1st International Conference of Biology for Student 2022
Volume 2022
http://dx.doi.org/10.11594/nstp.2022.2613

NST Proceedings
OPEN ACCESS

Conference Paper

Phenological Characteristics, Distinctness, Uniformity, and Morphological Stability of Potential Genotypes of Upland Rice

Lailatul Badriyah[1], Dewi Nawank Sary[1], Thoriq Ahmad Syauqy[1], Ricoh Darisman Sihombing[1], Eries Dyah Mustikarini[2], Gigih Ibnu Prayoga[2], Ratna Santi[2], Budi Waluyo[1]*

[1]Agroecotechnology Study Program, Brawijaya University, Malang 65145, Indonesia
[2]Department of Agrotechnology, University of Bangka Belitung, Kepulauan Bangka Belitung 33172, Indonesia

*Corresponding author:
E-mail:
budiwaluyo@ub.ac.id

ABSTRACT

Every cultivar has characteristics that distinguish it from another cultivar. As opposed to within the cultivar it is required to be uniform and not indicate variations due to segregation. Knowledge of the characteristics of local rice and high-yielding cultivar will be more advantageous if it is supported by knowledge of the morphological changes of plant parts at each stage of growth. This study was conducted to determine the distinctness, uniformity, and stability of 10 potential upland rice genotypes and obtain information about growth stages based on phenology. The research was conducted based on an experimental study using a randomized block design with three replications. Observation of rice genotype characteristics was carried out based on the phenological measurement guide from the Biologische Bundesanstalt, bundessortenamt und CHemische Industrie (BBCH) for rice, and the DUS characterization guide from UPOV. The results showed that the growth stages of 10 rice genotypes consisted of 10 primary growth phases and there are variations in phenological phases in each genotype. Morphological characterization showed that 10 genotypes had a uniform and stable morphology and were grouped into 2 clusters. Cluster 1 consisting of G1, G2, G3, G4, G5, G8, and G10. Cluster 2 consists of G6, G7, and G9. The phenology of rice and morphological differences indicate variations in the genetic potential that each genotype possesses. The timing of morphological and agronomic observations of rice can be determined using the information on plant phenology.

Keywords: Phenology, distinctness, uniformity, stability, characterization

Introduction

Rice is a staple food source for most of the world's population (± 40%) and is the main food ingredient for the population of Southeast Asia. Consequently, rice is a commodity that has a significant impact on the realms of social, economic, and politics (Rembang et al., 2018). Every cultivar has characteristics that distinguish it from another cultivar within the same species. As opposed to within the cultivar it is required to be uniform and not indicate variations due to segregation. It is necessary to continue identifying significant features in local rice to understand its potential in plant breeding projects. Exploring the potential of local rice by morphologically characterizing plants can be done based on distinctness, uniformity, and stability or commonly referred to as DUS test/DUS characterization. According to Tadao (2014), the DUS test is used to establish whether a new line or variety is considered different from existing varieties of the same species (Distinctness) and whether the characteristics that indicate distinctiveness are uniform (Uniformity) and not change over the next period or generation (Stability).

How to cite:
Badriyah, L., Sary, D. N., Syauqy, T. A. et al. (2022). Phenological Characteristics, Distinctness, Uniformity, and Morphological Stability of Potential Genotypes of Upland Rice. *1st International Conference of Biology for Student 2022*. NST Proceedings. pages 100-111. doi: 10.11594/ nstp.2022.2613

Knowledge of the characteristics of local rice will be more advantageous for plant breeders, agronomist, and rice cultivation management practices if it is supported by knowledge of developmental stages or phenology of rice. Phenology is the study of the phases that naturally occur in plants, and the current phase is affected by environmental factors (Yulia, 2007). Each plant will behave differently in terms of its growth pattern. To ascertain changes in the morphology of plant parts at each stage of development, it is crucial to study plant phenology (Trimanto et al., 2020). These morphological changes can be described using Biologische Bundesanstalt, bundessortenant und CHemische industrie (BBCH) scale for rice. Numerous phenological observations are made using the BBCH scale to help identify rice plant growth stages and to better understand rice phenology (Vicente-guijalba et al., 2014). The information acquired from phenological observations can be utilized to assess the superiority of different genotypes and rice varieties under the test. In this research, 10 rice genotypes from the collection of the University of Bangka Belitung were subjected to phenological observations and DUS testing. This research is expected to provide information related to the growth stage based on phenology and to determine the distinctness, uniformity, and morphological stability of genotypes under the test so it can be used as basic information in the assembly of varieties for plant breeders, plant conversation, and management practices of local rice and superior varieties.

Material and Methods

Data was collected in Jatimulyo experimental field of Faculty of Agriculture, Universitas Brawijaya, Lowokwaru District, Malang City from March to June 2022. The average temperature in Lowokwaru is 24.25°C (World Weather Online, 2022), the average precipitation is 128.37 mm^{-1} month, and the elevation is 504 m above sea level (Google Earth, 2021). This research is an experimental study using Randomized Block Design (RBD). Ten rice genotypes from the Universitas Bangka Belitung were tested with 3 replications (Table 1). Before testing, seeds were imbibed in warm water at 50°C for 24 hours and then cured for 24 hours. Each line was planted in a separate plot, measuring 4 m×5 m, with a distance of 1 m between plots, and a plant spacing of 25×25 cm.

