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Agronomic Characters Diversity of Pokem (*Setaria italica* L. Beauv) Accessions from Numfor Island, Papua, Indonesia

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Abstract*—Foxtail millet (*Setaria italica* L. Beauv) or Jewawut, or expressly by the Papuan people as Papuan wheat or referred to as "Pokem" (*Setaria italica* L. Beauv). This is an endemic plant frequently found on Numfor Island, a part of Biak-Numfor Regency. The high potential and benefits of pokem present an opportunity to produce new varieties via plant breeding initiatives based on the diversity of pokem accessions from Numfor Island regarding superior accessions and germplasm conservation. The classification grouping can be determined based on the diversity of plant accessions. Based on the physical traits of pokem plant accessions, this study aims to discover and quantify their genetic diversity. The study was conducted at the Experimental Garden of the University of Papua's School of Agriculture in Amban Manokwari using pokem seeds collected from already-cultivated regions. This study utilized a Randomized Block Design (RBD) consisting of 15 pokem plant accessions with 4 (four) replications and 60 experimental units. On eleven agronomic characteristics, kinship observations were made. Using PCA, cluster, and biplot analyses, genetic distance was determined. The position of the panicle on the stem, leaf length, flag leaf width, stem length, stem diameter, panicle length, grain color, flowering duration, and number of long internodes all contribute to the 74.285% total diversity. The two pokem accessions from Numfor island with the highest genetic similarity are Kameri 2 (KM2) and Kansai 2 (KN2), but Kameri 1 (KM1) and Rimba Raya 3 (RR3) are genetically distant. It may serve as the parental cross. Stem and leaf lengths exhibited the most variability based on biplot results, while Kameri 1 (KM1) and Rimba Raya 3 (RR3) accessions exhibited the largest diversity based on agronomic parameters.

***Keywords*— Pokem; *Setaria italica*; diversity; numfor island; agronomic characters.**

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I. INTRODUCTION

The total population of Indonesia in 2010 was 237.6 million people, which has continued to increase to 270.2 million people (an increase of 32.56 million people) in 2020 [1]. The increase in population must also be balanced with the availability of food to overcome possible food shortages at any time. One of the efforts to overcome the issue is using local food as an alternative. Utilizing local food as an alternative food can increase food diversification and reduce people's dependence on rice or other imported food. One of the local foods could be used as an alternative food is pokem.

Foxtail millet (*Setaria italica* L. Beauv) or Jawawut or known explicitly by the Papuan people as Papuan wheat or referred to as "Pokem" (*Setaria italica* L. Beauv) is an endemic plant often found on Numfor Island as part of Biak-Numfor Regency. The islanders of Numfor have known and consumed the plant since the Dutch colonial era, not only as an alternative staple food but also to substitute taro, *petatas* (sweet potato), cassava, green beans, sago, aibon (mangrove fruit) and paddy [2], [3], [4]. This plant is also a functional food for health, especially for disadvantaged community groups, such as pregnant women, infants, and ill people [2]. In addition, according to Ref. [5], pokem can be used as a substitute for corn as poultry feed.

Domestication and cultivation of *S. italica* plants have been practiced for 4,000 years ago [6], while [7], [8] estimated that it was thousands of years earlier and was then widely cultivated in India, Nigeria, Japan, and Australia [9]. As its essential, it is one of prominent plants widely grown in China, and [10] stated that its greatest diversity was found in East Asia Countries, such as China, Korea, and Japan, based on rDNA analysis through PCR-RPLF.

Pokem is classified as an annual plant growing in clumps with a height of 60-150 cm [11]. The harvest age is 75-90 days after planting, depending on the soil type and the

environment. The best planting time is July to mid-August in tropical climates [12]. According to Ref. [11], the types of pokem widely cultivated are: *Setaria italica* (L) Beauv., *Setaria italica* (Var.) Metzgeri, and *Setaria italica* (Var.) Stramiofructa. Among the millet varieties, the most abundant type is pearl millet (*Pennisetum glaucum*), accounting for about 40% of worldwide production spread across all production sites, followed by foxtail millet (*Setaria italica*), or white millet (*Panicum miliaceum*) and finger millet (*Eleusine coracana*) [13]. Based on the comparative morphology of foxtail millet accessions, [14] identified three races: (1). moharian race from Europe, Southeast Asia, Afghanistan, and Pakistan; (2). The maxima race is common in eastern China, Georgia (Eurasia), Japan, Korea, Nepal, and North India; and (3) the indica race, found in other parts of India and Sri Lanka. A new classification system recognizes four breeds: maxima, moharia, indica, and nana of foxtail millet [15].

