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Research Article

Variations and Phenetic Analysis of Peanut Cultivars (*Arachis hypogaea* L.) Based on Morphological Characteristics

Purnomo[1]* and Nurul Khotimah[1]
1) Faculty of Biology, Universitas Gadjah Mada, Jl. Teknika Selatan, Sekip Utara, Yogyakarta, Indonesia, 55281

*Corresponding author, email: purnomods@ugm.ac.id

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ABSTRACT
Peanut (*Arachis hypogaea* L.) is a food commodity that is widely cultivated in Indonesia. At present there has been no analysis of the relationship between peanut cultivars with phenetic methods based on the morphological properties of the plants. Four cultivars of *Arachis hypogaea* L. Tuban, Talam 1, Talam 2, and Talam 3 used in this research. Morphological characters data was analyzed by description to construct identification key. Similarity index was counted by Simple Matching Coefficient (SSm) formula based on morphological scoring. Cluster analysis was conducted by UPGMA (Unweighted Pair Group Methods using Arithmetic Averages) method to construct dendrogram. PCA (Principal Component Analysis) were performed to defined role of each morphological character in grouping of accessions with MVSP (Multivariate Statistical Program) v. 3.1 software. The dendrogram showed that four cultivars of *Arachis hypogaea* L. divided into two main clusters, 4 sub-clusters. The similarity index of clusters is 0.85%.

INTRODUCTION
Peanut (*Arachis hypogaea* L.) is a food commodity that is widely cultivated in Indonesia. Demand for peanuts increases over time. According to Astawan (2009), peanuts have the highest economic value among the results of legumes. Peanuts occupy the second position after soybeans. Peanuts are in great demand, especially for the people of Indonesia as food because they have high nutritional value. At every 100 grams of peanuts contains 2 grams of food fiber which means it has fulfilled 10% of the food fiber needs every day. Besides that it also contains vegetable protein and high fat.

According to Sumarno (1991), there are three types of peanuts, namely the Spanish, Valencia and Virginia types. In 1864 it was grouped based on the difference in the size of the pod by Van der Srok. Until now the number of peanut varieties according to the Agricultural Research and Development Center for Food Crop Research and Development (*Balitbang Pertanian*) (2009) there are around 30 superior varieties of peanuts in Indonesia. Cultivars that are widely grown in Indonesia include Tuban, Talam 1, Talam 2, and Talam3. In Indonesia, the phenetic relationship between cultivars has been studied using molecular methods by comparing the DNA sequences of each cultivar. According to Yuliani (2017), analysis of peanut cultivar DNA sequences was carried out to improve the genetic quality of plants through plant breeding. At present there has been no analysis of the relationship between peanut cultivars (*Arachis hypogaea* L.) with phenetic methods based on the morphological properties of the plants.

Phenetic relationship analysis begins with morphological characterization. Morphological characterization aims to simplify the object of study to find uniformity and diversity of plants.

Characterization is done by making a description of all parts of the plant organ so that various characters will appear. Diverse characters can be selected according to the desire to be used as parents in crossing plants. Character selection can determine the chance of success in plant breeding programs.

MATERIALS AND METHODS

Four cultivars of *Arachis hypogaea* L. Tuban, Talam 1, Talam 2, and Talam 3 used in this research. Sample accession was obtained from BALITKABI (Plant Research For Various Nuts And Tubers), Malang.

Observation has been conducted on April until June 2018. The research was carried out on agricultural land in Temuwangi, Pedan, Klaten. Soil planting groundnut is a type of semi clay soil. Abiotic conditions of cultivated land obtained soil moisture with wet + category, soil pH 6, air temperature 34.5°C, and low light intensity. Selected seeds with good conditions for each cultivar. Seven individuals were taken for each peanut cultivar. Then, reversing the soil by plowing or hoeing so that the soil becomes loose and rich in oxygen. The next stage is fertilization with organic fertilizer. Planting peanuts seeds of various cultivars with each of the 7 individuals on the prepared soil. Planting is done in a closed greenhouse to stabilize environmental factors and avoid pest damage. Check environmental parameters. Peanut plants were observed by seeing and describing each plant organ, such as early plant vigor, life form, growth habit, number of branches, branching pattern, height of main stem, plant width or spread, stem pigmentation, stem surface, days to 50% flowering, inflorescence type, leaf color, leaflet margin, leaflet shape, leaflet tip, petal color, plant height, peg pigmentation, pod length, pod width, pod beak, pod constriction, pod reticulation, days to maturity, primary seed color, secondary seed color, number of seeds per pod, pod yield per plant, and 100 seed weight.