Table 1. List of genotypes

No.	Genotypes	Origin	No	Genotypes	Origin
1.	19I-06-09-23-03	UBB	6.	Danau Gaung	UBB
2.	21B-57-21-21-23	UBB	7.	Inpago 8	UBB
3.	23A-56-20-07-20	UBB	8.	Inpago 12	UBB
4.	23A-56-22-20-05	UBB	9.	PBM UBB 1	UBB
5.	23F-04-10-18-18	UBB	10	Rindang	UBB

Note: UBB= Universitas Bangka Belitung (Indonesia)

Observations were recorded on 10 randomly selected plants of each genotype. Phenological observations were done based on the scale of Biologische Bundesanstalt, Bundessortenamt und CHEmische Industrie (BBCH) for rice (Meier, 2001). There are 10 main growth stages: germination, leaf development, tillering, stem elongation, booting, inflorescence emergence, anthesis, development of fruits, ripening, and senescence. Morphological characterization was done based on the DUS test guidelines from the International Union for The Protection of New Varieties of Plants (UPOV, 2020). Characters that were observed included plant growth habit, flag leaf attitude, panicle attitude, panicle attitude of branches, grain color, number of tillers, weight of filled grains, plant height, flag leaf length, panicle length, time to maturity, 1000 seeds weight, grain ratio length/width, time of inflorescence emergence, and yield per plot.

Data from the phenological observations were analyzed using descriptive statistics obtained from the observation data and then presented in a descriptive narrative manner using a BBCH scale with 2-digit numbers and documentation for each phase. Morphological and agronomic characterization data were analyzed using descriptive statistics for qualitative and quantitative characters and analysis of variance for yield per plot characters. Grouping based on morphological characters were carried out based on hierarchical analysis using SPSS software then displayed in the form of a dendrogram. Examining of uniformity and stability was carried out based on the coefficient of variation (CV) in each character within the genotype. The values of the coefficient of variation were divided into four categories: low (10%), moderate (10-20%), high (20-30%), and very high (>30%) (Ferreira et al., 2016). The higher the value of CV indicates, the more diverse the observed characters are. Genotypes that show uniform results can be considered to be stable (UPOV, 2011).

Results and Discussion

Phenological growth stages of ten genotypes of upland rice

Rice phenology consists of 10 main growth stages covering the entire growth cycle from germination to senescence. Stages 0 to stage 3 are stages for vegetative phases and stages 4 to 9 are for generative phases. Each of the 10 primary growth stages is further divided into several secondary growth stages, which describe the developmental stage of rice plants in more detail (Table 5). Each genotype of rice has different phenological timing. There are some genotypes of rice that have a phenological phase that is more concurrent, sooner, or later than the other genotypes.

Principal Growth Stage 0: Germination

The principal growth stage 0 describes the period from dry seed to the development of the imperfect leaf at the tip of coleoptile (Table 2). Stage 00 is the stage of dry seed and stage 01 marks the stage of germination process. Water began to imbibed into the seed after soaking and broke the seed dormancy, causing radicles to start emerge (secondary growth stage 05) and followed by emerge of coleoptile. Development of imperfect leaf will occur after the coleoptile appears (secondary growth stage 09). The secondary growth stage mostly takes place underground and takes time around 6-7 days. In genotype 19I-06-09-23-03, 23A-56-22-20-05, Danau Gaung, Inpago 8, and Inpago 12 this stage lasted for 6 days, while in 21B-57-21-21-23, 23A-56-20-07-20, 23F-04-10-18-18, PBM UBB 1, and Rindang lasted for 7 days (Figure 1). This phenological stages occurs when the air temperature is 23.5°C (Figure 2) with a rainfall 6.1 mm (Figure 3).

Principal Growth Stage 1: Leaf Development

The principal growth stage 1 defines the time of leaf development starting with the opening of the imperfect leaf and the emergence of the true leaf from the soil surface (secondary growth stage 10). The first leaf opened then followed by the second leaf, and so on until more than 9 leaves opened. In PBM UBB 1 and 23F-04-10-18-18 this stage takes place for 26 days, followed by genotype 21B-57-21-21-23, Inpago 8, and Inpago 12 for 27 days. Genotype 23A-56-20-07-20, Danau Gaung, and Rindang last for 28 days. On 19I-06-09-23-03 last for 29 days and on 23A-56-22-20-05 last for 30 days. The earliest genotypes to enter the leaf development stage were 19I-06-09-23-03, 23A-56-22-20-05, Danau Gaung, Inpago 8, and Inpago 12 at 7 days after emergence (Figure 1) when the air temperature was 23°C (Figure 2). While the other genotypes at 8 days after emergence when the air temperature was 22°C.

