Tiller profile diversity of upland rice germplasm in ICABIOGRAD gene bank

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Abstract. Tillering ability is an important agronomic trait that determines the yield of rice. Tiller type in rice is categorized as primary, secondary and tertiary tiller which produces panicle at generative phase. Tillering ability as well as the tiller type varies between varieties, especially among germplasms. Our study aimed to identify the tiller profile diversity of upland rice germplasm in ICABIOGRAD Genebank. A total of 100 accessions of local upland rice varieties were planted in a randomized completely block design with two replications under greenhouse condition. The number of tiller from each type was observed weekly from 35 to 63 days after sowing (DAS). The result of the study showed that the number of primary tiller increased slowly from 35 DAS until 63 DAS. After 49 DAS there was no significant addition in secondary tiller number. Generally, the average mean number of tertiary tiller accross the accessions was far below compared to the number of primary and secondary tiller. The highest number of primary tiller, i.e. 8, was expressed by Pae Daye Indolobye (North Sulawesi), Padi Pulut Pute Iteung (East Kalimantan) and K. Puyuk (Central Kalimantan). Up to 22 secondary tillers were formed by Gadabung, a local upland rice variety from Central Kalimantan. Information on tillering ability of local upland variety will benefit rice breeder for selecting appropriate accessions as a gene source for breeding.

Keywords: tiller, accessions, diversity, germplasm, breeding.

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops in the world [1]. In tropical countries such as Indonesia, upland rice has significant contribution in supplying staple food for people living in marginal dryland areas [2]. Upland rice cultivation has existed since ancient times in Indonesia. Almost every island in Indonesia are already familiar with upland rice, especially for regions with arid and marginal land. In order to compete, upland rice productivity must be enhanced by the use of new varieties [3].

Tillering and panicle branching are important agronomic traits that affect rice grain yield [4,5]. Characteristics of tillers can be observed starting from the initial growth until the maximum tillering is reached in the filling phase of the seed. Primary tillers grow from the main stems, secondary ones grow from primary, tertiary from secondary tillers, and so on. During the vegetative phase, the maximum number of tiller formed is more than the number of productive tiller in the generative phase

[6]. At generative stage, each tiller type can produce panicle. The panicle that comes out from each type of tiller is called primary, secondary, tertiary and quarternary panicle, respectively [7].

Indonesia is rich in the diversity of rice germplasms. ICABIOGRAD Gene Bank holds a collection of rice germplasm consisting of lowland rice, upland rice, swamp rice and tidal rice. The ability to produce the number of tiller as well as the tiller type varies between varieties, especially among germplasms. Tillering ability of rice is an important parameter for developing new varieties of upland rice. The aim of this study was to identify the tiller profile diversity of upland rice germplasms in ICABIOGRAD Gene Bank.

2. Materials and methods

The experiment used 100 upland rice accessions, of which 10 were planted as lowland rice (Tabel 1). These accessions were originated from 16 provinces in Indonesia. The experiment was done in 2016 under greenhouse condition. Two seeds of each variety were sown in pots (35 cm height and 30 cm in diameter) containing 8 kg of dry soil. Each pot received optimal irrigation treatment and fertilized with 5 g of urea, 2 g of SP36 and 2 g of KCl. Experiments were arranged in a randomized completely block design with two replications. From the beginning of the tiller emergence, each type of tiller was marked with ribbon of different colors. The number of primary, secondary and tertiary tillers were observed weekly starting from 35 days after sowing (DAS) until 63 DAS (figure 1).

Table 1. Upland rice accessions used in characterization of tillering ability.