Data analysis

Morphological data were analyzed by description for characterization to construct identification key. Similarity index was counted by Simple Matching Coefficient (SSm). Cluster analysis was conducted by UPGMA (Unweighted Pair Group Methods using Arithmetic Averages) analysis to create a dendrogram with MVSP (Multivariate Statistical Program) v.3.1 software. PCA (Principal Component Analysis) was also performed to defined role of each morphological character in the grouping accessions.

RESULTS AND DISCUSSION

The morphological characterization is the first step in the description and classification of germplasm. It is a traditional way that used to highlight differences among cultivars. Plant breeders also can use genetic similarity information to complement phenotypic information (Ammar et al., 2014).

Based on observation on four cultivars of *Arachis hypogaea* L. Tuban, Talam 1, Talam 2, and Talam 3 known have many diversities. In root organ, has taproot and is a seasonal herb (annual), which shows the entire life cycle of the seed and then flowering until it returns to produce seeds in one season. The difference is seen in the root length. Tuban cultivars show that their roots can penetrate the soil with an average depth of 5-13 cm, have a nodule at the root with a moderate level density distributed on the lateral roots than the main roots (Fig. 1.a). Talam 1 peanut cultivars have roots that can penetrate the soil with an average depth of 7-15 cm, has a nodule at the root with medium density spread on the lateral roots than the main root (Fig. 1.b). Talam 2 peanut cultivars have roots that can penetrate the soil with an average depth of 3-12 cm, has a nodule at the root with medium density (Fig. 1.c). Talam 3 cultivars have roots that can penetrate the soil with an average depth of 9-15 cm, has nodules spread on the lateral roots (Fig. 1.d).

Figure 1. a. roots and pods of Tuban cultivars, b. Roots and pods of Talam 1 cultivars, c. Roots and peanuts cultivars Talam 2, and d. roots and peanut Talam 3

Nodules are typical structures of Legum to respond to Rhizobium symbiont at the roots (Hirsch, 1992). In accordance with Uheda et al. (2001), nodules in peanut roots only develop on the lateral roots, while in most legumes, nodules usually

develop in root hairs (Uheda et al, 2001). According to Tajima et al. (2006), nodules form on the first lateral root branch in the basal section. All nodules in the four test cultivars were black which showed non-active nodule. The effectiveness of nodules is marked in red. Root nodules showed their effectiveness at ± 57 days after planting (Widoretno and Santoso, 2000). The nodules on the four cultivars showed ineffectiveness and were black because the observations were made after the pods were ripe.

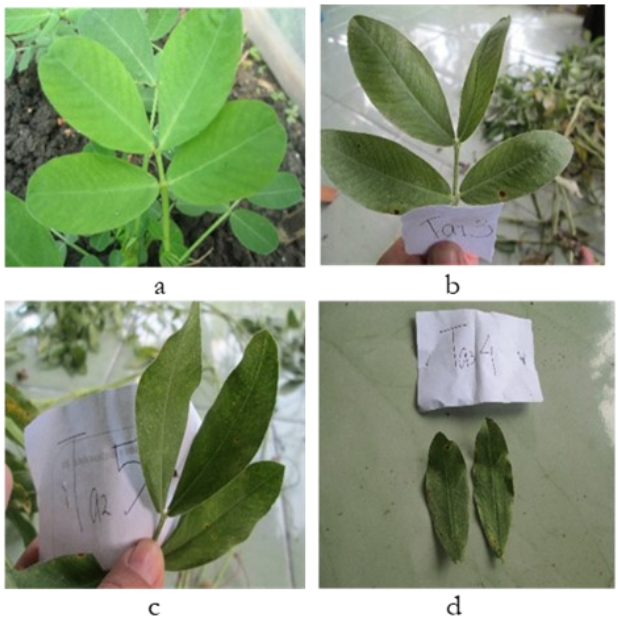

Figure 2. a. Tuban leaves, b. Talam 1 leaves, c. Talam 2 leaves, and d. Talam 3 leaves.