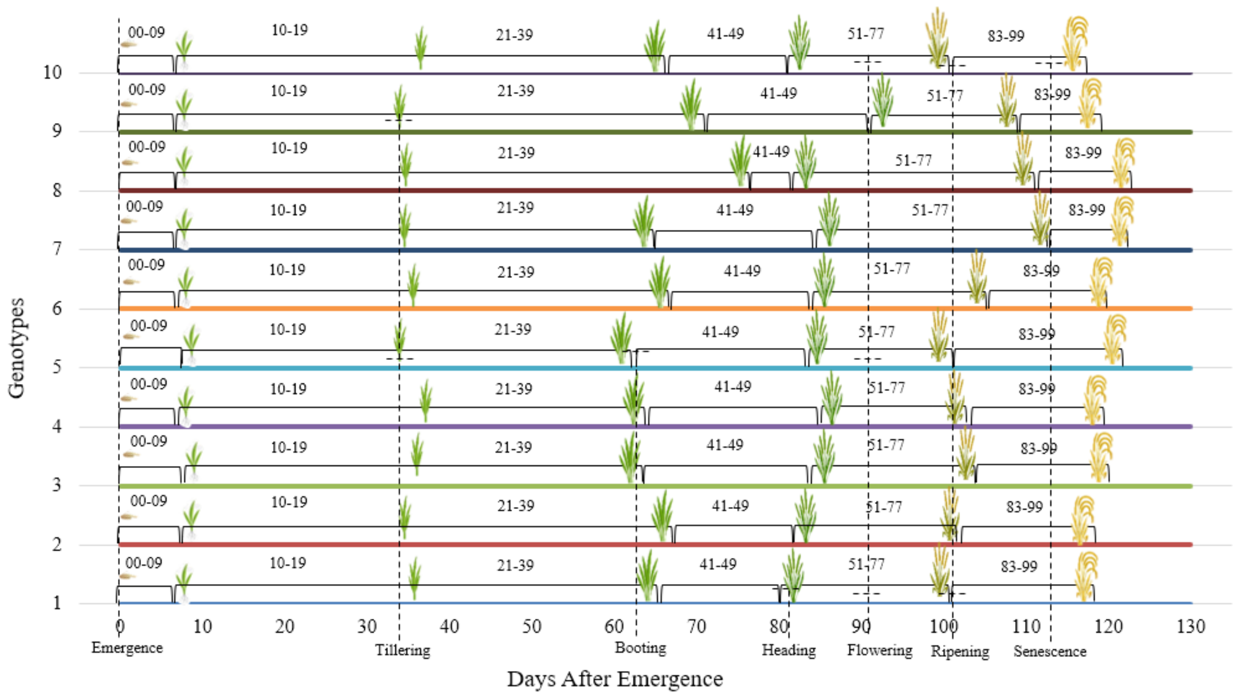
Principal Growth Stage 2: Tillering

The principal growth stage 2 describes tillering development (Table 2). All growth stages take place above ground. The first tiller began to appear at ±35 days after emergence (secondary growth stage 21). Each genotype showed a different time of emergence of the first tiller. Tillers will keep increasing until reach the maximum number of tillers (secondary growth stage 29) and this stage will occur simultaneously with the stem elongation stage. This stage was observed until the 3rd tiller appeared because the rice stalks began to elongate before the maximum number of tillers was seen. The first tiller at 23F-04-10-18-18 and PBM UBB 1 emerged 34 days after emergence (DAE) then followed by 21B-57-21-21-23 and Inpago 8 at 35 DAE. Then on 19I-06-09-23-03, 23A-56-20-07-20, Danau Gaung, and Rindang at 36 DAE.

Table 2. Phenological phases of 10 genotype of upland rice Based on BBCH scale

BBCH Code	Principal Growth Stages	Days After Emergence (DAE)									
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
00	Germination	0-6	0-7	0-7	0-6	0-7	0-6	0-6	0-6	0-7	0-7
01	Leaf development	7-35	8-34	8-35	7-36	8-33	7-35	7-34	7-34	8-33	8-35
02	Tillering*	36…	35…	36…	37…	34…	36…	35…	35…	34…	36…
03	Stem elongation	43-66	39-67	40-63	39-64	37-62	41-67	38-65	38-77	41-71	40-67
04	Booting	67-80	68-81	64-83	65-84	63-82	68-84	66-85	78-82	72-91	68-81
05	Inflorescence, Heading	81-90	82-91	84-91	85-92	83-90	84-91	86-92	83-92	92-97	82-90
06	Flowering, Anthesis	91-98	92-98	92-97	93-99	91-99	92-97	93-97	93-102	98-102	91-98
07	Development of Fruit	99-101	99-102	98-103	100-103	100-102	98-107	98-113	103-111	103-109	99-101
08	Ripening	102-114	103-114	104-115	104-115	103-116	108-115	114-119	112-118	110-118	102-113
09	Senescence	115-119	115-119	116-120	116-120	117-121	116-120	120-122	119-122	119-120	114-118

Notes: DAE= Days After Emergence, G1= 19I-06-09-23-03, G2= 21B-57-21-21-23, G3= 23A-56-20-07-20, G4= 23A-56-22-20-05, G5= 23F-04-10-18-18, G6= Danau Gaung, G7= Inpago 8, G8= Inpago 12, G9= PBM UBB 1, G10= Rindang; *Stem elongation begins before the end of tillering so that it continues to stage 3 (Meier, 2001).



Notes: DAE= Days After Emergence, G1= 19I-06-09-23-03, G2= 21B-57-21-21-23, G3= 23A-56-20-07-20, G4= 23A-56-22-20-05, G5= 23F-04-10-18-18, G6= Danau Gaung, G7= Inpago 8, G8= Inpago 12, G9= PBM UBB 1, G10= Rindang

