# Comparison-SDC-GJS

*by* Iwan Binanto

# Comparison of Similarity Coefficients on Morphological Rodent Tuber

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*Abstract*— **Many comparisons of similarity coefficient done by researchers, especially in the field of biology. This comparison aims to find the most appropriate similarity coefficient for some cases. Many results show that Sorensen-dice coefficient and Jaccard coefficient is close or identical. This paper show the correlation using Spearman's correlation as predecessors did and using ANOVA to ensure the results. This method provides almost similar results from predecessors.**

*Keywords*— *Generalized Jaccard Similarity, Sorensen-Dice Similarty, similarity coefficient, comparison, rodent tuber*

## I. Introduction

Similarity is necessary to examine the objects of investigation; in this case, the mutant of Rodent Tuber (Typhonium flagelliforme Lodd.) derived from breeding with its parent, called control plant. The research of Rodent Tuber were performed by Sianipar, et. al. in [1]–[5] utilizing NTSys, which is proprietary software. One of their research objective is to find similarity. By the discovery of similarity, it will be easier to find its dissimilarity, because the real purpose of the breeding is to find the diversity of produced mutants.

One of Sianipar's investigations is the morphological observation of Rodent Tuber, which has been given gamma irradiation. According to this investigations, gamma irradiation at 6 Gy's dose was able to increase the number of shoots and leaves, and also the height of the plant of the Rodent clones which are compared to the control plants [4]. This paper using the data from [4] as in Table I.

Sianipar et. al. measure the similarity between the mutants of Rodent Tuber and the control plant using Sorensen-Dice coefficient [1]–[5]. The formula of Sorensen-Dice coefficient is:

$$SDC(A,B) = \frac{2\,|A \cap B|}{|A| + |B|} \qquad (1)$$

Beside of Sorensen-Dice coefficient, there are many coefficient similarity, one of them is Jaccard coefficient which had approximately identical results in [6], [7] or have close result in [8] or a very close result in [9] to Sorensen-Dice coefficient. The Jaccard coefficient originally created for analyses in phytology [10] and works well with binary data as well as Sorensen-Dice coefficient. Many research using Jaccard coefficient for measuring similarities in various field [6]–[15]. The formula of Jaccard coefficient is:

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} \qquad (2)$$

Jaccard coefficient is simple and effective in many applications [11], [16] but it can not handle properly for sets with real-value or weighted sets [16] or any pair of vectors [17], therefore it redefine and explained well as the Generalized Jaccard Coefficient in [17], for short we call it GJS, and also introduced and used in [16]–[20] as:

$$GJS(A,B) = \frac{\sum_i min(A_i, B_i)}{\sum_i max(A_i, B_i)} \qquad (3)$$

This paper discuss Generalized Jaccard Coefficient compared to Sorensen-Dice Coefficient (result from proprietary software namely NTSys) using Spearman's correlation as [6]–[9] did.

## II. Literature Review

Rodent Tuber is a plant native to Indonesia that has been used as traditional medicine for many years. This plant contains detoxification and anti-cancer compounds. These anticancer compounds exist in all parts of the plant, including roots, tubers, stems and leaves. Unfortunately, this plant does not have much genetic diversity, so it becomes an obstacle in terms of obtaining plants that have higher anticancer compounds. Sianipar et. al. began to develop mutants using gamma radiation [21]. To test the genetic diversity of the mutant plants produced, Sianipar et. al. did a similarity test

using the NTSys software with Sorensen-Dice coefficient [1]–[5].

Duarte et. al. in [6] compared eight similarity coefficients using the Spearman's correlation and dendrogram to test similarity in common beans based on the RAPD marker. One of the result is Sorensen-Dice and the Jaccard coefficient has identical result. Murguia et. al. in [7] compared nine similarity coefficients to estimate the effect of biogeographic classification, the result is Sorensen-Dice and Jaccard coefficient had identical results. Silva et. al. in [8] compared eight similariy coefficient using Spearman's correlation and the result is Sorensen-Dice and Jaccard coefficient had close result. Dalirsefat et. al. in [9] compared three similarity coefficient one of comparison tools is the Spearman's correlation and of the result of correlation value between Sorensen-Dice and Jaccard coefficient is 1 which means exactly same.