In stem organ, based on the research, the growth of Tuban cultivar stems and Talam 1 have erect type of stems, while cultivars Talam 2 and Talam 3 are of type Decumbent-3. Peanuts have several types of growth that can be seen from the main stem and lateral branches. The type of growth of peanuts is divided into 6 types, including: Procumbent-1, Procumbent-2, Decumbent-1, Decumbent-2, Decumbent-3, and Erect (Trustinah, 2015). All individual cultivars of groundnut of Tuban, Talam 1, Talam 2, and Talam 3 have green stems without pigmentation. Meanwhile, according to Bogor Biogen, Tuban cultivar stems are purple, Talam 1 cultivar stems are green, Talam 1 cultivar stems are purplish green, and Talam 3 cultivar stems are purplish green (BB Biogen, 2016). The four cultivars belong to Spanish-type peanuts with sequential branching patterns and erect growth (Pittman, 1995). On the stem surface of all Tuban cultivars, Talam 1, Talam 2, and Talam 3 have a type of moderately-hairy stem surface. The highest height of peanut stems is the highest of Tuban. Cultivars Talam 1, Talam 2, and Talam 3 have almost the same average height. The highest average stem width is in Talam 1.

In leaf organ, young leaves and old leaves on the four cultivars of peanuts have fine hair on the edges of the white leaves. Young leaves have more fine hair than old leaves. Tuban, Talam 1, Talam 2, and Talam 3 have yellowish green leaves (Fig. 2). The measurement using the RHS color chart shows the category for the fourth leaf color of the cultivar is Strong Yellow Green 143 C (Green group). According to BB Biogen (2016), the color of Tuban peanut cultivars, Talam 1, Talam 2, and Talam 3 are Green.

After meeting between male and female gamete cells, fertilization occurs, then the fruit will grow elongated and is called a gynophore. In general, the color of the gynophore in peanuts is green, if there is anthocyanin pigmentation the color becomes red or purple. The color of the green gynophore is caused by chlorophyll grains that can photosynthesize while still above the ground (Kasno and Harnowo, 2014). The four peanut cultivars have purple gynophore because of anthocyanin pigmentation. Flowers consist of petals (calyx) that are green, shaped like tubes that extend from the base of the flower and are called hypanthium. The flower crown (stigma) has 5 strands that are different in shape from each other. The biggest strand is called the flag. The flag is yellow in the middle and getting orange on the edge of the crown. In the middle of the yellow flag there are red lines. Other crown strands form the right and left wings smaller than the flag and are bright yellow like the center of the flag, then one of the smallest crowns forming a claw on the light-yellow bottom. Stamen (antheridium) and stigma (stigma) are found in the claws (Fig. 3).

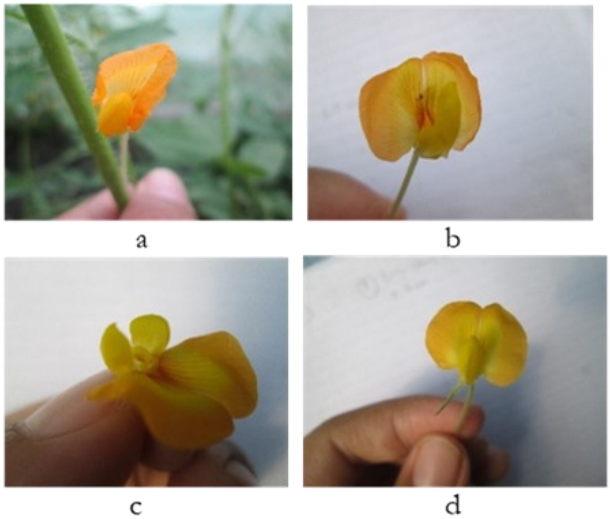

Figure 3. a. flower of Tuban, b. flower of Talam 1, c. Flowers of Talam 2, and d. flower of Talam 3.

