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Short Communication: Variation of panicle branching structure of new high yielding and local rice varieties from farmer's field

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Abstract. *Hastini T, Haryati Y, Noviana I, Nurbaeti B, Perdhana F, Kurnia, Sari R, Rohaeni WR, Susanto U. 2022. Short Communication: Variation of panicle branching structure of new high yielding and local rice varieties from farmer's field. Biodiversitas 23: 1336-1343.* The number of grains per panicle is one of the important factors determining the yields in rice. This study aimed to capture the panicle branching pattern of different rice varieties grown in different environments with various planting systems. The assessment was conducted in West Java during the planting season of 2020. The panicle of new high-yielding and local rice varieties was collected from 23 various rice-growing sites. The results revealed that the variance due to genotype, environment, and interaction between genotype and environment were significant for panicle branching trait. Two rice genotypes, such as Padjadjaran and Inpari 45 were stable and did not show any change when they were grown in the various environments with different agronomical practices. Whereas, Inpari 32, Cakrabuana, and Inpari IR Nutri Zinc showed different performances at different growing sites and planting systems. The characters of PL, NPB, NSB, PBL, NGPB, TLPB, TLSB, SbperPB, TNGSB and TFG showed positive and significant correlation with the number of total grains per panicle.

Keywords: Genotype and environment interaction, rice panicle branching, site

Abbreviations: AHC: Agglomerative Hierarchical Clustering; CV: coefficient of variation; MAL: main axis length; NGPB: number of grains per primary branches; NGSB: number of grains per secondary branches; NGT: number of total grains per panicle; NN: node number/groups of primary branches in the main axis; NPB: number of primary branches; NSB: number of secondary branches; PB: tip number of grains in the tip of primary branches; PBL: primary branches length; PCA: Principal Component Analysis; PL: panicle length; SBL: secondary branches length; SbperPB: number of secondary branches per primary branches; TFG: total of filled grains per panicle; TLPB: total length of primary branches; TLSB: total length of secondary branches; TNGSB: total grains in the secondary branches per panicle

INTRODUCTION

Grain number per panicle is one of the predominant components responsible for yield in rice which is determined by panicle architecture (Yamaki et al. 2010). Panicle architecture is composed of panicle length, panicle branch number and panicle compactness, which finally affects grain number per panicle and grain yield of rice (Bay et al. 2017; Li et al. 2021; Wang et al. 2020). Therefore, the improvement of panicle architecture can lead to rice yield improvement. The genetic mechanism controlling grain number per panicle in rice will help breeders develop an efficient strategy to improve rice yield (Li et al. 2021).

Indonesia has abundant rice varieties, i.e. local and national rice varieties. Prasetiyono et al. (2018) reported that diverse Indonesian rice varieties genotyped by SNP markers were identified. The genome type of the Indonesian rice varieties varied greatly, such as indica, japonica, and javanica types. Diverse in rice genome will result in different expression of phenotypes including panicle architecture trait. It is known that the local rice variety also shows large variations in panicle size (spikelet number per panicle) and panicle length. Phenotypic variation in panicle length occurs not only among rice species but also within subspecies. Panicle phenotypic variation was predicted caused by environmental conditions (Nurhasanah et al. 2017). Adriani et al. (2016) confirmed that panicle architecture varies among genotypes and is prone to genotype × environment interactions.

Artificial hybridization produces more panicle architecture diversity. Breeders create and develop new varieties from germplasm collection through a plant breeding program, although it might take a decade with not necessarily good quality (Weerakoon and Somaratne 2021). In Indonesia, during twenty years (from 2000 until 2020), there has been released 117 new rice varieties (ICRR 2020).