Shrivastava (2016) in [17] said that GJS (A, B) is often used to compare web documents, histograms (especially images), gene sequences, etc. Those are weighted sets or pair of vectors. Weighted sets or any pair of vectors are more commonly find than binary sets. If $A$ and $B$ are binary or sets, then the similarity measure is called Jaccard coefficient as mentioned in [6]–[15]. According to [16], [17], Jaccard coefficient cannot handle properly for sets with real-value called weighted sets or any pair of vectors.

### III. Method

This paper use raw data and Sorensen-Dice similarity table from [4] as in Table I and Table II respectively. Generalized Jaccard coefficient calculated with formula (3) and have a result as in Table III. It done using Microsoft Excel.

In order to calculate the correlation, each similarity table converted to be 1 column, so we have 2 columns which are Generalized Jaccard column and Sorensen-Dice column. From here, we can plot the data as in Fig. 1.
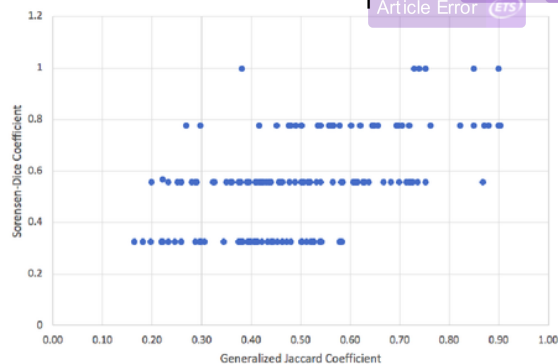


Fig. 1. Plot Sorensen-Dice and Generalized Jaccard coefficient

Then Spearman's correlation calculated to find the value of correlation between Table II and Table III. It done using MATLAB with simple script:

```
a = xlsread('Book2.xlsx','A:A')
b = xlsread('Book2.xlsx','B:B')
[RHO] = corr(a,b,'Type','Spearman');
```

The script generates RHO value 0.5052, which is the value of Spearman's correlation.

To ensure the correlation between Generalized Jaccard coefficient and Sorensen-Dice coefficient, we construct hypothesis which are:

$H_0$:No correlation between Generalized Jaccard coefficient and Sorensen-Dice coefficient
$H_a$:There is a correlation between Generalized Jaccard coefficient and Sorensen-Dice coefficient

These hypothesis evaluated with ANOVA using Microsoft Excel and the result provided as in Table IV.

### IV. Results And Discussions

Duarte et. al. in [6] concluded that the result is Sorensen-Dice and the Jaccard coefficient has identical result. Murguia et. al. in [7] had result that Sorensen-Dice and Jaccard coefficient had identical results. Silva et. al. in [8] concluded that Sorensen-Dice and Jaccard coefficient had close result. Dalirsefat et. al. in [9] had result that correlation value between Sorensen-Dice and Jaccard coefficient is 1 which means exactly same. They made comparison between Sorensen-dice coefficient and Jaccard coefficient where both are used binary data. This paper use Generalized Jaccard coefficient for real-value data. According to [17], Jaccard coefficient similar to Generalized Jaccard coefficient. But in this research, the result of Spearman's correlation is 0.5052 as above, which means there is a moderate positive correlation, as in Table V [22]. It is not close, very close, nor even identical.

To ensure the correlation, we calculate ANOVA and it give the value of F, greater than the value of F critical. It means that $H_0$ is rejected. Therefore, there is a correlation between Generalized Jaccard Similarity and Sorensen-Dice Similarity.