Figure 1. Phenological Phase of 10 Genotypes of Rice

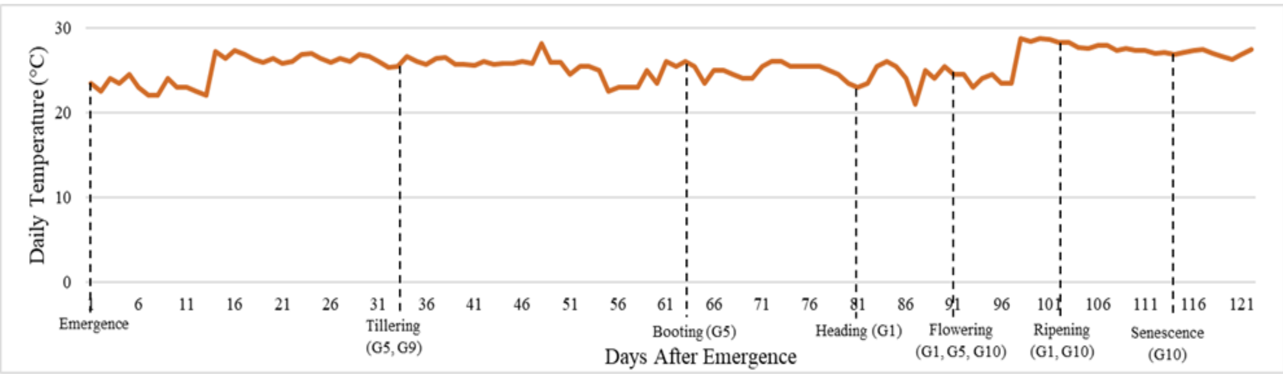
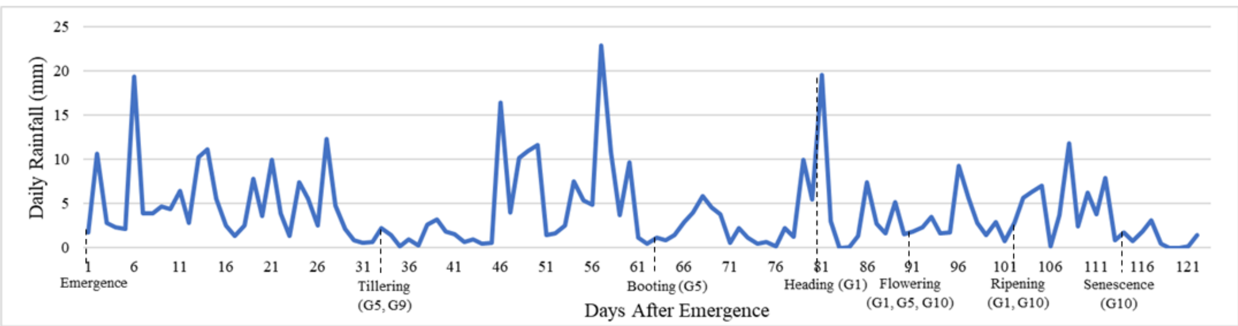


Figure 2. Daily Temperature of Lowokwaru District, Malang (March-June 2022)



Source: World Weather Online (2022)

Figure 3. Daily Rainfall of Lowokwaru District, Malang (March-June 2022)

Principal Growth Stage 3: Stem Elongation

The principal growth stage 3 describes the initiation of panicle and stem elongation (Table 2). At this stage, the second stages 30 and 32 are difficult to observe due to panicle initiation occurring inside the stem. Therefore, it is required to divide the rice stalks longitudinally to see the green ring and immature panicles. In the next secondary growth stage, it can be seen visually when the internode begins to elongate (secondary growth stage 37). Each genotype displayed a distinct timeframe for stem elongation, which was accompanied by an increase in the number of tillers.

Principal Growth Stage 4: Booting

The principal growth stage 4 defines the booting stage (Table 2). The stem began to thicken and the flag leaf sheath began to open. The booting stage is a sign that the vegetative phase is over and the rice has entered the generative phase. The booting stage is divided into several secondary stages. Early boot stage (secondary growth stage 41), when the stem starts to thicken. Mid-boot stage (secondary growth stage 43), when the flag leaf sheath swells and looks larger than the rest of the stem. The late boot stage (secondary growth stage 45) is marked by the flag leaf sheath reaching its maximum size. The booting stage ends when the flag leaf sheath is completely exposed. This stage started at ±63 days after emergence (DAE) and lasted until 80-90 DAE. The first genotypes to enter the booting stage were 23F-04-10-18-18 at 63 DAE when the air temperature was 26°C, and the last was Inpago 12 at 78 DAE at the air temperature was 25°C.

Principal Growth Stage 5: Inflorescence emergence, Heading

The principal Growth Stage 5 defines panicle development (Table 2). The secondary stage of this phase is grouped according to the percentage of panicles that emerge from the sheath, which ranges from 20% (secondary growth stage 52) to 80% (secondary growth stage 58). The first genotypes to enter the heading stage were 19I-06-09-23-03 at 81 days after emergence (DAE). In PBM UBB 1, the panicle development stage started last at 92 DAE but only lasted for 6 days, whereas in other genotypes panicle development takes place earlier but with a longer duration (7-11 days).

Principal Growth Stage 6: Flowering, Anthesis

The principal growth stage 6 describes the phenomenon of flowering in rice (Table 2). The flowering stage begins when the anther first appears at the tip of the panicle and then appears in the majority of the spikelets. This stage ends when all the grains have flowered and the anthers start to dry out. Each genotype in this phase has a different flowering period that begins between 91-102 days after emergence (DAE), with an average air temperature of 25.8°C. The rice flowers that appear are white, and when dry they are brownish yellow. The first genotypes to enter the flowering stage were 19I-06-09-23-03 and Rindang at 91 DAE, and the last were PBM UBB 1 at 98 DAE.

Principal Growth Stage 7: Development of fruit

The principal growth stage 7 describes grain development (Table 2). The development of the grains begins when the grains begin to fill with a watery liquid (secondary growth stage 71). As the grains continue to fill, the liquid gets more concentrated and turns milky (secondary growth stage 73-77). This period can persist up to two weeks in the 10 genotypes that were examined. Genotypes 19I-06-09-23-03 and 23F-04-10-18-18 had the fastest duration of 3 days, while in Inpago 8 grain development lasted 16 days. The earliest genotypes that entered this stage were 23A-56-20-07-20, Danau Gaung, and Inpago 8 at 98 DAE when the air temperature was 28.7°C. The latest genotypes to enter this stage were Inpago 12 and PBM UBB 1 at 103 DAE when the air temperature was 28.25°C.