The relationship between plant accessions can be used to determine the grouping in the classification. Character diversity data and specific morphology can also be used for cultivation, specifically in selecting crosses and seeds [16]. Information on kinship relationships is essential for producing superior varieties. The farther the genetic distance between the parents, the more excellent the opportunity to produce new accessions with broad genetic variables. Crosses between closely related parents often lead to narrow diversity. Therefore, plant kinship plays an important role in classification purposes and can also be used in other fields, such as plant breeding for the search and preservation of alternative food sources [17], [18].

Previous reports revealed that the diversity of pokem accessions on Numfor Island has still not been identified. According to Biak Numfor people in [2], [19], five varieties were found in this area, namely chocolate (vesyek), red (verik), white (vepyoper), black (vepaisem), and yellow (venanyar) pokem. However, the varieties cultivated by the community and can still be found include the black, red, and yellow variants [20]. This shows that identifying the diversity of its accessions based on agronomic characters must be carried out to create superior accessions and conserve germplasm. Therefore, this study aims to identify and determine the diversity of pokem accessions from Numfor Island, Papua, based on their agronomic characteristic.

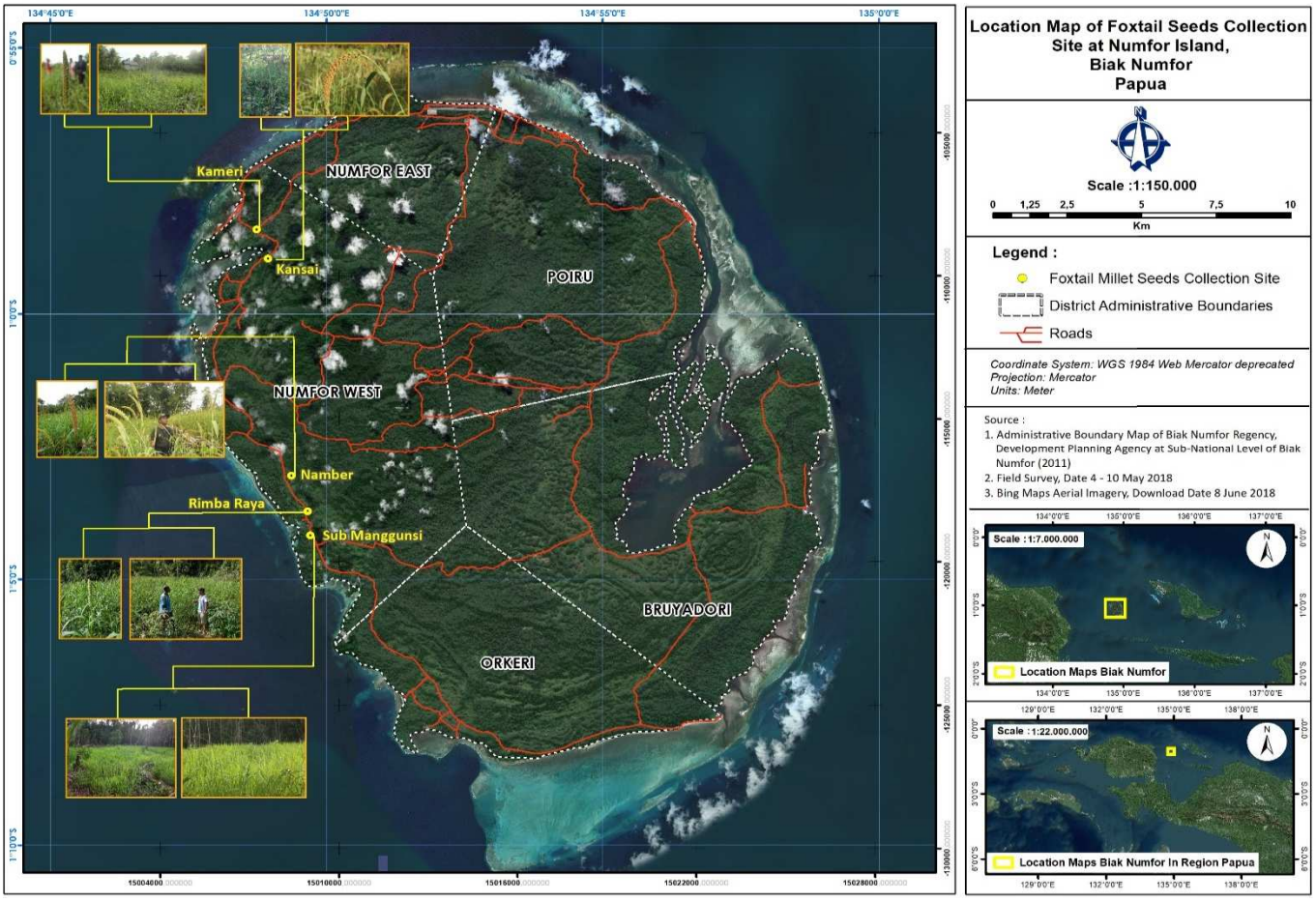

Fig. 1 Map of sampling locations

II. Materials and Method

The five-month research was conducted in the Faculty of Agriculture, University of Papua's experimental garden in Amban Manokwari from August to December 2018. The materials used in this study were pokem seeds taken from villages still cultivating pokem plants, namely the villages of Kameri, Kansai, Namber, Rimba Raya and Sub Manggunsi (Figure 1). This study used a Randomized Block Design (RBD) consisting of 15 pokem accessions with 4 (four) replications to obtain 60 experimental units. Kinship relations

were observed based on 11 agronomic characters, namely: 1). The position of the panicle on the stem; 2) Grain color; 3) Flowering time; 4) Leaf length; 5) Flag leaf width; 6) stem length; 7) stem diameter; 8) the number of long segments; 9) Flower stalk length; 10) panicle length; and 11) 1000 grain weight. The agronomic characters were identified using [21] and the International Union for the Protection of New Varieties of Plants [22] foxtail millet guide.