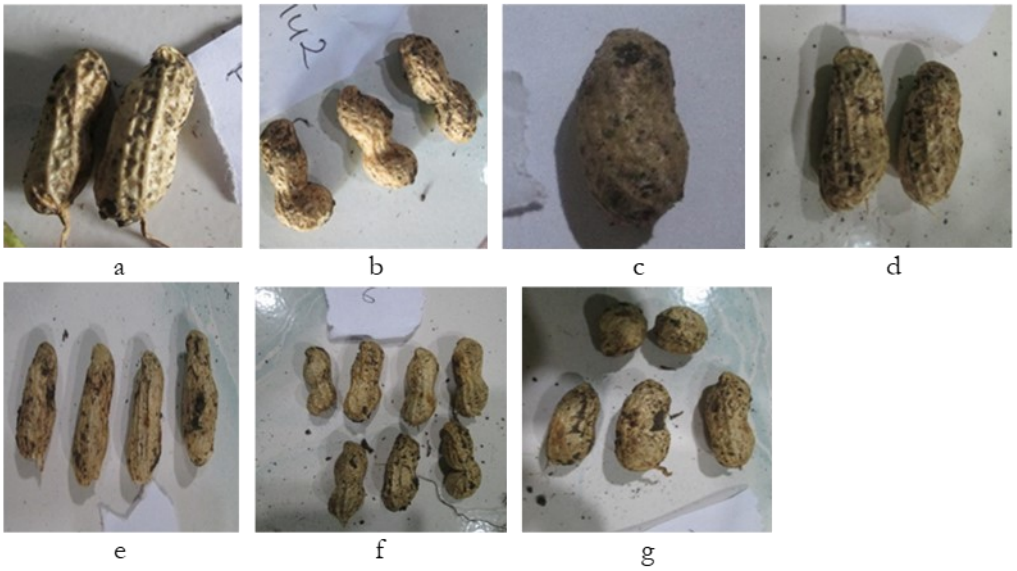

Figure 4. Pods of Tuban. a. Tu1, b. Tu2, c. Tu3, d. Tu4, e. Tu5, f. Tu6, and g. Tu7.

Figure 5. Pods of Talam 1. a. Ta11, b. Ta12, c. Ta13, d. Ta14, e. Ta15, f. Ta16, and g. Ta17

Fruit type of Peanut is legume (pod). Peanut pods vary in size, shape, beak, constriction and reticulation. The four cultivars had different characters. Individuals of Tuban (Fig. 4) have the following characters: Tu1 has moderate pods, moderate pods constricting, and moderate pod reticulation. Tu2 has the character of prominent pods, constriction deep and prominent pod reticulation. Tu3 has the character of moderate pods, constricts moderate pods, and moderate pod reticulation. Tu4 has the character of moderate pods, none constriction, and moderate reticulation. Individuals Tu5, Tu6 and Tu7 have the character of moderate pods, constrict moderate pods, and moderate pod reticulation. All Talam 1 cultivars, including Ta11, Ta12, Ta13, Ta14, Ta15, Ta16, and Ta17 have the following pod characteristics (Fig. 5): absent pods, none pods reticulation, and moderate pod reticulation. All individuals of Talam 2 (Fig. 6) have pod character with a beak shape of slight, constriction of none pod, and moderate pod reticulation. Individual of Talam 3 (Fig. 7) show similarities in pod character with Talam 2, which have a slight beak shape, none pod constriction, and moderate pod reticulation.

In seed organ, peanut has primary and secondary color. All cultivars had different types of primary and secondary colors. The color of peanut seeds was measured with the RHS color chart sixth edition issued by the Royal Horticultural Society. The primary color of the seeds for all Tuban cultivars is light yellowish pink with the code 159 A, Orange group. Talam 1 cultivar individuals (Fig. 8.b) have the same seed color as Tuban (Fig. 8.a), light yellowish pink with Orange white group code 159. Talam 2 (Fig. 8.c) has moderate yellowish pink primary seed color with the 173D code in the Greyed-Orange group. Talam 3 (Fig. 8.d) has the

primary color of pinkish white seeds with the code N155B in the white group. The secondary color of the seeds of the four cultivars has a combination type striped by forming a line on the surface of the seed with an older color than the primary color (Fig. 8.e).

Individuals of Talam 3 had the highest average plant pod weight than other cultivars, while Tuban had the lowest average plant pod weights of all cultivars. Individuals of Talam 3 100 seeds-weighed on the highest average than other cultivars, while individuals in Talam 2 has lowest 100 seeds-weighed.

The maturity of each individual cultivar is almost same, mature on > 90 days and the average fourth cultivar individual meets the harvest requirements on the 84th day. The characteristics of peanuts have entered the maturity period are some leaves begin to turn yellow and fall out, the pods are fully filled and brown in color, and the pods are hard.