Purwanto et al. (2018) reported that many environmental factors could affect rice variety's performances. In the highland site, the flowering time was longer than in the lowland one. Other characters, such as panicle length, yield and even the anthocyanin content were, differed when the same variety were planted at the different growing sites. The wider planting space, the longer panicle length and the more spikelets number. By increasing population density from 16.7 to 50 hills m^{-2}, panicle length decreased by 12% (Asmamaw 2017). Nguyen et al. (2011) reported that farmers' agronomical practices in different water environments affected the rice yield and the yield-related components. Rozen et al. (2018) reported that a significant difference for total grains per panicle, weight of total grains per panicle, weight of filled grains per panicle, weight of 1000 grains, and yield $plot^{-1}$ was observed in Batang Piaman and IR 42 rice varieties when they were cultivated at different locations. In addition, they also reported that the interaction between variety×location was observed in total grains $panicle^{-1}$, the weight of 1000 grains, and yield $plot^{-1}$. The objective of this study was to provide more information about rice panicle branching characters as a basis for breeders to create new, improved varieties based on panicle branching architecture.

MATERIALS AND METHODS

Study area

The assessment was conducted in West Java, Indonesia during the planting season of 2020. The material was collected from 23 various sites (Figure 1), with various agronomical practices from the farmer rice field (Table 1). Five panicles from a hill and three hills per site were observed for the panicle branching characters.

The parameters observed in the present study consisted of several rice traits such as panicle length (PL), main axis length (MAL), node number/groups of primary branches in the main axis (NN), number of total grains per panicle (NGT), number of primary branches (NPB), number of secondary branches (NSB), primary branches length (PBL), secondary branches length (SBL), number of grains per primary branches (NGPB), number of grains in the tip of primary branches (PBtip), number of grains per secondary branches (NGSB), total length of primary branches (TLPB), total length of secondary branches (TLSB), number of secondary branches per primary branches (SBperPB), total grains in the secondary branches per panicle (TNGSB), and total of filled grains per panicle (TFG).

Data analysis

Data of panicle length (PL), main axis length (MAL), node number/groups of primary branches in the main axis (NN), number of total grains per panicle (NGT), number of primary branches (NPB), number of secondary branches (NSB), primary branches length (PBL), secondary branches length (SBL), number of grains per primary branches (NGPB), number of grains in the tip of primary branches (PBtip), number of grains per secondary branches (NGSB), total length of primary branches (TLPB), total length of secondary branches (TLSB), number of secondary branches per primary branches (SBperPB), total grains in the secondary branches per panicle (TNGSB), and total of filled grains per panicle (TFG) were descriptively analyzed and followed by Agglomerative Hierarchical Clustering (AHC) and Principal Component Analysis (PCA). The R version 4.0.5 was used as statistical software to do statistical analysis.

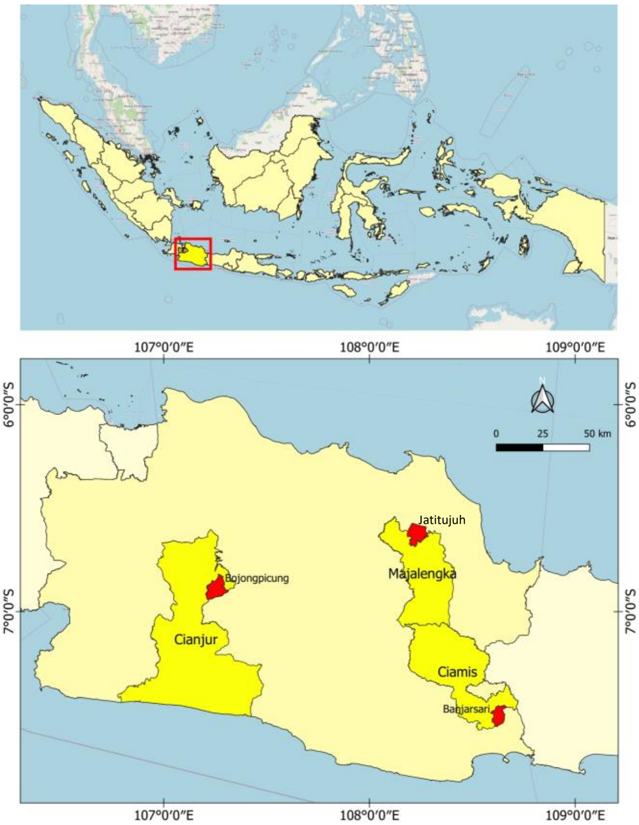

Figure 1. Location of farmer's field of rice varieties was collected from West Java, Indonesia, i.e. Bojongpicung (Cianjur), Jatitujuh (Majalengka) and Banjarsari (Ciamis)