PCA analysis was conducted to determine the agronomic characters contributing to diversity using the SPSS IBM 20 application. Grouping and genetic distance with cluster analysis were used to analyze the similarity based on the characters. Furthermore, grouping based on morphological similarity was analyzed using the UPGMA (Unweighted Pair Group Method with Arithmetic Means) with the Simqual function through the NTSYSpc2.1 program [23]. The results are then presented as a dendrogram with the distance correlation coefficient in the form of percentage dissimilarities. Biplot analysis was used to analyze the character relationships with the SAS 9.1.3 application.

III. Results and Discussion

A. PCA (Principal Component Analysis) 15 Pokem Accessions

PCA (Principal Component Analysis) identifies the characteristics contributing to genetic diversity. This analysis used the Eigenvalue to determine the percentage of variables affecting pokem accessions from Numfor Island. At the same time, the loading factor in PCA explains the contribution of the important variables. Therefore, PCA was used to assess the diversity of 11 agronomic characters from 15 pokem accessions in Numfor Island. From the results, the first three main components had an eigenvalue range of 1.344 - 4.935 with a cumulative diversity of 74.285%. The eigenvalue > 1.0 indicates that genetic influence significantly contributes to the variation of plant characters [24].

TABLE I
THE EIGENVALUE OF POKEM AGRONOMIC CHARACTER FROM NUMFOR ISLAND

PCi	Eigenvalues	Variance (%)	Cumulative (%)
1	**4.935**	44.864	44.864
2	**1.893**	17.205	62.069
3	**1.344**	12.216	74.285
4	0.878	7.981	82.267
5	0.580	5.275	87.542
6	0.540	4.908	92.450
7	0.362	3.288	95.738
8	0.232	2.106	97.844
9	0.146	1.331	99.174
10	0.074	0.671	99.845
11	0.017	0.155	10.000

Description: numbers in bold indicate eigenvalues greater than 1.00

Table 1 shows each character's eigenvalues and variances, while Table 2 shows the loading factor value. Based on the table, the first three main components (principal component/PC) have an eigenvalue >1.0. The first three main components have ordered eigenvalues. The first (PC1), second (PC2), and third (PC3) components have eigenvalues of 4.935, 1.893, and 1.344, with variances of 44.864%, 17.205%, and 12.216%, respectively. Furthermore, the character contribution as the principal component value is presented in Table 2.