The relationship between the peanut cultivars was tested using analytical clusters with dendrogram reconstruction. Dendrogram can be reconstructed based on the similarity index of morphology and UPGMA cluster analysis (Sokal and Sneath, 1963). Based on Fig. 9 it can be seen that there are 2 clusters with 4 sub-clusters with Tu1, Tu4, Tu3, Tu6, Tu5, and Tu7 in 1 cluster, Ta11, Ta17, Ta12, Ta13, Ta14, Ta15, Ta16, Ta21, Ta23, Ta25, Ta26, Ta27, Ta32, Ta34, Ta36, Ta22, Ta24, Ta31, Ta33, Ta35, and Ta37 are in the other clusters. All cultivars fused at 85% similarity index. The sub-clusters formed were Talam A, Talam B, Tuban A, and Tuban B. Group A consisted of Ta21, Ta23, Ta25, Ta26, Ta27, Ta32, Ta34, Ta36, Ta22, Ta24, Ta31, Ta33, Ta35, and Ta37. B's page consists of Ta11, Ta17, Ta12, Ta13, Ta14, Ta15, Ta16. Tuban A consists of

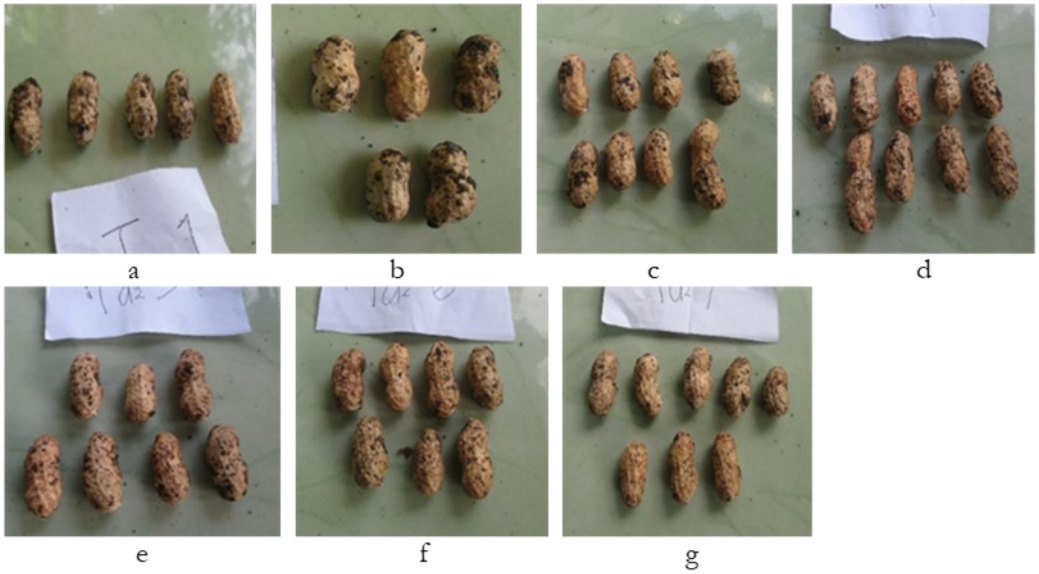

Figure 6. Pods of Talam 2. a. Ta21, b. Ta22, c. Ta23, d. Ta24, e. Ta25, f. Ta26 and g. Ta27.

Figure 7. Pods of Talam 3. a. Ta31, b. Ta32, c. Ta33, d. Ta34, e. Ta35, f. Ta36 and g. Ta37.

Figure 8. a. seed primary color of Tuban, b. seed primary color of Talam 1, c. seed primary color of Talam 2, d. seed primary color of Talam 3, and e. seed secondary color of Tuban, Talam 1, Talam 2, and Talam 3.

Tu2 individuals, and Tuban B consists of Tu1, Tu4, Tu3, Tu6, Tu5, and Tu7. Almost all Tuban cultivars except Tu2 are in one cluster, so they are divided into two sub-clusters with a similarity index of 91.4%.

Based on Fig. 10, scatter plots of PCA show that individuals from 4 cultivars form 4 sub-clusters, namely Talam A, Talam B, Tuban A, and Tuban B. The groups of Talam A include Ta21, Ta23, Ta25, Ta26, Ta27, Ta32, Ta34, Ta36, Ta22, Ta24, Ta31, Ta33, Ta35, and Ta37. Talam B includes Ta11, Ta17, Ta12, Ta13, Ta14, Ta15, Ta16. Tuban A includes Tu2 individuals, and Tuban B includes Tu1, Tu4, Tu3, Tu6, Tu5, and Tu7. In PCA (Fig. 10) it is not only shown the direction of distribution, but also the influence of the size of the characters that are shown by lines of different lengths (Sari et al, 2016). The longer the arrow line, the greater the influence given in grouping.