Table 1. Rice varieties and agronomical practices which were collected from farmer's rice field

Varieties	Sites	Planting system
Inpari IR Nutri Zinc	Cianjur	Legowo 4, without biopesticide
Inpari IR Nutri Zinc	Cianjur	Legowo 2, with biopesticide
Inpari IR Nutri Zinc	Cianjur	Legowo 2, without biopesticide
Inpari IR Nutri Zinc	Majalengka	Legowo 2, with biopesticide
Mantap	Majalengka	Legowo 2, without biopesticide
Inpari 45	Majalengka	Legowo 2, with biopesticide
Pamelen	Majalengka	Legowo 2, without biopesticide
Inpari 32	Majalengka	Legowo 2, without biopesticide
Inpari IR Nutri Zinc	Majalengka	Legowo 2, without biopesticide
Inpari 45	Majalengka	Legowo 2, without biopesticide
Cakrabuana	Cianjur	Legowo 2, without biopesticide
Ciherang	Ciamis	Legowo 2, without biopesticide
IR 64	Ciamis	Legowo 2, without biopesticide
Padjadjaran	Cianjur	Legowo 5, with biopesticide
Cakrabuana	Cianjur	Legowo 2, with biopesticide
Inpari 42	Ciamis	Legowo 2, without biopesticide
Cakrabuana	Ciamis	Legowo 2, without biopesticide
Siliwangi	Ciamis	Legowo 2, without biopesticide
Inpari IR Nutri Zinc	Ciamis	Legowo 2, without biopesticide
Mawar	Ciamis	Legowo 2, without biopesticide
Padjadjaran	Ciamis	Legowo 2, without biopesticide
Inpari 32	Ciamis	Legowo 2, without biopesticide

RESULTS AND DISCUSSION

The average of the panicle branching characters observed is presented in Table 2. The range of coefficient of variation (CV) was 5.91-22.26. As the CV is the ratio of standard variation to the mean, greater CV means greater dispersion around the mean. CV is also used to measure and compare quantitative characters' variation (Pélabon et al. 2020). The panicle branching characters, such as the total length of secondary panicle branches and total grains in the secondary panicle branches, had the highest value of CV (>20%). It was predicted that total length of secondary panicle branches and total grains in the secondary panicle branches were affected by the number of secondary panicle branches and the length of secondary panicle branches. The results also showed that the angle of TLSB vs. NSB and TLSB vs. SBL was < 90^o (Figure 3), indicating that there was a correlation to each other.

The 22 rice varieties were grouped into two main clusters with sub-clusters (Figure 2). Of these, mawar, a local rice variety derived from Ciamis showed different performance in panicle branching characters (Mawar, legowo 2, without biopesticide) and no others rice varieties were grouped in the same group with Mawar. Mawar had the longest panicle, primary branch, the total length of primary branches, the greatest number of grains on the tip of the primary branch, and the number of grains on the secondary branch. These panicle characters of Mawar were in line with previous local rice observation that the most local rice varieties had long panicles (Perdhana et al. 2021). The sub-clusters of varieties were presented in Table 3, and the value of the panicle branching characters observed was presented in Table 4.

This study showed that Padjadjaran and Inpari 45 were not grouped into more than one group, while Inpari 32, Cakrabuana, and Inpari IR Nutri Zinc were do. Inpari 32, planted at different sites, showed the difference in panicle branching performance and belonged to the first and fourth clusters. Cakrabuana and Inpari IR Nutri Zinc were clustered into the third and fourth clusters due to the difference in both planting sites and agronomical practices. Thus, it is predicted that Padjadjaran and Inpari 45 were stable genotypes on their panicle branching characters. A stable genotype has the performance of a constant character irrespective of environmental conditions changing. Moreover, the stable genotype is the one that has a low contribution in the interaction with the environment (Fasahat et al. 2015).