Principal Growth Stage 8: Ripening

The principal growth stage 8 describes the phenomenon of rice grain ripening (Table 2). The milk-like liquid in the grain will harden gradually and become soft dough, which will then harden into a hard dough. During this stage, the grains' contents are checked using the thumb. When the grain is difficult to split with the thumb, it indicates that the grain has entered the end of the ripening stage and is fully ripe (secondary growth stage 89). This phase may last for 6 to 14 days.

The earliest genotype to enter this stage was 19I-06-09-23-03 and Rindang at 102 DAE when the air temperature was 28.25°C. The latest genotypes to enter this stage were Inpago 8 at 114 DAE when the air temperature was 26.85°C but it lasted for just 6 days, which is shorter than other genotypes, while the longest ripening duration was 23F-04-10-18-18 for 14 days.

Principal Growth Stage 9: Senescence

The principal growth stage 9 describes plant death and harvest of grain (Table 2). The grains are fully ripe (secondary growth stage 92) and cannot be split with the thumbnail. The plant begins to turn yellow and fall. At this stage, harvesting can be done. It can take 2 to 5 days for fruit to reach the senescence stage. Rindang was the earliest genotype to enter this phase at 114 DAE when the air temperature was 26.85°C. While the last genotype to enter this phase was Inpago 12 at 120 DAE when the air temperature was 26.25°C.

Distinctness of ten genotypes of rice-based of morphological and phenological characters

The distinctiveness test was undertaken using visual scoring (Table 4) based on DUS test guidance. Hierarchical clustering analysis on the morphology and phenology of 10 rice genotypes is shown in Figure 4. Based on the cluster analysis, it can be seen that genotypes 19I-06-09-23-03 (G1), 21B-57-21-21 -23 (G2), 23A-56-20-07-20 (G3), 23F-04-10-18-18 (G5), 23A-56-22-20-05 (G4), Inpago 12 (G8), and Rindang (G10) are distinct from Danau Gaung (G6), Inpago 8 (G7), and PBM UBB 1 (G10) morphologically and phenologically at a dissimilarity coefficient of 24.94. Out if 10 qualitative characters and 5 quantitative characters showed variation between two major clusters.

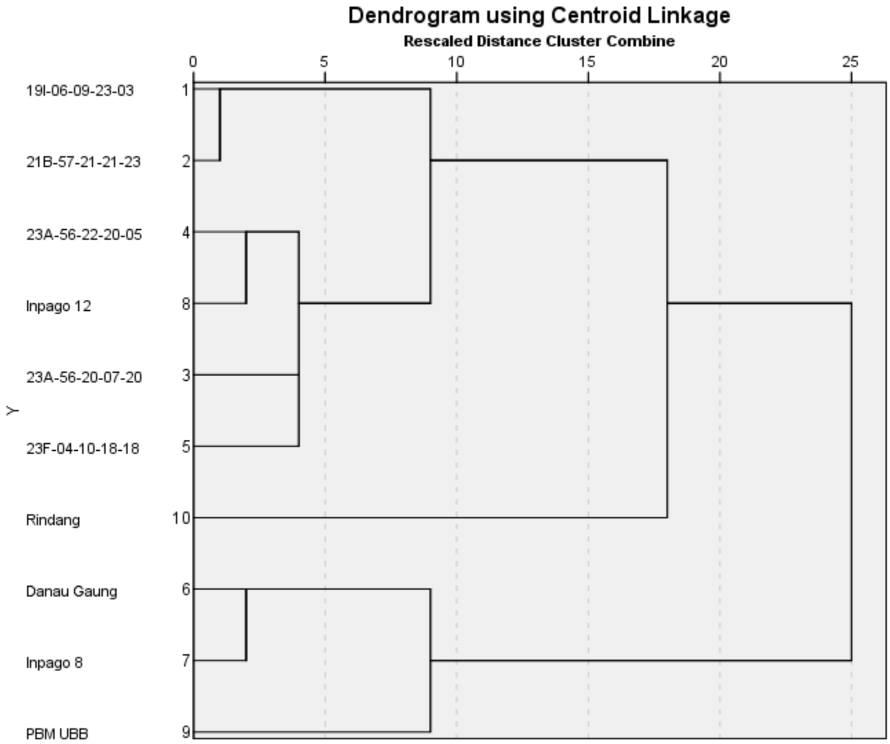


Figure 4. Dendrogram of classification of 10 genotypes of rice based on morphological and phenological characteristics

Clustering provided 2 major clusters and a value of 24.94 for the largest dissimilarity coefficient, indicating that the genotypes included in each of these clusters varied morphologically and phenotypically. the greater the value of the dissimilarity coefficient, the further the grouping distance. On the other hand, the smaller the dissimilarity value, the closer the grouping distance is (Selviana et al., 2018). Cluster 1 consists of 19I-06-09-23-03, 21B-57-21-21-23, 23A-56-20-07-20, 23A-56-22-20-05, 23F-04-10-18-18, Inpago 12, and Rindang have similar characteristics in grain color (light brown), plant height (short category), and panicle length (short category). Cluster 2 consists of Danau Gaung, Inpago 8, and PBM UBB 1 which have similarities in the characteristics of plant growth habit (erect category), the number of tillers (medium category), plant height (medium category), flag leaf length (short category), and grain length/width ratio (2.99) or long spindle-shaped grain. In addition, in cluster 2 there are similarities in the phenological phases, including the booting stage, panicle development stage, flowering, ripening stage, and senescence. In this phase, the phenology of the genotype in cluster 2 appears later than the other genotypes. Meanwhile, the phenology in cluster 1 was highly variable. Differences in morphology and phenology of the genotypes are caused by differences in the traits of each genotype. each type of rice has its characteristics so in terms of morphology, there are no rice varieties that have the same shape. The differences seen between varieties are due to differences in varietal traits. However, among the rice varieties, some characteristics are similar or the same (Hanas et al., 2017).