TABLE I.    Raw Data From [4]

| Clone | Shoot | Leaf | Plant Height (cm) |
|---|---|---|---|
| control | 0 | 1 | 3.5 |
| 6-3-3-6 | 1 | 6 | 4 |
| 6-9-3 | 2.5 | 3.5 | 4 |
| 6-9-4 | 0.4 | 4 | 12.5 |
| 6-2-5-3 | 0.5 | 7 | 12 |
| 6-3-2-5 | 1.5 | 8 | 13.5 |
| 6-1-1-2 | 3.5 | 2 | 6 |
| 6-9-1 | 2.5 | 11 | 4.5 |
| 6-2-4-1 | 0 | 2 | 3 |
| 6-6-3-7 | 0.5 | 6 | 7.5 |
| 6-6-3-6 | 1 | 6 | 12.5 |
| 6-2-7 | 0 | 5.5 | 12 |
| 6-2-6-3 | 0 | 5 | 5.5 |
| 6-1-2 | 4.5 | 15 | 8.3 |
| 6-1-1-6 | 1 | 2 | 5 |
| 6-2-8-2 | 2.5 | 11.5 | 6.5 |
| 6-9-5 | 0 | 12.5 | 10.3 |
| 6-3-3-10 | 0 | 1.5 | 7.5 |

### V. Conclusions

In previous research on the comparison between Jaccard coefficient and Sorensen-Dice coefficient [6]–[9], showing the results that both have close correlations up to identical.

But Jaccard coefficient can not handle properly for sets with real-value or weighted sets [16] or any pair of vectors [17], so the Generalized Jaccard coefficient is used. In this study, Sorensen-Dice coefficient compared with Generalized Jaccard coefficient and the result is there are a moderate correlation with the Spearman's correlation value is 0.5052. This result less similar than the previuos researh in [6]–[9]. We recommending not to use Generalized Jaccard coefficient if already use Sorensen-Dice coefficient to avoid confusion.

TABLE II.    RESULT OF SORENSEN-DICE COEFFICIENT

| | control | 6-3-3-6 | 6-9-3 | 6-9-4 | 6-2-5-3 | 6-3-2-5 | 6-1-1-2 | 6-9-1 | 6-2-4-1 | 6-6-3-7 | 6-6-3-6 | 6-2-7 | 6-2-6-3 | 6-1-2 | 6-1-1-6 | 6-2-8-2 | 6-9-5 | 6-3-3-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| control | 1 | | | | | | | | | | | | | | | | | |
| 6-3-3-6 | 0.56 | 1 | | | | | | | | | | | | | | | | |
| 6-9-3 | 0.78 | 0.56 | 1 | | | | | | | | | | | | | | | |
| 6-9-4 | 0.78 | 0.33 | 0.56 | 1 | | | | | | | | | | | | | | |
| 6-2-5-3 | 0.56 | 0.33 | 0.33 | 0.78 | 1 | | | | | | | | | | | | | |
| 6-3-2-5 | 0.33 | 0.78 | 0.33 | 0.56 | 0.78 | 1 | | | | | | | | | | | | |
| 6-1-1-2 | 0.56 | 0.33 | 0.78 | 0.56 | 0.33 | 1 | 1 | | | | | | | | | | | |
| 6-9-1 | 0.56 | 0.56 | 0.78 | 0.33 | 0.33 | 0.33 | 0.56 | 1 | | | | | | | | | | |
| 6-2-4-1 | 1 | 0.56 | 0.78 | 0.78 | 0.56 | 0.33 | 0.56 | 0.56 | 1 | | | | | | | | | |
| 6-6-3-7 | 0.56 | 0.56 | 0.33 | 0.56 | 0.78 | 0.56 | 0.56 | 0.33 | 0.56 | 1 | | | | | | | | |
| 6-6-3-6 | 0.33 | 0.78 | 0.33 | 0.56 | 0.78 | 1 | 0.33 | 0.33 | 0.33 | 0.56 | 1 | | | | | | | |
| 6-2-7 | 0.56 | 0.56 | 0.33 | 0.78 | 1 | 0.78 | 0.33 | 0.33 | 0.56 | 0.78 | 0.78 | 1 | | | | | | |
| 6-2-6-3 | 0.56 | 0.56 | 0.33 | 0.56 | 0.78 | 0.56 | 0.56 | 0.33 | 0.56 | 1 | 0.56 | 0.78 | 1 | | | | | |
| 6-1-2 | 0.33 | 0.33 | 0.56 | 0.33 | 0.33 | 0.33 | 0.78 | 0.78 | 0.33 | 0.56 | 0.33 | 0.33 | 0.56 | 1 | | | | |
| 6-1-1-6 | 0.56 | 0.56 | 0.56 | 0.56 | 0.33 | 0.56 | 0.78 | 0.33 | 0.56 | 0.56 | 0.56 | 0.33 | 0.56 | 0.56 | 1 | | | |
| 6-2-8-2 | 0.33 | 0.33 | 0.56 | 0.33 | 0.33 | 0.33 | 0.78 | 0.78 | 0.33 | 0.56 | 0.33 | 0.33 | 0.56 | 1 | 0.56 | 1 | | |
| 6-9-5 | 0.56 | 0.33 | 0.33 | 0.78 | 0.78 | 0.56 | 0.33 | 0.56 | 0.57 | 0.56 | 0.56 | 0.78 | 0.56 | 0.56 | 0.33 | 0.56 | 1 | |
| 6-3-3-10 | 0.78 | 0.33 | 0.56 | 0.78 | 0.56 | 0.33 | 0.78 | 0.33 | 0.78 | 0.78 | 0.33 | 0.56 | 0.78 | 0.56 | 0.78 | 0.56 | 0.56 | 1 |