Biplot analysis informed that the first dimension explains 49.8% of the total variation, while the second one explains 27.4% of the total variation. This biplot could explain 77.2% of the total variation (Figure 3). PCA Biplot gave the information about the similarity of genotypes, variance, mean and correlation among panicle branching characters. The similarity of characters was shown by the adjacency of the similar objects. The vector length showed the variance of the characters observed. The longer vector, the higher the variation. Correlation among characters was shown by the angle of the vector. When the angle <90^o, that means there was a correlation, but while the angle = 90^o, there was no correlation between the two characters. The negative correlation was shown by the angle was >90^o. The mean of characters was shown by its position relative to the vector arrow. When the value was above the mean value, it would be laid in the same direction as the vector. While the value was below the mean value, it would be laid in the opposite direction with the vector. The treatment similarity was shown by its proximity on the biplot (Kohler and Luniak 2005). Ramburan et al. (2012) said that the proximity of environments on the biplots was an indication of their similarity, and the treatments in this trial were equivalent to the environments on the Ramburan's research. This similarity also presented in the grouping of treatments by using dendrogram.

Table 2. Data of panicle branching characters observed from all varieties and planting sites

Characters	Mean±Stdev	CV (%)	Minimum	Maximum	Median
PL	25.22±1.91	7.57	22.15	29.45	25.35
MAL	16.21±2.42	14.92	13.15	22.55	16.14
NN	8.38±0.84	10.02	6.47	9.67	8.47
NGT	152.21±21.41	13.79	111.60	191.73	157.53
NPB	10.47±1.19	11.34	8.07	12.40	10.87
NSB	28.23±4.71	16.69	17.60	35.60	29.50
PBL	11.39±1.16	10.19	8.84	14.25	11.24
SBL	3.04±0.38	12.55	2.47	3.70	2.89
NGPB	14.83±2.04	13.77	11.02	19.57	14.51
Pbtip	5.78±0.34	5.91	5.21	6.79	5.80
NGSB	3.30±0.22	6.53	2.95	3.68	3.25
TLPB	119.05±15.15	12.73	92.10	152.06	120.63
TLSB	86.97±19.36	22.26	47.57	115.72	89.16
SbperPB	2.73±0.47	17.17	1.72	3.85	2.45
TNGSB	94.48±18.44	19.52	54.47	125.13	97.17
TFG	136.88±18.12	13.24	94.07	165.27	140.50

Note: PL: panicle length; MAL: main axis length; NN: node number; NGT: number of total grains per panicle; NPB: number of primary branches; NSB: number of secondary branches; PBL: primary branches length; SBL: secondary branches length; NGPB: number of grains per primary branches; Pbtip: number of grains in the tip of primary branches; NGSB: number of grains per secondary branches; TLPB: total length of primary branches; TLSB: total length of secondary branches; SbperPB: number of secondary branches per primary branches; TNGSB: total grains in the secondary branches per panicle; TFG: total of filled grains per panicle; CV: coefficient of variation

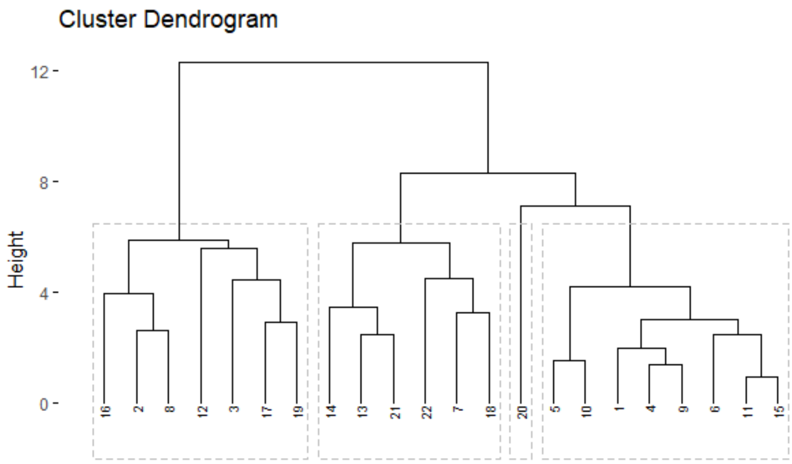

Figure 2. Dendrogram of rice genotypes constructed from the 22 planting sites and agronomical practices based on panicle branching characters