Code No.	Accession No.	Name	Origin[b]	Code No.	Accession No.	Name	Origin[b]
1	05020-20377	Misik A[a]	1	51	05020-9997	Maisuri	12
2	05020-19976	P. Nyuhu[a]	2	52	05020-20310	Merah	8
3	05020-20497	Umbang Putih[a]	1	53	05020-10272	Pulut Bambo	11
4	05020-15138	Pare Bakato Kaka[a]	3	54	05020-15442	Segajah	6
5	05020-20468	Gerunsai[a]	1	55	05020-20890	Pae Daye Indolobye	7
6	05020-20774	Rebo[a]	3	56	05020-19368	Parab	4
7	05020-20406	Amuntai[a]	1	57	05020-20489	Buntut Kuda	1
8	05020-20417	Pitik	1	58	05020-20924	Ketan Huma	3
9	05020-20991	Rendi Lau	2	59	05020-20426	Korundung	1
10	05020-8555	Munjaw	2	60	05020-20491	Ketan Tomang A	1
11	05020-19974	P. Timai	2	61	05020-20457	Juka	1
12	05020-20465	Merawi	1	62	05020-20731	Ikelo	3
13	05020-5511	Gombal	4	63	05020-20726	Ikiola	3
14	05020-15128	Unknown	3	64	05020-20408	Talun Undang	1
15	05020-19995	Padi Pulut Pute Iteung	2	65	05020-20414	Tokong	1
16	05020-20391	Lengkuas	1	66	05020-4282	Kapas B	1
17	05020-20418	Kahayangan	1	67	05020-20985	Dupa	2
18	05020-20397	Ketan Bahandang	1	68	05020-5205	Papah Aren	9
19	05020-20411	Lemo	1	69	05020-20432	Ketan Saru A	1
20	05020-9200	Ndabulu	5	70	05020-20791	Kemala Water	3
21	05020-15440	Sedang menawan	6	71	05020-19975	P. Pulut Timai	2
22	05020-20450	Talon Jangko	1	72	05020-20502	Humbang	1

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Code No.	Accession No.	Name	Origin[b]	Code No.	Accession No.	Name	Origin[b]
23	05020-8294	Pulut Hitam	1	73	05020-20576	Segi	4
24	05020-20466	Talun Sarai	1	74	05020-20422	Sahang	1
25	05020-20581	Pusaka	4	75	05020-20492	Ketan Tomang B	1
26	05020-10479	Paredolo	5	76	05020-20504	Ketan	1
27	05020-12379	Padi Bangkok	4	77	05020-20416	Ketan Baburak	1
28	05020-20427	K. Puyuk	1	78	05020-4170	Si Gupai Kandang	8
29	05020-20018	Sipelang	8	79	05020-20409	Raden Kuning	1
30	05020-20746	Mama Laka	3	80	05020-20775	Muha	3
31	05020-20486	Barito	1	81	05020-20622	Way Rarem	4
32	05020-7950	Surau Parigi	5	82	05020-20467	Ketan Nyaling	1
33	05020-20506	Garu	1	83	05020-9205	Meeto	5
34	05020-5207	Genjah Mayangan	9	84	05020-20768	Nggondo	3
35	05020-20420B	Sangahi	1	85	05020-19980	Padi Saleng	2
36	05020-20500	Umbang Hitam	1	86	05020-20747	Madha Kedhi	3
37	05020-19369	Pare Sintung	4	87	05020-20419	Lanung	1
38	05020-20403	Padi Uwan	1	88	05020-20448	Satum	1
39	05020-20425	Boruk	1	89	05020-20442	Talun Bura	1
40	05020-5505	Segon	4	90	05020-12392	Padi Rabig	4
41	05020-20974	Limar	4	91	05020-19998	P. Turi	2
42	05020-4180	Panada	10	92	05020-20447	Ganahi	1
43	05020-9188	Sakaolutu	5	93	05020-9186	Wulu Mata	5
44	05020-20484	Gunsai	1	94	05020-9550	Ketan Hitam	12
45	05020-20472	Taun Suar	1	95	05020-6345	Markuti[a]	13
46	05020-20405	Siung Basalo	1	96	05020-7545	Si Tambak Padang[a]	8
47	05020-20429	Gadabung	1	97	05020-7390	Sicur[a]	14
48	05020-5247	Sewalan	9	98	05020-21658	Slegreng	15
49	05020-20485	Ti'ung	1	99	05020-21652	Lokal A	15
50	05020-20256	Bho	8	100	05020-INT	Cabacu	16

[a] Also planted as lowland rice in the experiment.
[b] 1 = Central Kalimantan, 2 = East Kalimantan, 3 = East Nusa Tenggara, 4 = West Java, 5 = Southeast Sulawesi, 6 = Lampung, 7 = North Sulawesi, 8 = Nanggroe Aceh Darussalam, 9 = D.I. Yogyakarta, 10 = South Sulawesi, 11 = Riau, 12 = South Sumatra, 13 = East Java, 14 = West Sumatra, 15 = Central Java, 16 = introduction.

