summer. Moderate rain, high relative humidity 73-98% and Northwest wind with speed about 30 km hr⁻¹. Rice seed used were Inpago 8, a new potential one (V1), IR64, susceptible aerobic rice cultivars (V2) and Situbagendit, a normal aerobic rice cultivar (V3) obtained from Indonesian Center for Rice Research (ICCR) in Sukamandi, Indonesia.

2.2. Experimental Design

The experiment was set in split-split plot design with three replications and the treatments were priming seed with poly ethylene glycol PEG with concentration 200 g L⁻¹, treated (P1) untreated (P0) as sub-sub-plot. The three cultivars mentioned above was set as sub-plot. The irrigation intervals were: irrigated every 5 days (W1), irrigated every 10 days (W2) and irrigated every 15 days (W3) set as main plot. Based on treatments and replication, a total of numbers of 54 experimental units were used in the experiment (3W X 3V X 2P = 18) x 3 replication).

3. Results

Effects of treatments, water interval, varieties, seed priming and their interaction on harvest index of aerobic rice was shown in table 1. In addition, response of the plant to the treatments indicated by some vegetative growth parameters and yield are also shown in table 1.

3.1. Harvest Index

The largest number harvest index had found that recorded by the treatment W₁V₁P₀ that about 0.827 and the smallest one by the treatment W₁V₃P₁ was 0.495. The maximum harvest index reported by W₁ was 0.68 and the minimum by W₃ about 0.57. Harvest index of V₂ variety found to be the highest equal 0.62 and V₁ the shortest one equal 0.60. Although seed priming P1 had the smallest was 0.57 and P0 the greatest was 0.64 (table 1)

Table 1. Effects of water interval (W), varieties (V), seed priming (P) and their interaction (W × V × P) on some vegetative growth parameters of aerobic rice

Treatment	Harvest Index	Day of 50% Flowering (DAS)	Number of Reproductive Tillers/hill	Panicle Length (cm)	Number of Grain per Panicle	Weight of 1000 Seed (g)	Grain Yield (ton ha ⁻¹)	Straw Yield (ton ha ⁻¹)
Water Intervals								
W ₁	0.68 ^a	89.17 ^b	22.65 ^a	23.35	99.37	20.44 ^a	4.1 ^a	11.58 ^a
W ₂	0.58 ^b	97.17 ^a	18.25 ^b	22.68	92.84	19.26 ^b	3.15 ^b	9.19 ^b
W ₃	0.57 ^b	93.89 ^a	15.56 ^c	22.5	82.55	18.26 ^b	2.26 ^c	6.7 ^c
Varieties								
V ₁	0.61	94.61	18.65	25.48 ^a	110.4	19.56	3.7 ^a	11.23 ^a
V ₂	0.62	91.78	18.31	21.46 ^b	78.33	19.18	3.2 ^b	7.38 ^b
V ₃	0.61	93.83	19.5	21.59 ^b	85.95	19.23	2.7 ^c	9.06 ^c
Seed Priming								
P ₀	0.65	94.07	18.32	22.44	89.95	19.59	3	8.28 ^b
P ₁	0.58	92.74	19.32	23.241	93.23	19.05	3.34	10.17 ^a
SE±	0.051	3.42	1.36	0.92	6.11	0.85	0.38	1.32
C.V%	12.02	6.33	12.5	6.96	11.55	7.64	20.54	24.72

DAS = days after sowing.

Values not sharing the same letters in same column differ significantly at p < 0.05

3.2. Day of 50% Flowering

The fastest and latest area reached to days of 50% flowering recorded by W₃V₂P₁ and W₂V₃P₀ after 90.33 and 102.67 days from sowing date respectively (table 1). Days of 50% flowering substantially longest for W₂ was 97.17 compared with the shortest W₁ about 89.17 days. V₁ was equal 94.61 as longest time and V₂ equal 91.78 as shortest time for days of 50% flowering (table 1). Beside that P₀ the latest period and P₁ the earliest one were 94.04 and 92.74, respectively.

3.3. Number of Reproductive Tillers per Plant

Table 1 shows that the W₁V₂P₁ treatment indicate that the maximum number of reproductive tillers/plant about 24.67 tillers and W₃V₂P₀ treatment was the minimum one which was 13 tillers. On the factor of water interval management Number of reproductive tillers/plant was highest by W₁ was 22.65 and smallest by W₃ was 15.56. The largest Number of reproductive tillers/plant recorded for V₃ was 19.5 compared with V₂ the lowest one was 18.31. For seed priming management highest number of reproductive tillers/hill about 19.32 by P₁ and the lowest about 18.31 by P₀.

3.4. Panicle Length

Panicle length substantially longest for treatments W₁V₁P₁ was 26.99 compared with shortest one that was 20.06 recorded by the treatment W₂V₃P₀ (table 1). The different between water concept by W₁ and W₃ as highest panicle length (cm) was 23.34 and the shortest about 22.49 cm. V₁ and V₂ agreed the longest and shortest which were 25.48 and 21.4 days respectively. P₁ raised panicle length (cm) about 23.24 cm and P₀ the lowest about 22.44 cm.