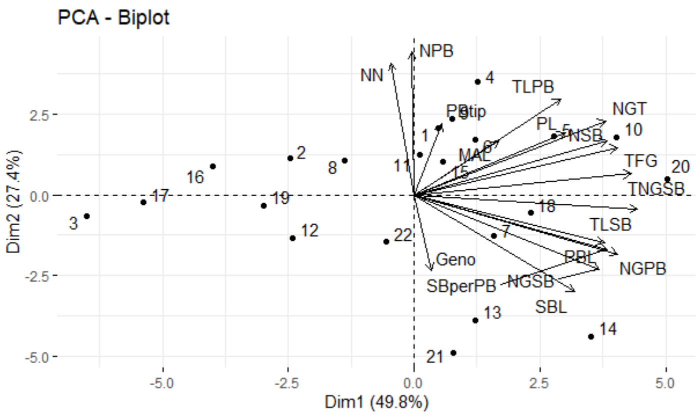

Figure 3. PCA Biplot of rice panicle branching was planted at various planting sites and agronomical practices

Table 3. Sub clusters of 22 varieties were planted at various planting sites and agronomical practices based on panicle branching characters

Cluster	No.	Varieties	Sites	Agronomical practices
1	20	Mawar	Ciamis	Legowo 2, without biopesticide
2	7	Pamelen	Majalengka	Legowo 2, without biopesticide
	18	Siliwangi	Ciamis	Legowo 2, without biopesticide
	14	Padjadjaran	Cianjur	Legowo 5, with biopesticide
	13	IR 64	Ciamis	Legowo 2, without biopesticide
	21	Padjadjaran	Ciamis	Legowo 2, without biopesticide
	22	Inpari 32	Ciamis	Legowo 2, without biopesticide
3	6	Inpari 45	Majalengka	Legowo 2, with biopesticide
	5	Mantap	Majalengka	Legowo 2, without biopesticide
	10	Inpari 45	Majalengka	Legowo 2, without biopesticide
	11	Cakrabuana	Cianjur	Legowo 2, without biopesticide
	15	Cakrabuana	Cianjur	Legowo 2, with biopesticide
	1	Inpari IR Nutri Zinc	Cianjur	Legowo 4, without biopesticide
	4	Inpari IR Nutri Zinc	Majalengka	Legowo 2, with biopesticide
	9	Inpari IR Nutri Zinc	Majalengka	Legowo 2, without biopesticide
4	12	Ciherang	Ciamis	Legowo 2, without biopesticide
	3	Inpari IR Nutri Zinc	Cianjur	Legowo 2, without biopesticide
	19	Inpari IR Nutri Zinc	Ciamis	Legowo 2, without biopesticide
	17	Cakrabuana	Ciamis	Legowo 2, without biopesticide
	8	Inpari 32	Majalengka	Legowo 2, without biopesticide
	16	Inpari 42	Ciamis	Legowo 2, without biopesticide
	2	Inpari IR Nutri Zinc	Cianjur	Legowo 2, with biopesticide

Table 4. Value of panicle branching characters of varieties was planted at various planting sites and agronomical practices

