



Research Title: Allelopathic Potential of Rose Apple (*Syzygium jambos*) Extract against Mung Beans (*Vigna radiata*) in Soil Sample from Chonradsadronumrung School

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ABSTRACT

This current environmental research aims to assess if there is a significant difference in various soil parameters measured at Chonradsadornumrung School and to evaluate the allelopathic potential Rose Apple (*Syzygium jambo*) ethanolic and boiled extracts. The quality of the soil from the sampling site was tested using the standard protocol from Globe and equipment from Extech. In allelopathy test, 3 treatments were used namely control (Distilled water), 100% ethanolic and boiled extracts of Rose apple. Two methods were used to discover the allelopathic potential of the plant. The results of the different experiments were observed, gathered, and compared using one-way ANOVA and Tukey HSD Test. Based on the experimentations, results and gathered data, the researchers concluded that there was a significant difference ($p < 0.05$) in soil pH, relative humidity, and air temperature of the study site, except for soil temperature ($p > 0.05$) that was measured at 5cm and 10cm depth. Additionally, the ethanolic and boiled extracts of Rose Apple (*Syzygium jambo*) possess an allelopathic potential because it can inhibit the growth of Mung beans (*Vigna radiata*). This capacity of the plant is due to its allelochemicals such as alkaloids, tannins, phenolic compounds, flavonoids, and Leucoanthocyanins.

Keywords: Allelopathic potential, soil parameter, ANOVA and Tukey HSD Test

INTRODUCTION

The primary goals of the current environmental research are to determine the allelopathic capability of Rose Apple (*Syzygium jambos*) ethanolic extract against Mung Beans (*Vigna radiata*) in soil sample from Chonradsadronumrung School, as well as to assess the soil quality on the campus. The said school is one of the famous public secondary schools located in the Eastern part of Thailand that promotes academic excellence. The Educational Service Area Office evaluated and certified the school as an ASEAN model school at the educational area level. This is due to the fact that the results of the national achievement test for Mathayom Suksa 3 (Grade 9) and Mathayom 6 (Grade 12) students were higher than the average scores at the provincial and national levels. Numerous infrastructures have recently been constructed on campus to address the issue of a lack of classrooms as well as sports facilities to improve the students' athletic endeavors. The campus's soil quality could be significantly impacted by the development, which could also have an impact on the viability of numerous plants there. In addition, the area where the school is located has been experiencing drought because it hasn't rained in almost three months. As a result, the ground surrounding the school is completely dry. The current soil quality inside the school must be assessed, hence soil testing is unquestionably required.

The situations above prompted the researchers to conduct this environmental research entitled “Allelopathic Potential of Rose Apple (*Syzygium jambos*) Ethanolic Extract against Mung Beans (*Vigna radiata*) in Soil Sample from Chonradsadronumrung School. The allelopathy testing aimed to determine the potential of rose apple extract to inhibit the growth of other plant and whether the soil type from the school can support the growth of living organisms like mung beans. Allelopathy is a common biological phenomenon in which one organism produces biochemicals that influence growth, survival, development, and reproduction of organisms. These biochemicals are known as allelochemicals and have beneficial or detrimental effects on target organisms (Fang Cheng et al., 2015). Soil testing aimed to determine the quality of soil in the said school. In addition to soil quality testing and allelopathic screening, the researchers are also looking for strategies to use less chemicals in agriculture. Thailand imports a number of deadly chemicals that have terrible consequences for both soil and people (Thailand Pesticide Alert Network, 2017). According to studies, the main culprit behind soil degradation, loss of biomass, and water retention is

herbicide (Mada et al., 2013). This environmental research aimed to find an alternative substance that can be used by the consumers as natural herbicide that are safe to everyone and no negative impact to the quality of soil.

Research Questions:

1. Is there a significant difference in various soil parameters measured for four times at Chonradsadornumrung School?
2. Do Rose Apple (*Syzygium jambo*) ethanolic extract possess allelopathic potential?
3. What phytochemical constituents are present in the ethanolic extract of Rose Apples (*Syzygium jambos*)?

Objectives:

1. To find out whether there is significant difference in soil parameters measured for four times at Chonradsadornumrung School.
2. To evaluate the allelopathic potential of Rose Apple (*Syzygium jambos*) ethanolic extract using the soil sample from Chonradsadornumrung School.
3. To determine the secondary compounds possessed by the extract of Rose Apple (*Syzygium jambos*).