In Fig. 10 it can be seen that the arrow lines show the characters affecting the spread of the second cluster, the primary seed color, pod length, pod beak, pod constriction, weight of 100 seeds, pod yield per plant, pod width, number of seeds per pod and pod reticulation. The longer the arrow line, the greater the influence of the character in the spread of individual cultivars. The longest arrow line or character that most influence is the primary seed color. The primary color of the seeds is the most influential character with a correlation value of 0.64 because each cultivar has different characteristics. Tuban and Talam 1 had primary light yellowish pink color, Talam 2 were moderate yellowish pink, and Talam 3 were pinkish white (Fig. 10).

Based on Table 1 shows the magnitude of the correlation / influence of the characters on the spread of peanut cultivars. According to Adebisi et al. (2013) and Susandarini et al. (2013), the most influential character in grouping is the correlation value> 0.3, while the correlation value <0.2 is a correlation value that has no effect on grouping.

After making PCA, it can be known the characters that influence the spread of individual cultivars. Then an identification key is made based on qualitative characters. Based on the morphological characters of peanut cultivars.

The following are key identification points for cultivars or peanut cultivar groups:

1. (a.) Pod constriction moderate / deep ……...(2)
   (b.) Pod constriction none ……(3)
2. (a.) The color of the primary seed is light yellowish pink, the pod beak is moderate, pod constriction is moderate, pod reticulation moderate…… …….. (Tu1, Tu3, Tu4,Tu5, Tu6, Tu7)
   (b.) The color of the primary seed is light yellowish pink, the beak is prominent, pod constriction is deep, pod reticulation prominent ……...(Tu2)
3. (a.) The color of the primary seed is light yellowish pink, the beak of the pod is absent, pod constriction none, pod reticulation moderate ……...(Ta11, Ta12, Ta13, Ta14, Ta15, Ta16, Ta17)
   (b.) Primary seed color is moderate yellowish pink, the beak of the pod is slight, pod constriction none, pod reticulation moderate……. ……...(Ta21, Ta22, Ta23, Ta24, Ta25, Ta26, Ta27)
   (c.) The primary seed color is pinkish white, the beak of the pod is slight, pod constriction none, pod reticulation moderate…… ……...(Ta31, Ta32, Ta33, Ta34, Ta35, Ta36, Ta37)

CONCLUSION

Based on the research that has been done, it can be concluded that Peanut (*Arachis hypogaea* L.) cultivars of Tuban, Talam 1, Talam 2, and Talam 3 have distinguishing characteristics in primary seed color, pod tip, pod length, pod constriction, pod reticulation and pod yield per plant and have a very close relationship with a similarity index of 0.85%. Talam cultivars are divided into 2 groups into Talam A and B, Tuban cultivars are divided into 2 groups Tuban A and Tuban B.

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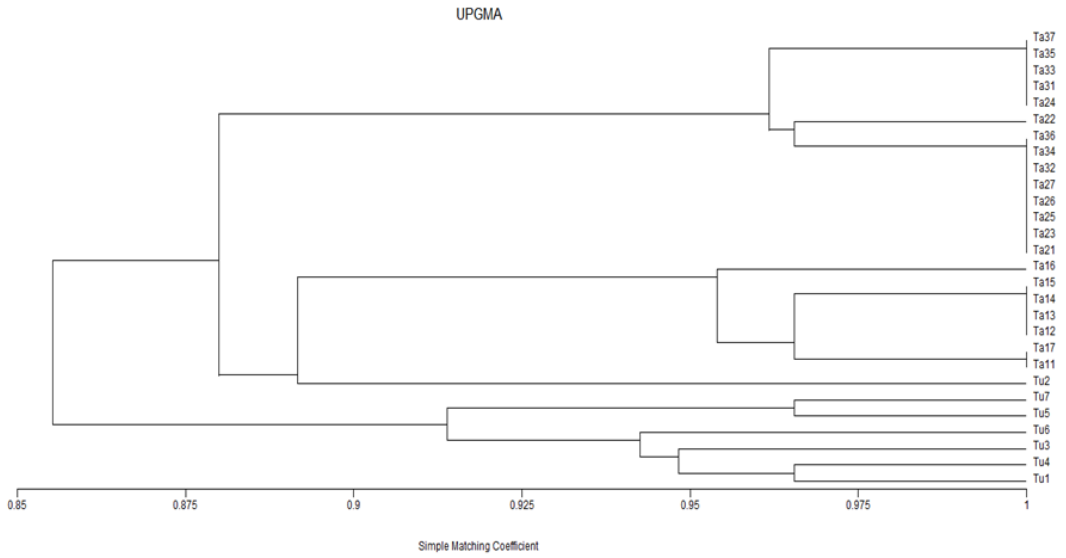