TABLE III.    RESULT OF GENERALIZED JACCARD COEFFICIENT

| | control | 6-3-3-6 | 6-9-3 | 6-9-4 | 6-2-5-3 | 6-3-2-5 | 6-1-1-2 | 6-9-1 | 6-2-4-1 | 6-6-3-7 | 6-6-3-6 | 6-2-7 | 6-2-6-3 | 6-1-2 | 6-1-1-6 | 6-2-8-2 | 6-9-5 | 6-3-3-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| control | 1 | | | | | | | | | | | | | | | | | |
| 6-3-3-6 | 0.75 | 1 | | | | | | | | | | | | | | | | |
| 6-9-3 | 0.45 | 0.68 | 1 | | | | | | | | | | | | | | | |
| 6-9-4 | 0.27 | 0.43 | 0.42 | 1 | | | | | | | | | | | | | | |
| 6-2-5-3 | 0.23 | 0.53 | 0.37 | 0.82 | 1 | | | | | | | | | | | | | |
| 6-3-2-5 | 0.20 | 0.48 | 0.38 | 0.73 | 0.85 | 1 | | | | | | | | | | | | |
| 6-1-1-2 | 0.39 | 0.45 | 0.65 | 0.42 | 0.38 | 0.38 | 1 | | | | | | | | | | | |
| 6-9-1 | 0.25 | 0.61 | 0.56 | 0.34 | 0.47 | 0.52 | 0.44 | 1 | | | | | | | | | | |
| 6-2-4-1 | 0.73 | 0.45 | 0.50 | 0.30 | 0.26 | 0.22 | 0.43 | 0.3 | 1 | | | | | | | | | |
| 6-6-3-7 | 0.32 | 0.72 | 0.50 | 0.63 | 0.72 | 0.61 | 0.50 | 0.5 | 0.36 | 1 | | | | | | | | |
| 6-6-3-6 | 0.23 | 0.56 | 0.40 | 0.87 | 0.90 | 0.85 | 0.41 | 0.4 | 0.26 | 0.72 | 1 | | | | | | | |
| 6-2-7 | 0.26 | 0.50 | 0.38 | 0.87 | 0.90 | 0.76 | 0.38 | 0.4 | 0.29 | 0.70 | 0.90 | 1 | | | | | | |
| 6-2-6-3 | 0.43 | 0.72 | 0.58 | 0.53 | 0.54 | 0.46 | 0.52 | 0.5 | 0.48 | 0.75 | 0.54 | 0.60 | 1 | | | | | |
| 6-1-2 | 0.16 | 0.40 | 0.36 | 0.40 | 0.50 | 0.54 | 0.41 | 0.6 | 0.18 | 0.50 | 0.48 | 0.44 | 0.38 | 1 | | | | |
| 6-1-1-6 | 0.56 | 0.58 | 0.64 | 0.42 | 0.38 | 0.35 | 0.70 | 0.4 | 0.63 | 0.52 | 0.41 | 0.38 | 0.61 | 0.29 | 1 | | | |
| 6-2-8-2 | 0.22 | 0.54 | 0.49 | 0.41 | 0.54 | 0.58 | 0.49 | 0.9 | 0.24 | 0.60 | 0.51 | 0.46 | 0.51 | 0.74 | 0.39 | 1 | | |
| 6-9-5 | 0.20 | 0.42 | 0.30 | 0.56 | 0.69 | 0.67 | 0.30 | 0.6 | 0.22 | 0.58 | 0.63 | 0.64 | 0.46 | 0.70 | 0.29 | 0.71 | 1 | |
| 6-3-3-10 | 0.50 | 0.38 | 0.41 | 0.53 | 0.46 | 0.39 | 0.58 | 0.3 | 0.47 | 0.64 | 0.46 | 0.51 | 0.56 | 0.32 | 0.62 | 0.37 | 0.39 | 1 |