Hypotheses:

Alternative: There is a significant difference in various soil parameters measured at Chonradsadornumrung School and the extract of Rose Apple (*Syzygium jambos*) has allelopathic activity.

Null: There is no significant difference in various soil parameters measured at Chonradsadornumrung School and the extract of Rose Apple (*Syzygium jambos*) has no allelopathic activity.

RESEARCH METHODOLOGY

Research Design

This environmental science research employed a true experimental research design, which relies on statistical analysis to prove or disprove a hypothesis. It is the most accurate type of experimental design for this type of environmental research because it includes a control group as well as variables that can be manipulated by the researcher. This is extremely relevant and useful for soil testing and allelopathic screening. The data gathered during the measurement of soil quality and allelopathy test were compared using the

appropriate statistical tool. Following that, the researchers can choose to accept or reject the given hypothesis. Descriptive research was also used, that involves observing and describing a subject's behavior without influencing it in any way. It is extremely important during the qualitative testing of the phytochemical constituents found in the experimental plant, as well as in describing the quality of soil inside Chonradsadronumrung School campus.

Materials and equipment used in this environmental research.

Thermo Hygrometer	4 in 1 Soil Survey Instrument	Autoclave
pH Meter	2 in 1 Soil Analyzer	Beakers
Stirring rod	Digital Balance	Hot plate
Vernier caliper	Petri dishes	Test tubes
Meterstick	3 Way Soil Meter	Graduated cylinders
Shovel	Test tube rack	Forceps

Study Site

The study site is located at Bansuan, Chonburi Coastal Area with Latitude 13°20'59.9"N, and Longitude 100°58'33.0"E

Survey and Preparation of Materials

The researchers conducted a survey around Chonradsadornumrung School, a government school located in Bansuan, Chonburi, Thailand. The soil near the Emerald pool was chosen as the study site because it is an ideal location for soil testing and soil sample collection. After the survey and selection of the study site, needed laboratory materials and equipment for soil quality testing were procured from the science laboratory of Chonradsadornumrung School.

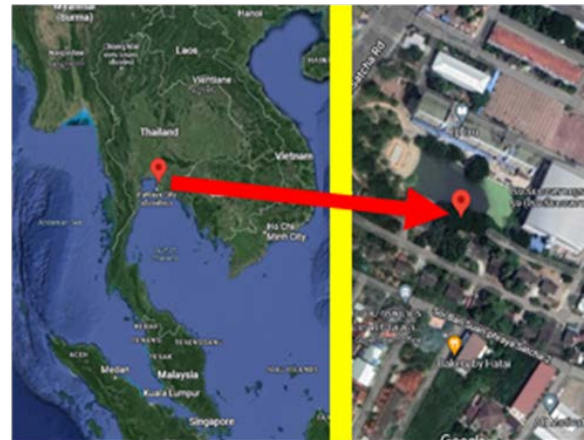


Figure 1. The study site at Bansuan, Chonburi, Thailand.



Figure 2. Researchers at the study site.

Some of the materials used to dig the soil such as shovel and hand forks were borrowed from the home economics department of the school.

Soil Quality Testing

Various soil parameters were considered in assessing the quality of soil at Chonradsadornumrung School such as soil pH, temperature, moisture, soil texture, soil consistency, soil fertility, also the air temperature and relative humidity of the study site was included. To determine the soil pH, the following steps were carried out: 40 g of dried and sieved soil with 40 mL of distilled water (or other amount in a 1:1 soil to water ratio) was mixed in a beaker using the stirring rod, the mixture was allowed to settle until a supernatant (clearer liquid above the settled soil) formed, the pH of the supernatant was measured using the pH meter. The same steps were followed for the 2 soil samples in separate beakers taken from the same site and soil horizon. Extech standard thermo-hygrometer was used to determine the air temperature and relative humidity of the study site. The soil characterization protocols from www.globe.gov were used in all the tests needed to evaluate the current soil status of the soil found in the said school.

Screening for the Allelopathic Potential of Experimental Plants.

Two methods were used for allelopathy testing namely using the petri dishes to observe the growth of mung beans and the actual planting on the soil sample from the study site. For the first method, the petri dishes were sterilized in the autoclave for 15 minutes at 121° Celsius with 15 psi to ensure that no other contaminants are present



Figure 3. Assessing soil pH using the pH meter.