Uniformity and stability of ten genotypes of rice based on morphological and phenological characters

Qualitative characters related to the morphology and agronomy of upland rice were observed in three phenological stages, specifically characters' number of tillers and time of inflorescence emergence were observed at the panicle development stage (principal growth stage 5). Characters of flag leaf length, plant height, and panicle length were observed at the ripening stage (principal growth stage 8). On the character of the weight of filled grains, Time to maturity, 1000 seed weight, grain length/width ratio, and yield per plot were observed at the senescence stage (principal growth stage 9). Uniformity analysis on the morphological and agronomic characters using the coefficient of variation (CV) showed that all the characteristics had low CV (Table 3). The value of coefficient variation is considered to be low if it has a value <10% (Ferreira et al., 2016).

Table 3. Uniformity analysis on the morphological and agronomic characters

Phenological stage	Characters	Coefficient of Variation (%)									
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
Panicle development (5)	Number of tillers	0.33	0.25	0.38	0.22	0.30	0.17	0.14	0.58	0.41	0.17
	Time of inflorescence emergence	0.02	0.02	0.01	0.03	0.06	0.01	0.01	0.02	0.02	0.03
Ripening (8)	Flag leaf length	0.17	0.14	0.10	0.06	0.13	0.09	0.09	0.23	0.11	0.03
	Plant heigh	0.12	0.07	0.10	0.15	0.08	0.05	0.06	0.10	0.07	0.07
	Panicle length	0.08	0.11	0.08	0.09	0.09	0.06	0.06	0.07	0.05	0.03
Senescence (9)	Weigh of filled grains	0.34	0.23	0.32	0.23	0.28	0.29	0.14	0.26	0.28	0.18
	Time to maturity	0.01	0.01	0.01	0.01	0.03	0.01	0.02	0.01	0.02	0.02
	1000 seed weigh	0.04	0.04	0.03	0.04	0.09	0.04	0.29	0.20	0.09	0.11
	Grain length/widh ratio	0.45	0.14	0.19	0.41	0.05	0.60	0.06	0.18	0.06	0.08
	Yield per plot	0.04	0.03	0.06	0.05	0.07	0.18	0.07	0.15	0.07	0.00

Notes: G1= 19I-06-09-23-03, G2= 21B-57-21-21-23, G3= 23A-56-20-07-20, G4= 23A-56-22-20-05, G5= 23F-04-10-18-18, G6= Danau Gaung, G7= Inpago 8, G8= Inpago 12, G9= PBM UBB 1, G10= Rindang

Table 4. Characterization of Upland Rice as per DUS Guidelines

No	Genotypes	Plant growth habit	Flag leaf attitude	Panicle attitude	Panicle attitude of branches	Grain color	Number of tillers	Weigh of filled grains	Plant heigh
1	19I-06-09-23-03	5	1	2	3	5	3	2	1
2	21B-57-21-21-23	5	1	1	3	5	3	1	1
3	23A-56-20-07-20	3	1	1	1	5	4	2	1
4	23A-56-22-20-05	3	4	1	1	5	4	2	1
5	23F-04-10-18-18	2	2	1	1	5	3	2	1
6	Danau Gaung	1	3	2	3	6	3	2	5
7	Inpago 8	1	2	3	3	5	3	3	5
8	Inpago 12	2	3	2	3	5	4	2	1
9	PBM UBB 1	1	4	3	1	5	3	2	5
10	Rindang	2	3	4	3	5	3	2	1
No	Genotypes	Flag leaf length	Panicle length	Time to maturity	1000 seed weigh	Grain length/width ratio	Time of inflo-rescence emer-gence	Yield per plot*	
1	19I-06-09-23-03	1	3	2	5	5	2	10.63 d	
2	21B-57-21-21-23	1	3	2	5	5	2	13.33 e	
3	23A-56-20-07-20	1	3	2	5	5	2	10.09 d	
4	23A-56-22-20-05	1	3	2	3	5	3	7.11 bc	
5	23F-04-10-18-18	2	3	2	5	4	3	6.14 b	
6	Danau Gaung	2	3	2	5	5	2	4.06 a	
7	Inpago 8	2	5	2	3	5	3	16.65 f	
8	Inpago 12	1	3	2	3	5	3	6.37 bc	
9	PBM UBB 1	2	5	2	3	5	3	7.44 c	
10	Rindang	2	5	2	7	4	2	10.01 d	

Table 5. Description of Phenological Phases of 10 Genotype of Upland Rice According to the two-digit BBCH Scale