3. Results and discussion

A typical primary, secondary and tertiary tiller type of rice is shown in Figure 1. Overall, the number of primary tiller increased slowly from 35 DAS until 63 DAS, whereas the number of secondary tiller increased sharply from 42 DAS to 49 DAS, but increased slightly after 49 DAS (Figure 2). Tertiary tiller started to grow at 49 DAS but its average number accross the accessions was far below the number of primary and secondary tiller.

The ability of plant to form tiller at an early growth stage will largely determines grain yield. All accessions were able to grow primary tiller at 35 DAS in a range of 1 to 10 tillers (Figure 3). The highest number of primary tiller (8) was obtained from three accessions: Pae Daye Indolobye (North Sulawesi), Padi Pulut Pute Iteung (East Kalimantan) and K. Puyuk (Central Kalimantan). Secondary tillers were already observed at 35 DAS by >50 accessions, with the highest number (3) was expressed by Pae Daye Indolobye.

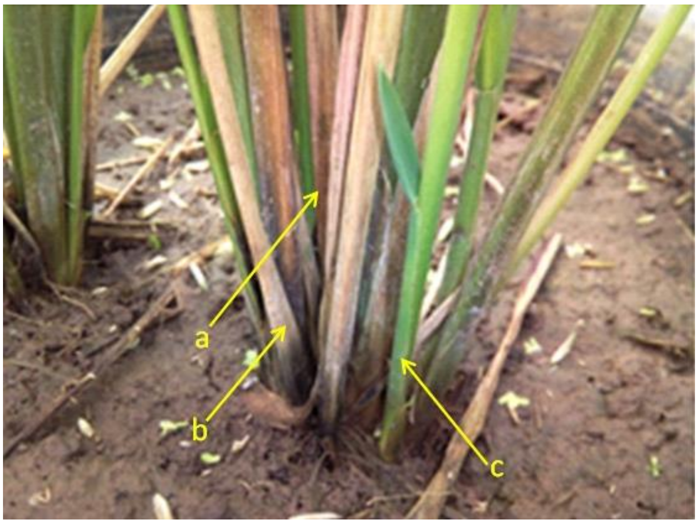

Figure 1. An example of primary (a), secondary (b) and tertiary (c) tiller of rice.

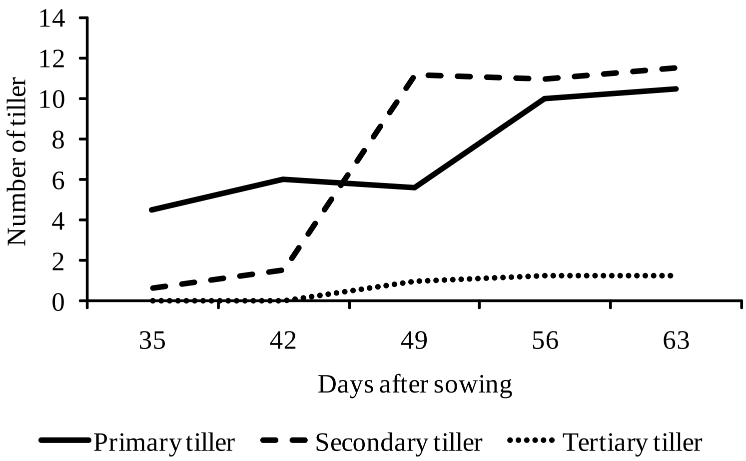

Figure 2. Growth profile of primary, secondary and tertiary tiller of 100 accessions of upland rice.