Figure 4. Sterilization of the equipment using the autoclave.

in the equipment. Filter papers and 3 treatments were prepared. Control (distilled water) is the first treatment, 100% ethanolic extract of Rose Apple for the second treatment, and Boiled Rose apple leaves for the third treatment. The filter papers were soaked in each treatment and then placed in separate petri dishes. Then, 5 Mung beans were added in each petri dish with certain treatment. After the treatments, all petri dishes were incubated in the room temperature and observed for 5 days. The length of the shoot and the root of mung beans in every treatment were measured using the vernier caliper.

For the second method, soil sample from the study site was placed in 9 holes of a seedling tray. Three holes were prepared for the 3 treatments (Control, 100% ethanolic extract, and boiled extract of Rose apple). After this, 3 mung beans were planted in each hole with soil. The first 3 holes with soil and mung beans served as the control set-up and were watered using 10mL of distilled water. The next 3 holes were watered using the 10mL of 100% rose apple ethanolic extract, and the last 3 holes were watered with 10mL of rose apple boiled leaves. For 5 days each set-up was added with 5mL of each treatment to ensure that enough substances are received by the mung beans. After 5 days of observation, the researchers measured the growth of mung beans in each treatment using the vernier caliper.

Phytochemical Screening

Phytochemical screening procedures from the book of Guevarra et.al., 2005 were applied to evaluate the presence of the secondary compounds responsible for allelopathic activity of the plant like Alkaloids, Saponins, Tannins, Phenolic Compounds, Flavonoids, and Leucoanthocyanins.

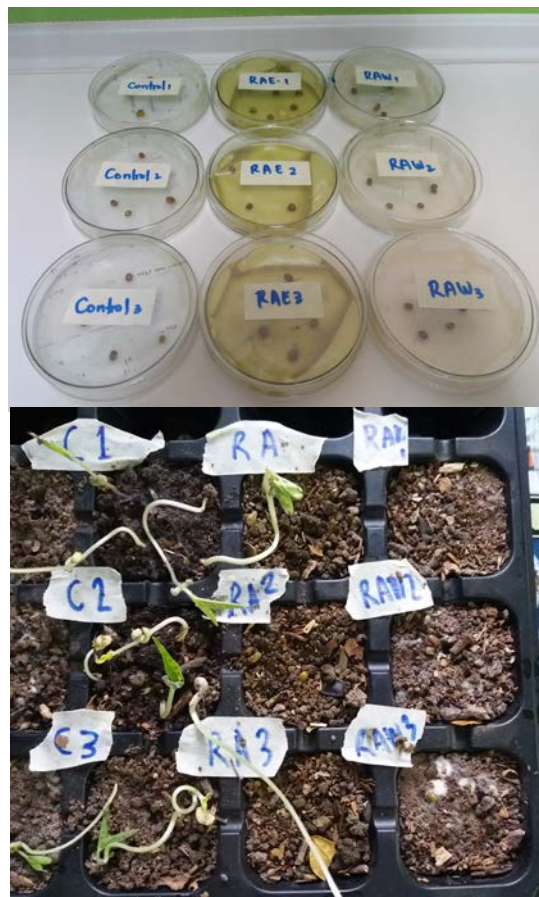


Figure 5. Allelopathy Testing in petri dishes and soil.

RESULTS AND DISCUSSIONS

The figures below until the next page show the data encoded on Globe web page from December 2022 to January 2023. Figures 7 to 13 shows the Globe data entry for air temperature, relative humidity, soil temperature, and soil pH measured at Chonradsadronumrug School, Chonburi, Thailand.