CS	No	PL	MAL	NN	NGT	NPB	NSB	PBL	SBL	NGPB	PB tip	NGSB	TLPB	TLSB	SB per PB	TNG SB	TFG
1	20	29.45	18.95	7.80	182.27	10.67	29.67	14.25	3.68	17.09	6.79	3.68	152.06	110.31	2.79	110.00	165.27
2	7	25.07	16.95	8.20	154.20	9.53	30.20	12.22	3.38	16.00	5.22	3.37	116.67	102.31	3.13	103.80	145.67
	18	26.94	16.49	8.33	164.20	10.13	29.33	12.66	3.38	16.14	5.95	3.53	128.49	99.49	2.86	104.07	146.07
	14	23.94	13.27	6.87	160.20	8.27	31.53	12.59	3.65	19.57	5.27	3.67	104.00	115.72	3.85	117.00	148.47
	13	24.95	14.89	7.47	139.67	8.40	25.80	12.85	3.70	16.68	5.21	3.67	107.95	94.82	3.11	95.47	131.00
	21	23.65	13.69	6.47	137.73	8.07	27.20	12.25	3.67	17.01	5.43	3.48	98.90	101.12	3.30	94.07	126.40
	22	22.15	13.55	7.93	153.60	10.07	26.80	11.18	3.10	15.20	6.04	3.38	112.88	84.39	2.70	93.13	137.33
3	6	27.61	19.51	9.07	169.20	11.07	31.87	11.04	2.99	15.08	5.76	3.26	123.17	97.43	2.84	105.13	137.07
	5	27.21	18.61	9.00	182.60	11.20	33.93	11.48	3.07	16.24	5.91	3.39	128.63	105.25	3.02	116.67	152.53
	10	27.23	19.55	9.07	191.73	11.20	35.60	11.70	3.11	17.03	5.92	3.46	131.23	112.47	3.20	125.13	164.13
	11	26.22	16.56	8.40	161.53	11.47	30.13	11.07	2.87	13.85	5.82	3.27	128.17	87.43	2.68	95.00	138.13
	15	26.28	16.21	8.47	164.27	11.27	30.07	11.51	2.89	14.48	5.79	3.24	130.38	88.30	2.73	98.87	142.87
	1	25.93	16.12	8.80	169.93	11.60	31.80	11.08	2.75	14.45	5.71	3.22	129.21	88.41	2.72	103.67	143.53
	4	26.29	16.75	9.67	179.53	12.40	34.00	11.31	2.73	14.34	5.82	3.11	140.43	93.35	2.77	107.20	156.07
	9	25.76	16.17	9.53	169.73	11.67	32.40	11.37	2.77	14.54	5.81	3.15	132.87	89.92	2.79	102.47	151.53
4	12	23.78	22.55	7.40	128.80	9.20	23.47	11.01	2.88	13.91	5.74	3.19	101.57	67.56	2.54	75.73	113.20
	3	22.73	13.15	8.47	111.60	9.73	18.73	9.44	2.55	11.41	5.65	2.96	92.10	48.27	1.98	56.47	94.07
	19	25.63	15.45	8.67	130.13	10.13	23.07	10.85	2.90	12.83	5.82	3.07	110.20	67.23	2.29	71.53	117.07
	17	24.57	15.10	7.87	117.87	10.60	17.60	10.24	2.67	11.02	6.02	3.05	108.60	47.57	1.72	54.47	110.13
	8	22.80	14.33	8.67	154.87	11.27	26.20	11.01	2.88	13.78	6.17	3.18	123.93	76.49	2.40	85.27	145.00
	16	22.24	13.61	9.60	144.47	11.20	25.40	8.84	2.47	12.64	5.60	3.07	99.53	64.05	2.18	80.87	127.60
	2	24.48	15.22	8.67	146.53	11.20	26.20	10.53	2.70	13.03	5.70	3.11	118.08	71.46	2.37	82.53	118.33

Note: CS: Cluster; PL: panicle length; MAL: main axis length; NN: node number; NGT: number of total grains per panicle; NPB: number of primary branches; NSB: number of secondary branches; PBL: primary branches length; SBL: secondary branches length; NGPB: number of grains per primary branches; PBtip: number of grains in the tip of primary branches; NGSB: number of grains per secondary branches; TLPB: total length of primary branches; TLSB: total length of secondary branches; SBperPB: number of secondary branches per primary branches; TNGSB: total grains in the secondary branches per panicle; TFG: total of filled grains per panicle