TABLE IV.    ANOVA SINGLE FACTOR

**SUMMARY**

| Groups | Count | Sum | Average | Variance |
|---|---|---|---|---|
| GJS | 153 | 75.8055923 | 0.49546139 | 0.02869388 |
| DICE | 153 | 84.09 | 0.54960784 | 0.03544327 |

**ANOVA**

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Between Groups | 0.22428566 | 1 | 0.22428566 | 6.99393895 | 0.0086034 | 3.87222952 |
| Within Groups | 9.74884679 | 304 | 0.03206857 | | | |
| Total | 9.97313245 | 305 | | | | |

TABLE V.    INTERPRETING CORRELATION COEFFICIENT [22]

| Correlation Value | Interpretation |
|---|---|
| 0.90 to 1.00 (-0.90 to -1.00) | Very High Positive/Negative Correlation |
| 0.70 to 0.90 (-0.70 to -0.90) | High Positive/Negative Correlation |
| 0.50 to 0.70 (-0.50 to -0.70) | Moderate Positive/Negative Correlation |
| 0.30 to 0.50 (-0.30 to -0.50) | Low Positive/Negative Correlation |
| 0.00 to 0.30 (0.00 to -0.30) | Negligible Correlation |

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**Article Error** You may need to use an article before this word.

**Sentence Cap.** Remember to capitalize the first word of each sentence.

**Frag.** This sentence may be a fragment or may have incorrect punctuation. Proofread the sent to be sure that it has correct punctuation and that it has an independent clause with a complete subject and predicate.

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**Article Error** You may need to remove this article.

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**Wrong Article** You may have used the wrong article or pronoun. Proofread the sentence to make sure that the article or pronoun agrees with the word it describes.

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**Article Error** You may need to remove this article.

**Article Error** You may need to use an article before this word.

**Article Error** You may need to use an article before this word. Consider using the article **the**

**S/V** This subject and verb may not agree. Proofread the sentence to make sure the subject agr with the verb.

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**Garbled** Grammatical or spelling errors make the meaning of this sentence unclear. Proofread sentence to correct the mistakes.

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**S/V** This subject and verb may not agree. Proofread the sentence to make sure the subject agr with the verb.

**Article Error** You may need to remove this article.

**Missing ","** You may need to place a comma after this word.

**Verb** This verb may be incorrect. Proofread the sentence to make sure you have used the corr form of the verb.

**S/V** This subject and verb may not agree. Proofread the sentence to make sure the subject agr with the verb.

**Article Error** You may need to use an article before this word. Consider using the article **the**

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