3.5. Number of Grain per Panicle

Biggest number of seed per panicle obtained by treatments W₁V₁P₁ was 129.24 seeds/panicle and smallest by W₃V₂P₀ about 70.50 seeds/panicle (table 1). W₁ and W₃ varied on their recorded thus W₁ equal 99.37 and W₃ was 82.55 seed/panicle, V₁ recorded 110.48 and V₂ was 78.33 seed per panicle/plant. P₁ cleared the biggest number but P₀ the smallest about 93.23 and 89.95 seeds, respectively.

3.6. Weight of 1000 Seed

$W_1V_3P_1$ reported the highest value of weight of 1000 seed (g) about 21.87g and $W_3V_3P_0$ treatment was the lowest one which was 16.47 g with the range about 5.4 g. The biggest weight of 1000 seed (g) has reported by W_1 that was 20.44 g and smallest by W_3 was 18.26 g (table 3). Among varieties V_1 was 19.56 compared with the light value was 19.18g by V_2 . Seed priming management for P_1 found the highest score of weight of 1000 seed (g) was 19.59 and P_0 about 19.05 g the lowest one (table 1).

3.7. Grain and Straw Yield

Grain yield ton ha^{-1} substantially highest for treatments $W_1V_1P_1$ that 4.40 ton ha^{-1} compared with lowest one that was 1.60 ton ha^{-1} recorded by the treatment $W_3V_2P_0$. For the effected of water interval W_1 registered the highest grain yield ton ha^{-1} equal 4.1 and W_3 the lowest one equal 2.26 ton ha^{-1} . V_1 and V_3 had the biggest and smallest performance of grain yield ton ha^{-1} about 3.7 and 2.7 respectively. Seed priming management P_1 the highest weight was 3.34 and P_0 the lowest weight was 3 ton ha^{-1} .

Straw yield ton ha^{-1} was highest value by the treatment $W_1V_1P_1$ was 15.36 ton ha^{-1} and smallest value obtained by $W_3V_2P_1$ was 5.33 ton ha^{-1} (table 1). The maximum Straw yield ton ha^{-1} wrote by W_1 about 11.58 and the minimum by W_3 was 6.7 ton ha^{-1} . V_1 had been the largest Straw yield ton ha^{-1} was 11.23 and 7.38 by V_3 . Seed priming increased Straw yield ton ha^{-1} in P_1 was 10.17 and decreased in P_0 equal 8.28.

4. Discussion

The result of the effects of water interval (W), varieties (V) and seed priming and their interaction on harvest index and some yield components of aerobic rice recorded significant and insignificant difference. In spite of, there was no significant difference in the date of W_1 (irrigated every 5 days) and primed seed revealed the highest data compared with W_2 (irrigated every 10 days). W_3 (irrigated every 15 days) and non-primed seed and depend upon aerobic rice cultivars.

The significance of water interval on reproductive parameters may be due to significant effect of water management on the number of tillers, this result confirmed with [3] who applied that water regime management significantly affected number of tillers and the interaction between water regime management and varieties was also significant. Among straw and grain yield the significant differences may be due to the small total dry matter which related to the relatively shallow root system and stomata closure and reduced photosynthesis in response to surface soil drying which agreed with Lafitte and Benett [9] and Kato *et al.* [6].

The significant effect of varieties on reproductive parameters explained with genetic constitution beside sometimes interacts with environment that cleared with Amano *et al.* [10] and Cheng and Min [11] aerobic or super-rice cultivars have been released in China, which have shown a markedly high yield potential when planted in the aerobic conditions. However, these aerobic rice cultivars are commonly characterized by unstable yields across environments (locations and years) [12, 5]. Therefore, it is imperative to clarify the responses of their growth and yield formation to environments so it is well known that final yield (phenotype) of a given cultivar is dependent on both genetic factors and growth conditions.

The insignificant effect of varieties on harvest index and some yield components may be due to similarity in morphological aspects of vegetative growth between aerobic rice cultivars such as time to heading initiation and duration of the grain heading for example, biomass accumulation in the form of stem biomass reaching at heading and decline during grain filling which finally effect yield output. These results followed same results of Chen *et al.* [13] the rice cultivars shown obvious similarity in the change of stem biomass between aerobic rice cultivars and little increase after booting stage, whereas different in duration from booting stage to heading stage.

Seed priming during reproductive period of rice clearly reported its effect on harvest index and reproductive stage components attributes may be to pre-germination metabolic activities making the seed ready for radical protrusion which lead to good crops establishment and resistance to different treatments, confirmed with reported that number of tillers of primed seed with PEG increased compared

with control [14], but not followed the same result of time of flowering initiation, time of maturity because non-primed faster than primed seed, thus this fact was true so priming techniques help plant to be tolerant against bad conditions especially water-stress, drought and water scarcity and this consist with the work of Desclaux and Roumet [15] who noted that switch from vegetative growth to reproductive growth was earlier under water-stress than under wetter condition.

By applying appropriate irrigation management in rice cultivation, a large volume of water can be saved which would help to bring more land under cultivation using the same available amount of water. This will not only enhance food security but water security as well.

5. Conclusion

Depend upon genotype, water interval management to maintain suitable soil water contents before later irrigation between 44.48 to 18.20% will lead to cultivate aerobic rice under drought (water scarcity) conditions with assistant of seed priming technology using PEG solution 200 g L⁻¹ concentration not more.

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