According to Zhai et al. (2020), the potential yield of rice is determined by the balance of source capacity, sink strength, and flow fluency. Wang et al. (2019) also confirmed that the yield of rice was determined by the source, sink and relationship of both. As the yield was presented by NGT as the most important trait, the other characters which had a positive and significant correlation with yield were very important characters (Yan and Frégeau-Reid 2018). There were ten characters that showed a positive and significant correlation with the number of total grains per panicle (Table 5). The ten characters were panicle length, number of primary branches, number of secondary branches, primary branches length, number of grain on primary branches, total length of primary branches, total length of secondary branches, number of secondary branches per primary branches, total of grain number on secondary branches, and total of filled-grain per panicle. These ten characteristics were sunk strength, because these tissues absorb and utilize photosynthesis and spikelets were major of primary sink in rice (Li et al. 2018). Moreover, Shahruddin et al. (2014) declared that rice yield could be increased by increasing the number of grains in the panicle. The compact rice panicle type resulted in an increase in yield potential of 8-20% in comparison with the light one. On the other hand, the performance of plant was affected by genotype, environment and the interaction of genotype × environment (G × E). Plant spacing is one of the plant environment factors affecting plant height and the number of filled grains (Akondo and Hossain 2019). It is predicted that wider spacing resulted in better plant photosynthetic ability and soil nutrients more accessible and available. On the contrary, Anwari et al. (2019) reported that plant spacing had no effect on the character of panicle length. Still, the leaf color of the 25×25 cm plant space showed the maximum leaf greenness (chlorophyll content) other than the narrower one. As a result, wider spacing provided net photosynthesis assimilates because of the larger leaf area. In the narrow spacing, competition among plants to absorb sunlight and nutrient is predicted to cause the decrease of chlorophyll content.

Table 5. Correlation among panicle branching characters of varieties was planted at various planting sites and agronomical practices

	PL	**MAL**	**NN**	**NGT**	**NPB**	**NSB**	**PBL**	**SBL**	**NGPB**	**PBtip**	**NGSB**	**TLPB**	**TLSB**	**SBperPB**	**TNGSB**
MAL	**0.623**														
	0.002														
NN	0.223	0.151													
	0.297	0.502													
NGT	**0.679**	0.405	0.397												
	0.001	0.061	0.067												
NPB	0.364	0.227	**0.870**	**0.509**											
	0.096	0.311	**0.000**	**0.016**											
NSB	**0.583**	0.363	0.323	**0.924**	**0.361**										
	0.004	0.097	0.143	**0.000**	**0.099**										
PBL	**0.561**	0.258	**-0.471**	**0.468**	-0.340	**0.449**									
	0.007	0.246	**0.027**	**0.028**	0.122	**0.036**									
SBL	0.273	0.040	**-0.682**	0.225	**-0.660**	0.275	**0.893**								
	0.218	0.861	**0.000**	0.313	**0.001**	0.215	**0.000**								
NGPB	0.342	0.148	-0.414	**0.572**	-0.409	**0.655**	**0.814**	**0.863**							
	0.120	0.510	0.056	**0.005**	0.059	**0.001**	**0.000**	**0.000**							
PBtip	0.412	0.304	0.224	0.324	**0.498**	0.020	0.150	-0.121	-0.150						
	0.057	0.170	0.316	0.141	**0.018**	0.929	0.505	0.591	0.504						
NGSB	0.353	0.111	**-0.546**	0.429	**-0.493**	0.437	**0.878**	**0.939**	**0.919**	-0.027					
	0.108	0.624	**0.009**	0.046	**0.020**	0.042	**0.000**	**0.000**	**0.000**	0.904					
TLPB	**0.797**	0.442	0.434	**0.837**	**0.664**	**0.679**	**0.474**	0.084	0.248	**0.609**	0.224				
	0.000	0.039	0.044	**0.000**	**0.001**	**0.001**	**0.026**	0.710	0265	**0.003**	0.315				
TLSB	**0.562**	0.275	-0.147	**0.789**	-0.106	**0.850**	**0.792**	**0.735**	**0.934**	-0.034	**0.820**	**0.517**			
	0.006	0.215	0.513	**0.000**	0.639	**0.000**	**0.000**	**0.000**	**0.000**	0.882	**0.000**	**0.014**			
SBperPB	0.279	0.125	-0.351	**0.552**	-0.380	**0.716**	**0.703**	**0.764**	**0.957**	-0.352	**0.803**	0.185	**0.918**		
	0.208	0.578	0.109	**0.008**	0.081	**0.000**	**0.000**	**0.000**	**0.000**	0.109	**0.000**	0.409	**0.000**		
TNGSB	**0.579**	0.330	0.103	**0.912**	0.137	**0.954**	**0.634**	**0.518**	**0.834**	0.015	**0.676**	**0.616**	**0.955**	**0.839**	
	0.005	0.133	0.647	**0.000**	0.545	**0.000**	**0.002**	**0.014**	**0.000**	0.946	**0.001**	**0.002**	**0.000**	**0.000**	
TFG	**0.600**	0.301	0.237	**0.943**	**0.346**	**0.883**	**0.618**	0.401	**0. 676**	0.298	**0.564**	**0.799**	**0.841**	**0628**	**0.908**
	0.003	0173	0.287	**0.000**	**0.114**	**0.114**	**0.002**	0.064	**0.001**	0.178	**0.006**	**0.000**	**0.000**	**0.002**	**0.000**

