Observation of root architecture at vegetative stage of drought tolerant rice genotypes using mini pot method

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Abstract. One of the important root traits affecting drought tolerant in rice crop is root architecture. Sufficient number of vertical and deep root growth supports for higher capability of water and nutrient intake by plant. This research aimed to evaluate drought tolerance of 60 rice genotypes based on number and proportion of vertical root growth. The experiment was managed according to randomized complete block design of three replications. A pot is representing a unit data. The experiment was conducted in ICRR screen house in Sukamandi during October to December 2016. The seeds were placed on a modified sunken sieve in pot with soil media. The sieve was separated into three zones, i.e. representing vertical, medium, and horizontal root growth. The plant was established in optimum water condition for 42 days. The results showed that 42 genotypes had comparable root architecture with IR64 Dro1 line, a line having Dro1 gene which controlled vertical root growth. Among them, Inpari21, BP16178M-1D-SKI-13-8-1, HHZ5-SKI-7-1-0Kr-JK-IND, Inpari18, Towuti, and Bahbutong (1182) had either high number of vertical root growth (more than 10 roots) as well as high proportion of the vertical root growth (more than 40%). The genotypes were suspected to have good drought tolerant due to the root architecture.

1. Introduction
Drought is one of major problems in producing rice in Indonesia. It is around 50.000 to 300.000 ha areas affected by drought annually. It occurred evenly in the provinces across the country [1]. One million ha out of 5.14 million ha lowland areas in Indonesia are drought prone area. Global climate change makes longer dry season in rice production center provinces such as java, most part of Sumatera, East and South part of Kalimantan, Nusa Tenggara, and South Sulawesi [2]. There was also reduction on rainfall during June – August [3]. Drought is also happened in upland area.

Drought has serious impacts on the growth of rice plants, such as reducing the number of tillers, changing in root patterns, delaying time of flowering [4], reducing number of leaves per clump and leaf area [5] and reducing rice yield and grain quality [6]. Drought stress not only suppresses growth and yield but also causes plant death [7].

Root architecture is very important in drought tolerant controlling in rice plant. Many genes controlling root growth in different steps of root growth. The genes in turn related with drought stress tolerance of rice plant [8]. Introducing Dro1 gene into shallow rooting rice would increase avoidance from drought stress. Dro1 is a gene which is negatively regulated by Auxin in controlling root growth in more downward direction. It resulting in a line adaptable to drought by increasing deep rooting which maintain high yield under drought condition [9].
This study is aimed to learn root architecture of rice genotypes as prediction of its drought tolerance on field. IR64 near isogenic line containing Dro1 was used as one of the checks.

2. Methods

The experiment materials were 60 rice genotypes which were selected from previous drought tolerance screening using concrete box method included IR20 as susceptible standard and Dro1 gene containing IR64 near isogenic line as tolerance check (Dro1 line). The experiment was managed according to randomized complete block design of three replications. A pot is representing a unit data. The experiment was conducted in ICRR screen house in Sukamandi during October to December 2016.

Mix of soil and sand (1:1) was used as planting media. The media was filled into minipots with sieve at the top area of the pot. The minipot was made from PVC pipes with the diameter of 2 inch with the depth of 20 cm. Sieve was made in sunken dimension with the dept of 5 cm. Sieve diameter was managed to be fitted with the pot diameter. The sieve was marked by red colored string weaving into the sieve in two lines horizontally separating the sieve proportionally into three zone, i.e. representing vertical, medium, and horizontal root growth direction. The seeds were placed on the media on the sieve on the pot. The pots were placed in box with around 3 cm standing water to keep the humidity of the media. The plant was established for 42 days, so that the final observation was done at the end of vegetative plant growth phase. The observation was conducted for shoot length, tiller number, root length, and root number at zone 1 (horizontally growth), zone 2 (medium), and zone 3 (vertically growth).

3. Results and discussions

The plants grew well during the experiment. Observations was conducted at six weeks after direct planting (Figure 1). Analysis of variance results showed that there was no variation on the observed traits, i.e. shoot length (cm), tiller number, root length (cm), zone 1 root number, zone 2 root number, total root number, proportion of zone 3 root number, but zone 3 root number (Table 1). It indicated that zone 3 root number is genetically controlled and there is variation among rice genotypes. It is suggested that the genotypes having more root number in zone 3 are more tolerant to drought.

The materials tested in this study were most probably included in indica group. Indica rice has more variation on root traits [10]. It is in line with the finding in this study where the genotypes had variation on root characteristics, especially zone 3 root number.