BBCH Code	Descriptions
Principal Growth Stage 0: Germination	
00	Dry seed (caryopsis)
01	Beginning of seed imbibition
03	Seed imbibition complete (pigeon breast)
05	Radicle emerged from caryopsis
06	Radicle elongated, root hairs and/or side roots visible
07	Coleoptile emerged from caryopsis (in water-rice this stage occurs before stage 05)
09	Imperfect leaf emerges (still rolled) at the tip of the coleoptile
Principal Growth Stage 1: Leaf Development	
10	Imperfect leaf unrolled, tip of first true leaf visible
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1.	Stages continuous till…
19	9 or more leaves unfolded
Principal Growth Stage 2: Tillering	
21	Beginning of tillering: first tiller detectable
22	2 tillers detectable
23	3 tillers detectable
2.	Stages continuous till…
29	Maximum number of tillers detectable
Principal Growth Stage 3: Stem Elongation	
30	Panicle initiation or green ring stage: chlorophyll accumulates in the stem tissue, forming a green ring
32	Panicle formation: panicle 1–2 mm in length
34	Internode elongation or jointing stage: internodes begin to elongate, panicle more than 2 mm long (variety-dependent)
37	Flag leaf just visible, still rolled, panicle moving upwards
39	Flag leaf stage: flag leaf unfolded, collar regions (auricle and ligule) of flag leaf and penultimate leaf aligned (pre-boot stage)
Principal Growth Stage 4: Booting	
41	Early boot stage: upper part of stem slightly thickened, sheath of flag leaf about 5 cm out of penultimate leaf sheath
43	Mid boot stage: sheath of flag leaf 5–10 cm out of the penultimate leaf sheath
45	Late boot stage: flag leaf sheath swollen, sheath of flag leaf more than 10 cm out of penultimate leaf sheath
47	Flag leaf sheath opening
49	Flag leaf sheath open
Principal Growth Stage 5: Inflorescence Emergence, Heading	
51	Beginning of panicle emergence: tip of inflorescence emerged from sheath
52	20% of panicle emerged
53	30% of panicle emerged
54	40% of panicle emerged
55	Middle of panicle emergence: neck node still in sheath
56	60% of panicle emerged
57	70% of panicle emerged
58	80% of panicle emerged

59	End of panicle emergence: neck node level with the flag leaf auricle, anthers not yet visible
Principal Growth Stage 6: Flowering, Anthesis	
61	Beginning of flowering: anthers visible at top of panicle
65	Full flowering: anthers visible on most spikelets
69	End of flowering: all spikelets have completed flowering but some dehydrated anthers may remain
Principal Growth Stage 7: Development of Fruit	
71	Watery ripe: first grains have reached half their final size
73	Early milk
75	Medium milk: grain content milky
77	Late milk
Principal Growth Stage 8: Ripening	
83	Early dough
85	Soft dough: grain content soft but dry, fingernail impression not held, grains and glumes still green
87	Hard dough: grain content solid, fingernail impression held
89	Fully ripe: grain hard, difficult to divide with thumbnail
Principal Growth Stage 9: Senescence	
92	Over-ripe: grain very hard, cannot be dented by thumbnail
97	Plant death and collapsing
99	Harvest product

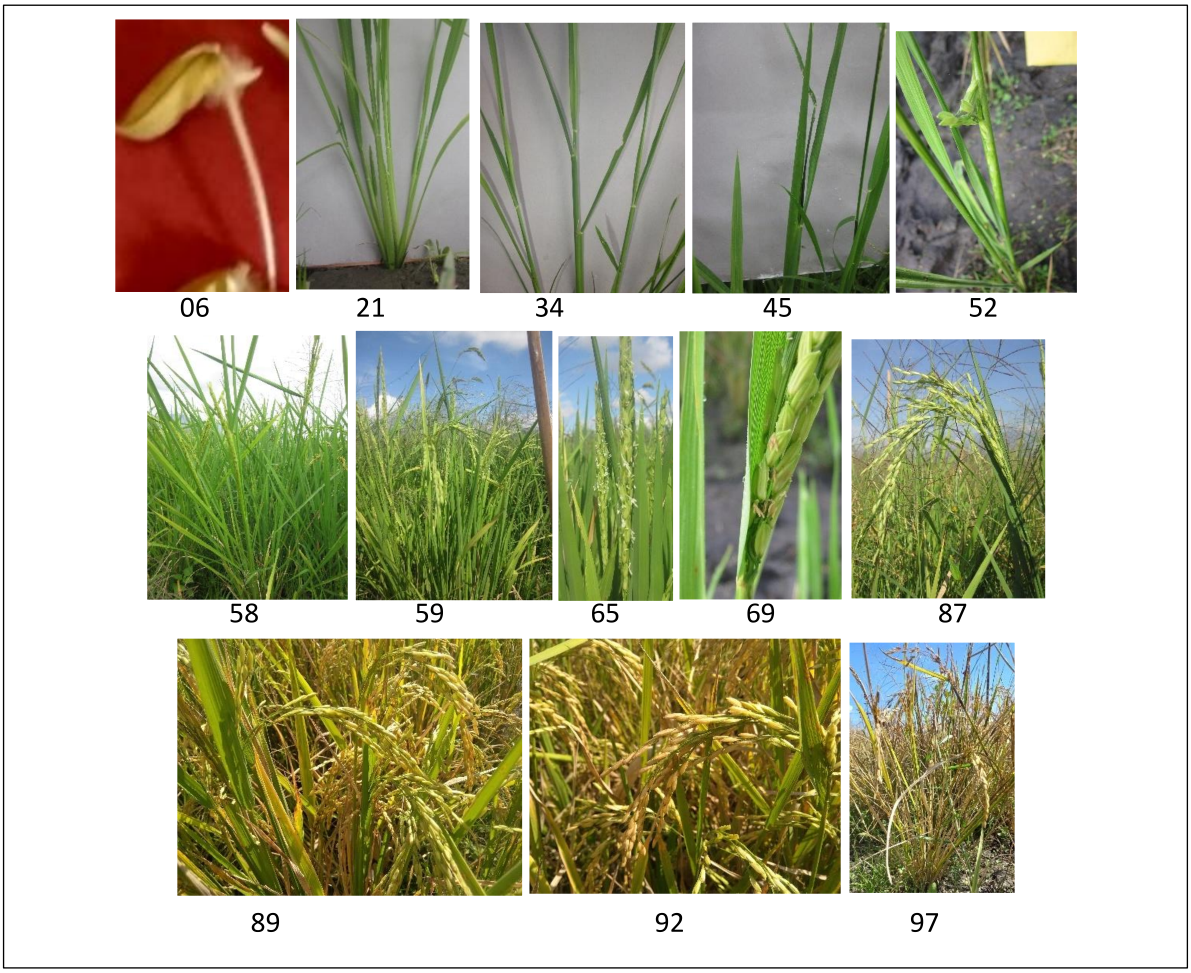


Figure 5. Principal Growth Stages of Upland Rice from Germination to Senescence According to BBCH scale (for instance, genotype 19I-06-09-23-03)