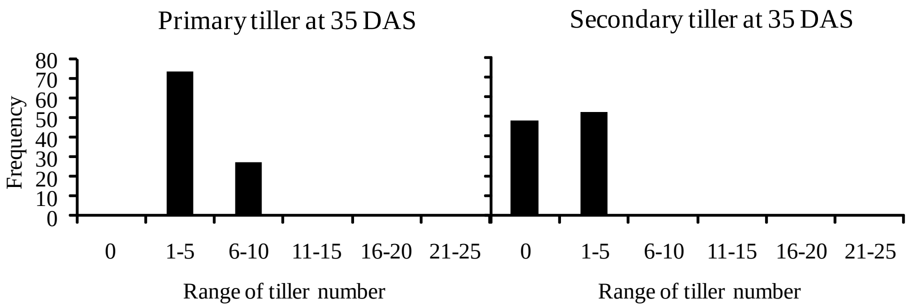

Figure 3. Histogram of primary and secondary tiller number in 100 accessions of upland rice at 35 days after sowing (DAS).

At 63 DAS the number of primary tiller ranged from 6 to 15, whereas a wider range number (1 to 20) of secondary tiller were observed (Figure 4). The majority of accessions (70) were able to grow tertiary tiller in the range of 1 to 6. Gadabung, an accession from Central Kalimantan, produced the highest number of secondary (22) and tertiary tiller (6) at 63 DAS.

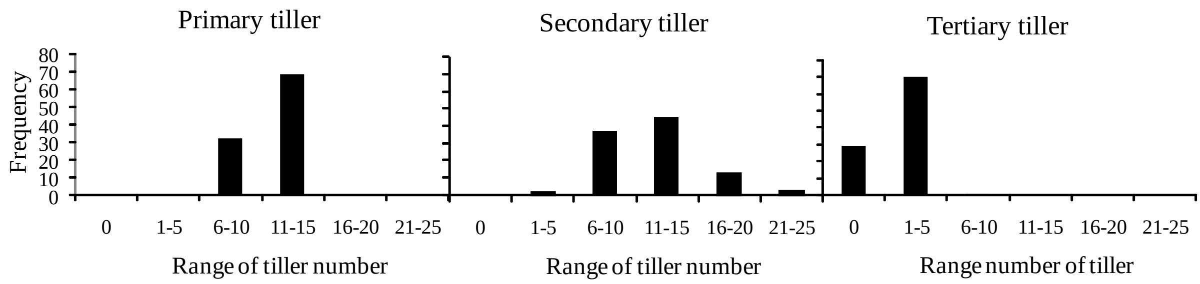

Figure 4. Histogram of primary, secondary and tertiary tiller number in 100 accessions of upland rice at 63 DAS.

Based on the observations from the experiment on 10 accessions which were grown in different soil environments, the tiller number on plants grown as upland rice was higher than those that were grown as lowland rice (Figure 5). From the data, it was found that the number of secondary tiller increased continuously and attained a maximum value at 49 DAS and 63 DAS for upland rice, and at 56 DAS for lowland rice. Generally, the number of tiller increase linerarly at 30 DAS until 70 DAS due to profuse tillering during vegetative growth and then decrease gradually due to plant death and plant aging [8]. The lowest number of panicle bearing tillers were due to mortality of non-effective side tiller [9].

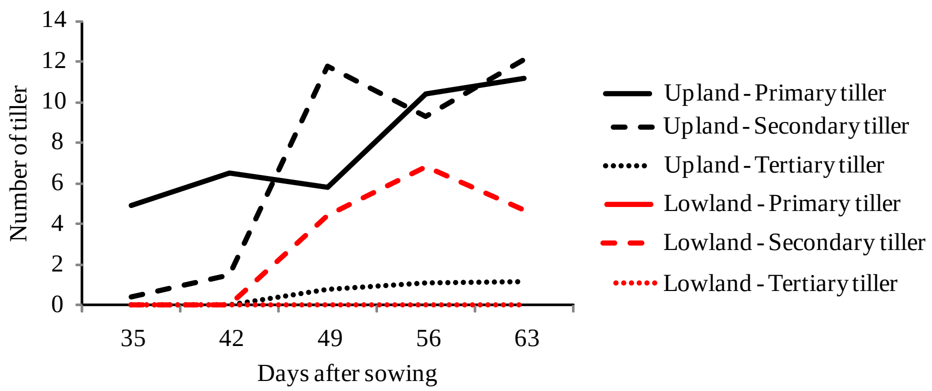

Figure 5. Growth profile of primary, secondary and tertiary tiller of 10 accessions planted as upland and lowland rice.