Figure 9. Dendrogram of kinship relationship between Tuban, Talam 1, Talam 2, and Talam 3

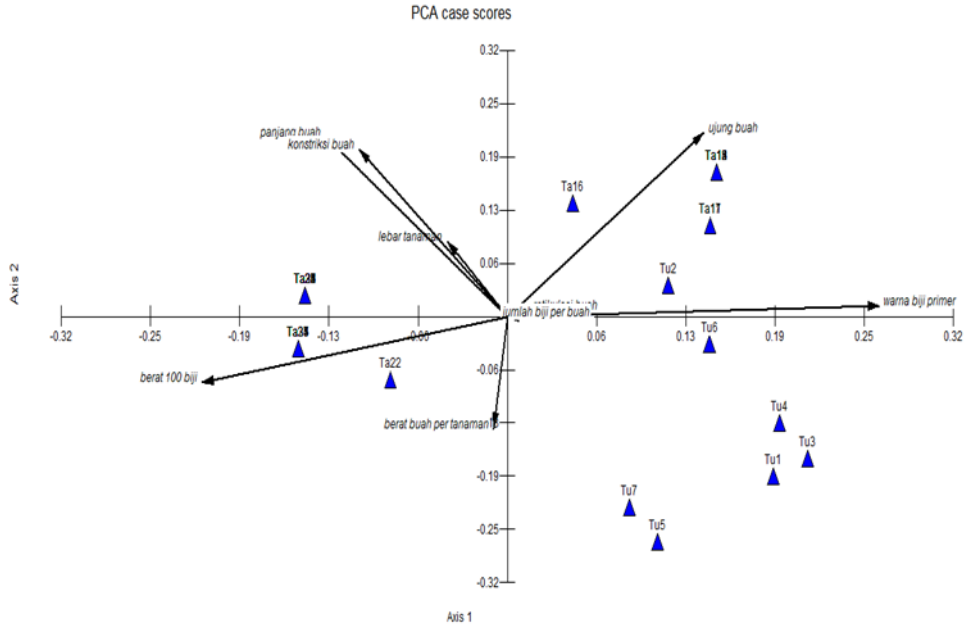

Figure 10. Scatter plot of PCA 4 cultivars of groundnut of Tuban, Talam 1, Talam 2, and Talam 3.

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Table 1. Correlation values of each character from 5 components.

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
Early plant vigour	0	0	0	0	0
Life form	0	0	0	0	0
Growth habit	0	0	0	0	0
Number of branches	0	0	0	0	0
Branching pattern	0	0	0	0	0
Height of main stem	0	0	0	0	0
Plant width or spread	-0.105	0.219	0.059	0.019	0.727
Stem pigmentation	0	0	0	0	0
Stem surface	0	0	0	0	0
Days to 50% flowering	0	0	0	0	0
Inflorescence type	0	0	0	0	0
Leaf colour	0	0	0	0	0
Leaflet margin	0	0	0	0	0
Leaflet shape	0	0	0	0	0
Leaflet tip	0	0	0	0	0
Petal colour	0	0	0	0	0
Plant height	0	0	0	0	0
Peg pigmentation	0	0	0	0	0
Pod length	-0.316	0.525	0.304	-0.304	-0.454
Pod width	0	0	0	0	0
Pod beak	0.342	0.538	0.185	0.429	-0.158
Pod constriction	-0.259	0.49	0.039	0.132	0.312
Pod reticulation	0.038	0.019	-0.076	0.449	0.178
Days to maturity	0	0	0	0	0
Primary seed colour	0.648	0.032	0.062	0.211	-0.129
Secondary seed colour	0	0	0	0	0
Number of seeds per pod	0	0	0	0	0
Pod yield per plant	-0.023	-0.329	0.925	0.075	0.126
100 seed weight	-0.532	-0.193	-0.062	0.674	-0.278

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