The amount of diversity in a set of data can be estimated using the coefficient of variation's value. CV with a high value can be an indicator that the data obtained from the research is not uniform. The high coefficient of variation (<30%) indicates that the experiments were highly diverse (Taylor, 2008). In this case, the genotypes observed in this study have a low CV value, so they can be said to have a stable morphology. A genotype can be said to be stable if it has a CV value that is not much different from the registered variety used (Zawieja et al., 2013). The CV values of genotypes 19I-06-09-23-03, 21B-57-21-21-23, 23A-56-20-07-20, 23A-56-22-20-05, and 23F-04-10-18-18, are not significantly different from the five cultivated varieties used (Danau Gaung, Inpago 8, Inpago 12, PBM UBB 1, and Rindang). In addition, if a genotype has shown uniform results, it can be categorized as stable (UPOV, 2011), so the 10 tested genotypes can be categorized as having stable morphology and agronomy. However, it is necessary to perform testing in a wider environment to further establish the stability of morphology and yield so that a genotype description and crop adaptability to different environments can be derived from these observations.

Conclusion

The phenological scale discussed above provides a thorough and precise description of the growth of 10 genotypes of upland rice. Additionally, the distinctness and uniformity of the genotype's morphology indicate differences in genetic potential possessed by each genotype as well as variations in their phenology. This information on phenology can be used to determine the timing of morphological observations of rice and can also be used to improve the accuracy of upland rice management practices. The DUS test result may support varietal registration, crop variety protection, and agricultural licensing.

Acknowledgment

Thank you to the research team of Universitas Bangka Belitung for providing the funding to carry out this research.

References

Ferreira, J. P., Schmildt, E. R., Schmildt, O., Cattaneo, L. F., Alexandre, R. S., & Cruz, C. D. (2016). Comparison of methods for classification of the coefficient of variation in papaya. *Rev. Ceres,* 138–144.

Google Earth. (2021). *Lahan Pertanian FP UB.*

Hanas, D. F., Kriswiyanti, E., & Ketut, I. (2017). Karakter morfologi beras sebagai pembeda varietas padi. *Indones. J. Leg. Forensic Sci., 1*, 23–28

Meier U, . (2001). *Growth stages of mono-and dicotyledonous plants BBCH monograph*. 2nd Edition. Berlin: Federal Biological Research Centre for Agriculture and Forestry.

Rembang, J. H. W., Rauf, A. W., & Sondakh, J. O. M. (2018). Karakter morfologi padi sawah lokal di lahan petani Sulawesi Utara. *Bul. Plasma Nutfah., 24*, 1–8.

Selviana, A., Turnip, M., & Linda, M. (2018). Variasi morfometrik dan pengelompokan spesies kantong semar (*Nepenthes* Spp.) di Desa Simpang Kasturi Kecamatan Mandor. *Protobiont. 7,* 29–36.

Tadao, M. (2014). *Role of DUS test and functional characteristic*. [http://eapvp.org/files/report/docs/05_Role of DUS test and Functional characteristics.pdf], 17 February 2022.

Taylor, S. L., Payton, M. E., & Raun, W. R. (2008). Relationship between mean yield, coefficient of variation, mean square error and plot size in wheat field experiments. *Commun. Soil Sci. Plant Anal., 30,* 1439–1447.

Trimanto, D. A., Pitaloka, & Metusala, D. (2020) Karakterisasi morfologi dan fenologi pembungaan dua aksesi *Kopsia pauciflora* Hook. f. bunga putih dan merah muda di Kebun Raya Purwodadi, Jawa Timur. *Bul. Plasma Nutfah, 26*, 77–88.

UPOV. (2011). *Document TGP/9 "Examining stability"*. Geneva: International Union for The Protection of New Varieties of Plants.

UPOV. (2020). *Guidelines for the conduct of test for distincness, uniformity and stability*. Geneva: International Union for The Protection of New Varieties of Plants.

Vicente-guijalba, F., Martinez-marin, T., Lopez-sanchez, J. M., & Member, S. (2014). Crop phenology estimation using a multi-temporal model and a kalman filtering strategy. *Journals & Magazines, 11*(6), 1-5. doi: 10.1109/LGRS.2013.2286214.

World Weather Online. (2022). *Lowokwaru Historical Weather*. [https://www.worldweatheronline.com/lowokwaru-weather-history/east-java/id.aspx], 24 June 2022.

Yulia, N. D. (2007). Kajian fenologi fase pembungaan dan pembuahan *Paphiopedilum glaucophyllum* J. J.Sm. var. glaucophyllum. *Biodiversitas, 8,* 58–62.

Zawieja, B., Bocianowski, J., Luczkiewicz, T., & Gacek, K. (2013). Analysis of uniformity of new oilseed rape lines (*Brassica napus* L. subsp. *oleifera*) using coefficient of variation. *African Journal of Agricultural Research, 8*(44), 5464-5467. Doi:10.5897/AJAR12.1137