Bold letter: significant correlation; PL: panicle length; MAL: main axis length; NN: node number; NGT: number of total grains per panicle; NPB: number of primary branches; NSB: number of secondary branches; PBL: primary branches length; SBL: secondary branches length; NGPB: number of grains per primary branches; PBtip: number of grains in the tip of primary branches; NGSB: number of grains per secondary branches; TLPB: total length of primary branches; TLSB: total length of secondary branches; SBperPB: number of secondary branches per primary branches; TNGSB: total grains in the secondary branches per panicle; TFG: total of filled grains per panicle

Budiono et al. (2019) reported that fertilizer also affected panicle length and the number of filled grains. The N fertilizer had an important role in panicle formation. It was stated that panicle length was one of the characteristics affected more by the environment because of its moderate heritability. Zhou et al. (2017) revealed that optimized nitrogen management had an increased number of secondary panicle branches (increased by 20.5% compared with traditional application) and spikelet (6.8-20.2 %), panicle length, and the number of vascular bundles in the panicle neck internode. Previous studies had shown that N application at the stage of young panicle differentiation could increase spikelet number. This could be explained that the number of the small and large vascular bundles was significantly greater after N application. As a result, transportation of nutrients, water and assimilates during the grain filling stage went well (Kamiji et al. 2011). In line with Zhou et al. (2017) statement, Ding et al. (2014) reported that applying nitrogen fertilizer before the panicle initiation stage could increase the flower number of rice. It was predicted that cytokinin (CKs) was the mediator in the relationship between N fertilizer and panicle branching. Not only in the phenotypic performance, but the interaction also occurs between QTL and environment. This interaction affected plant growth and development, including grain yield and yield-related traits such as panicle number (Wang et al. 2019).

The effect of biopesticide on rice growth has been reported by Kamarulzaman et al. (2016). The use of biopesticide had a positive effect on plant height, the number of tillers per plant, productive spikelets per plant (%), 100 grains weight, and grain yield per plant (g). Although primarily used to control pathogens, insects or other organisms, which had a devastating effect on plant growth, biopesticide could improve the productivity of rice through a physiological process (Yusof et al. 2018). Yusof et al. (2018) confirmed Kamarulzaman's report that biopesticide positively affected plant height, number of tillers, leaves width, number of leaves, and rice yield. The CKs content in the biopesticide was predicted to be a cause of the positive effect that occurred on panicle branching. Ding et al. (2014) reported that in the N fertilizer condition, CKs content was detected in the leaves and panicles. CKs content was higher in the panicles than those in the leaves. While another growth regulator content in the biopesticide, auxin (IAA) was reported could promote rice grain filling. The level of IAA is associated with grain development, particularly in the grain filling stage (Deng et al. 2021). According to Kwon and Paek (2016), Gibberellic Acid (GA) also had a positive effect on the rice grain, particularly playing an important role in spikelet fertility. In common, GA played a role in germination, growth of stem and root, cell division and flowering time.

To conclude, panicle branching characters were affected by genotype (G), environment (E), and interaction between G and E. Genotypes that were stable when grown at the various sites and did not show change significantly. i.e Padjadjaran and Inpari 45. However, some genotypes constantly change when grown at a different site and planting systems. Correlation occurred among panicle branching characters. Ten characters showed a positive and significant correlation with total grains per panicle. Planting space, fertilizer and biopesticide affected the panicle branching.

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