TABLE II
LOADING FACTOR VALUE OF 15 POKEM ACCESSIONS FROM NUMFOR ISLAND

Character	PC1	PC2	PC3
Position of the panicle on the stem	**0.793**	0.219	0.077
Grain color	0.098	**0.954**	0.056
Flowering time	0.016	**-0.896**	0.067
Leaf length	**0.904**	0.101	0.279
Flag leaf width	**0.759**	0.249	0.267
Stem length	**-0.653**	-0.135	0.484
Stem diameter	**0.818**	-0.076	0.131
Number of long segments	0.157	-0.001	**0.844**
Flower stalk length	0.397	0.436	0.421
Panicle length	**0.949**	0.005	0.098
1000 grain weight	**0.689**	-0.043	-0.353

Description: Numbers in bold have a contribution to diversity

The results showed 7, 2, and 1 influential character on PC1, PC2, and PC3, respectively. Characters that influence diversity in PC1 include panicle position on the stem, leaf length, flag leaf width, stem length, stem diameter, panicle length, and weight of 1000 grains, with a variation contribution of 44.864%. Furthermore, those influencing PC2 are grain color and flowering time, with a variation contribution value of 17.205%. The character on PC3 includes the number of long segments with a variation contribution value of 12.216%. Table 2 shows the correlation between the original component and the new component (principal component) formed by PCA, namely the loading value. The selected loading value must be above 0.5, which can explain the characters that influence the diversity of pokem plant accessions. Other variables with a value below 0.5 were considered to have little or no influence [25]. Characters contributed positively and negatively to the diversity of the pokem germplasm population in accession groupings. The positive values indicate that these characters influence the population grouping in the same group, while the negative values show that they affect the accession in a different group [26].

B. Analysis of the Similarity Level on 15 Pokem Accessions Based on Cluster Analysis

Based on the cluster analysis, the 15 pokem accessions from Numfor Island in Manokwari have a close similarity level based on quantitative data. This was indicated by the Euclidean distance of 0.03-0.13. From the dendrogram, there were 2 main clusters at a genetic distance of 0.13, as shown in Figure 2. The first cluster consisted of 2 accessions, including KM1 and SM1, while the second contains 13 accessions, namely KM2, KN2, RR1, KN1, NM2, SM2, RR2, NM1, KM3, SM3, KN3, NM3, and RR3. The analysis also showed that KM2 and KN2 have a small dissimilarity coefficient with a genetic distance of 0.03. This is because these accessions have similarities in the observed quantitative characters.

The greater the dissimilarity value, the smaller the similarity level between the individuals, and vice versa. The pokem accessions from Numfor Island cultivated ex-situ in

Manokwari with the greatest similarity include KM2 and KN2. They were in the same line or group with a dissimilarity coefficient of 0. Genotypes located on the same line tend to have low genetic diversity [27]. The accessions with large genetic diversity or distances can be used as the parent of the cross, namely KM1 and RR3 [28], [29].

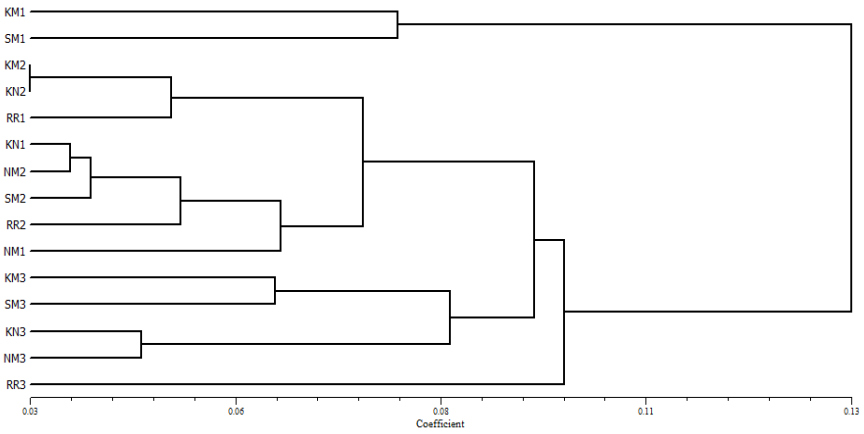

Fig. 2 Dendogram of kinship from 15 pokem accessions from Numfor Island based on 11 quantitative and qualitative characters. KM1=Kameri 1, KM2=Kameri 2, KM3=Kameri 3, KN1=Kansai 1, KN2=Kansai 2, KN3=Kansai 3, NM1=Namber 1. NM2=Namber 2, NM3=Namber 3, RR1=Rimba Raya 1, RR2=Rimba Raya 2, RR3=Rimba Raya 3, SM1=Sub Manggunsi 1, SM2=Sub Manggunsi 2, SM3=Sub Manggunsi 3

C. Biplot Analysis of Character Relationships on 15 Pokem Accessions

Biplot analysis can show the character contribution to the diversity through the size of the vector line from the origin. Furthermore, it was performed after the principal component analysis and can be used as a diversity selection tool to improve a variety [30].