Differential response in tillering ability was observed among 10 accessions when grown in different soil environment. Under upland environment, Umbang Putih (Central Kalimantan), Rebo (East Nusa Tenggara), P Nyuhu (East Kalimantan) and Misik A (Central Kalimantan) had the highest number of primary tiller (12) during the vegetative phase, whereas under lowland environment, Sicur (West Sumatra) was able to produce 10 primary tiller (Figure 6). For the secondary tiller, the highest number (16) on upland environment was observed on Misik A, whereas that on lowland was expressed by Markuti (East Java).

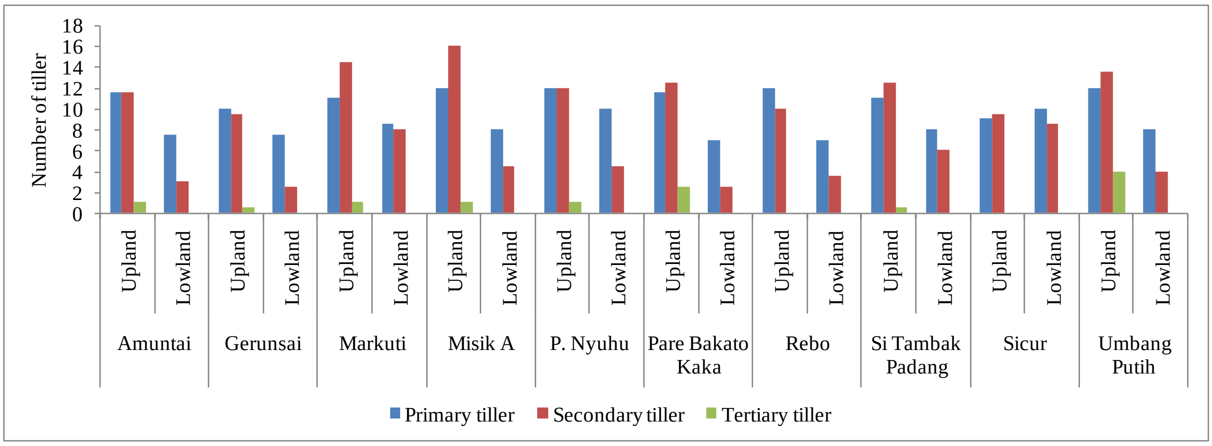

Figure 6. Mean number of primary, secondary and tertiary tiller of 10 rice accessions grown as upland and lowland rice.

During early vegetative growth, rice plant continuously forms new leaves in regular spatial and temporal patterns. The emerging tillers develop from axils of these leaves on the unextended nodes of the main shoot. The early initiated tillers on the main shoot also give rise to secondary tillers and secondary tillers produce tertiary tillers on their stem nodes [10].

Tiller production in rice is largely determined by environmental parameters, which supersede genetic features for expression of complete tillering ability [11]. Tiller development is regulated by a complex network of genetic, hormonal, and environmental factors, making tillering ability a highly plastic trait that allows wild cereals to adapt to different environmental conditions. It is also a major target for manipulation of plant architecture in breeding programs [12]. The formation of tillers plays an important role in determining grain yield, because it is closely related to the number of panicles of land area unit. Small tiller produce very little panicle, whereas too many tillers cause high tiller mortality rate, small panicle size and less optimal tiller, so the consequence is a lack of grain yield [13]. Indeed, reduced tillering has increased productivity in the domestication of maize [14]. In wild type rice plants, a tiller bud is normally formed at each leaf axil, but only those formed on the unelongated basal internodes can grow out into tillers and those formed on the elongated upper internodes become arrested. Secondary tillers are usually formed in wild-type plants, but higher-order tillers, such as tertiary, quaternary and quinternary ones are seldom developed [15].

4. Conclusions
The highest number of primary tiller during the vegetative growth (35 DAS) was expressed by Pae Daye Indolobye, Padi Pulut Pute Iteung and K. Puyuk, local upland rice accessions from North Sulawesi, East Kalimantan, and Central Kalimantan, respectively. Gadabung, an accession from Central Kalimantan had the highest number of secondary tiller (6) at 63 DAS. Information on the tillering ability of local upland rice provided in this study will benefit rice breeder for selecting breeding materials.

5. Acknowledgement
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