Figure 1. Experiment of root architecture of 60 rice genotypes, Sukamandi, 2016.
Table 1. Variance analysis of root traits of 60 rice genotypes in randomized complete block design of three replications

| Trait                  | Degree of Freedom | Sum of Square | Mean Square | F Value | P Value |
|------------------------|-------------------|---------------|-------------|---------|---------|
| Shoot length (cm)      | 59                | 10790         | 182.88      | 1.35    | 0.08    |
| Tiller number          | 59                | 36.73         | 0.62        | 1.07    | 0.37    |
| Root length (cm)       | 59                | 5551.73       | 94.10       | 0.90    | 0.66    |
| Zone 1 root number     | 59                | 602.06        | 10.20       | 1.41    | 0.06    |
| Zone 2 root number     | 59                | 1391.24       | 23.58       | 1.04    | 0.43    |
| Zone 3 root number     | 59                | 1163.39       | 19.72       | 1.47    | 0.04    |
| Total root number      | 59                | 4901.80       | 83.08       | 1.27    | 0.13    |
| Proportion of zone 3 root number | 59 | 1.87 | 0.03 | 1 | 0.49 |

Gene controlling root growth in downward direction had been identified. It called as Deeper Rooting 1 (Dro1) gene. It promotes a deep root system in rice plant. It had been identified from mapping a population made by crossing of rice genotype with shallow root system rice (IR64) with deep rotting system rice (Kinandang Patong) [11]. IR64 near isogenic lines (IR64 Dro1) was introduced in Indonesia and involved in the breeding activity for drought tolerant rice. The Dro1 line was used as check in this study to know if Indonesian rice genotypes have comparable, lower, or maybe higher seep root system compared to Dro1 line. Finding of new genotypes having more root in downward growth and deeper/longer root would open the chance new donor for the certain trait.

Forty-two genotypes had comparable characteristics with Dro1 line (Table 2). Lines with more roots in zone 3 was expected had better ability to absorb water in deeper soil zone area. Root characteristics related to vertical growth and root angle is constitutively controlled by genetic factor, and less affected by environment, including water regime condition [12]. It means that genetic selection of the trait would be effective. Selection of the genotypes for drought purpose is expected to be effective.

Yield, however, is very important for the final acceptance by farmers. Yield testing of the genotypes would give more information in selecting the genotypes for further breeding utilization. Combining the deep root system bearing genotypes with high yielding under drought, such as dDTY3.1, dDTY6.1, dDTY6.1 [13] would combine more superiority of the genotypes.

Table 2. Tolerance screening on drought stress

| No. | Genotype               | Plant height (cm) | Tiller Number | Root length (cm) | Zone 1 Root Number | Zone 2 Root Number | Zone 3 Root Number | Total Rooto Number | Propor* |
|-----|-----------------------|-------------------|---------------|------------------|--------------------|--------------------|--------------------|--------------------|--------|
| 1   | Dro1                   | 64.27             | 2.67          | 16.17            | 5                  | 8                  | 12                 | 25                 | 0.49   |
| 2   | Gajah Mungkur         | 67.17             | 1.67          | 15.20            | 3                  | 5                  | 10                 | 18                 | 0.58   |
| 3   | Lipigo4               | 64.27             | 2.00          | 16.73            | 4                  | 6                  | 8                  | 18                 | 0.45   |
| 4   | Inpari10              | 65.97             | 2.67          | 16.70            | 5                  | 13                 | 7                  | 25                 | 0.28   |
| 5   | Inpari18              | 66.30             | 1.67          | 16.13            | 4                  | 10                 | 12                 | 26                 | 0.46   |
| 6   | Towuti                | 57.93             | 2.00          | 17.57            | 5                  | 7                  | 10                 | 22                 | 0.48   |
| 7   | HHZ12-SKI-1-2-0Kr-JK-IND | 48.63          | 1.33          | 14.27            | 1                  | 5                  | 7                  | 12                 | 0.51   |
| 8   | TIL 3 (IR84636-13-12-2-6-3-3-2-2-B) | 62.00             | 2.00          | 13.50            | 3                  | 7                  | 7                  | 16                 | 0.42   |
| 9   | Huanghuazhan          | 51.47             | 1.33          | 13.37            | 2                  | 4                  | 4                  | 10                 | 0.39   |
| 10  | Kelimutu              | 62.27             | 1.00          | 19.37            | 2                  | 5                  | 4                  | 11                 | 0.46   |
| 11  | Batang Lembang (6661) | 49.23             | 1.00          | 17.47            | 3                  | 4                  | 6                  | 13                 | 0.53   |
| 12  | Dular                 | 67.17             | 1.33          | 16.47            | 2                  | 4                  | 12                 | 17                 | 0.68   |
| 13  | HHZ5-SKI-9-3-0Kr-JK-IND | 50.57          | 1.33          | 12.50            | 1                  | 8                  | 5                  | 14                 | 0.54   |
| 14  | BP14342f-7            | 62.07             | 1.67          | 13.53            | 3                  | 8                  | 8                  | 19                 | 0.45   |
| 15  | Limboto               | 47.80             | 1.00          | 14.80            | 1                  | 5                  | 5                  | 12                 | 0.48   |

Continued
### 4. Conclusions

Forty-two rice genotypes have comparable root growth pattern with *Dro1* containing line, indicating the line might be more tolerant to drought due to its ability to obtain water from deeper soil zone area. Examples of the genotypes are HHZ5-SKI-7-1-0Kr-JK-IND and Inpari 21 which had the highest number and proportion of root in downward direction. Verification of the drought tolerance at drought field condition would confirm more the tolerance of the genotypes.
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