Figure 3 shows the total diversity of 81.8% caused by the relationship between characters and accessions. Based on the biplot analysis, it can be seen that the observed pokem accessions differed based on the position of the panicle on the stem, grain color, leaf length, flag leaf width, stem length, number of long internodes, flower stalk length, and panicle length in quadrant I. Kansai 2 (KN2), Sub Manggunsi 1 (SM1), and Sub Manggunsi 3 (SM3) were the pokem accessions with the greatest variation in these characteristics (SM3).

Accessions with diversity based on stem length characters in quadrant II were Kameri 3 (KM3), Kansai 1 (KN1), Rimba Raya 1 (RR1), Rimba Raya 3 (RR3), and Sub Manggunsi 2 (SM2). Accessions having diversity based on the character of flowering time, 1000 grain weight and stem diameter in quadrant III were Namber 1 (NM1), Namber 2 (NM2), and Rimba Raya 2 (RR2), while accessions in quadrant IV did not show diversity based on the 11 observed characters which included accessions of Kameri 1 (KM1), Kameri 2 (KM2), Kansai 3 (KN3) and Namber 3 (NM3). This shows that the accessions in the same quadrant and close to the vector are accessions with similar characteristics and are superior based on certain characteristics.

The results of the biplot analysis showed that the character of stem length and leaf length contributed the greatest diversity of some pokem accessions from Numfor Island. Meanwhile, accessions RR3 and KM1 showed the greatest diversity based on agronomic characters because they were the farthest accessions from the origin (0).

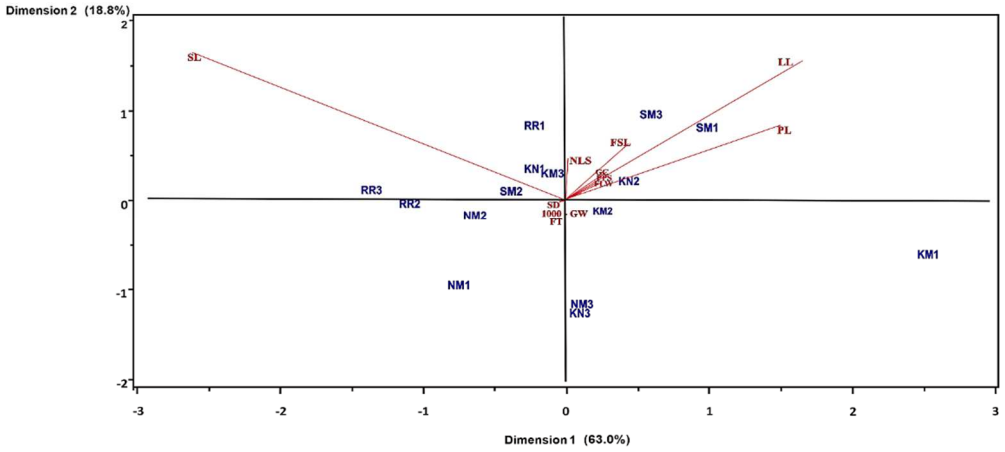

Fig. 3 Biplot of several pokem accessions from Numfor Island on Agronomic Characters. KM1=Kameri 1, KM2=Kameri 2, KM3=Kameri 3, KN1=Kansai 1, KN2=Kansai 2, KN3=Kansai 3, NM1=Namber 1. NM2=Namber 2, NM3=Namber 3, RR1=Rimba Raya 1, RR2=Rimba Raya 2, RR3=Rimba Raya 3, SM1=Sub Manggunsi 1, SM2=Sub Manggunsi 2, SM3=Sub Manggunsi 3, PPS=Position of the panicle on the stem, GC=Grain colour, FT=Flowering time, LL=Leaf length, FLW=Flag leaf width, SL=Stem length, SD=Stem diameter, NLS=Number of long segments, FSL=Flower stalk length, PL=Panicle length, 1000GW=1000 grain weight

IV. Conclusion

74.285% of the total diversity was contributed by characteristics such as the position of the panicle on the stem, leaf length, flag leaf width, stem length, stem diameter, panicle length, grain color, blooming time, and the number of long internodes. Two pokem accessions from Numfor Island share the most characteristics: Kameri (KM2) and Kansai 2 (KN2). In contrast, the accessions with the most significant genetic distance are Kameri 1 (KM1) and Rimba Raya 3 (RR3), which can be employed in plant breeding as parents. While stem length and leaf length had the most variability based on biplot data, accessions Kameri 1 (KM1) and Rimba Raya 3 (RR3) exhibited the largest diversity based on agronomic parameters.

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