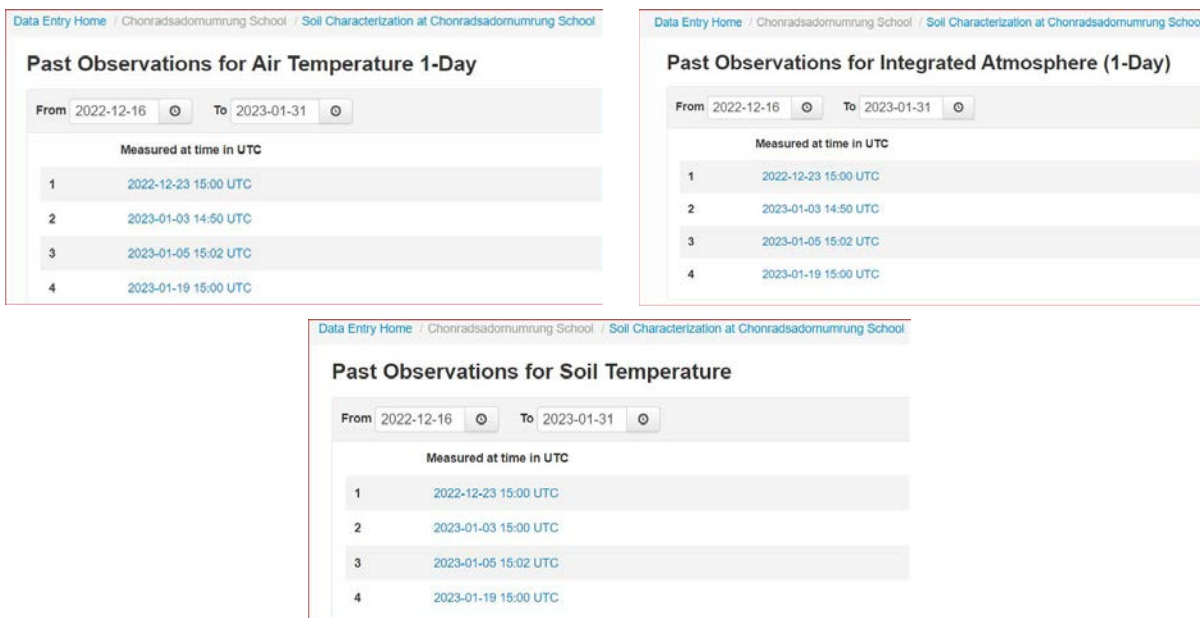


Figure 6. Globe Data Entry that has been entered from December 23, 2022 to January 19, 2023.

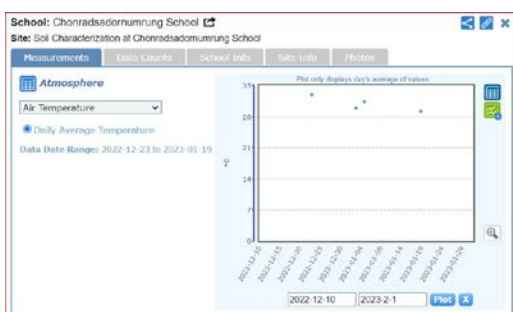


Figure 7. Globe Data Entry for air temperature.

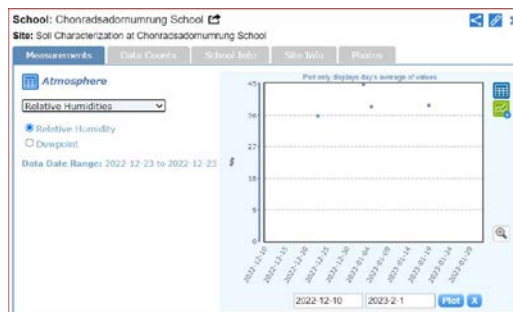


Figure 8. Globe Data Entry for relative humidity.

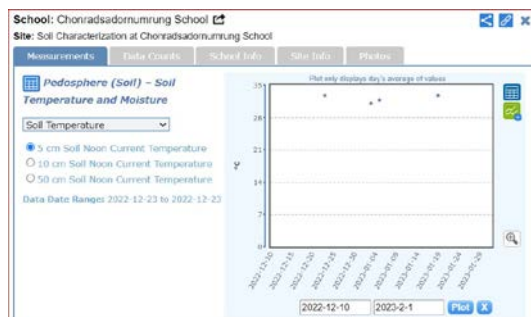


Figure 9. Globe Data Entry for soil temperature (5 cm).

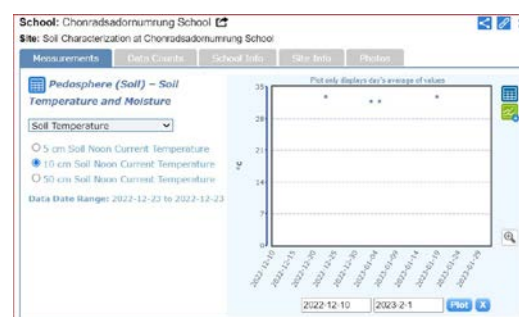


Figure 10. Globe Data Entry for soil temperature (10 cm).

Table 1. Average results of soil parameters measured at Chonradsadornumrung School.

Parameters	23 Dec. 2022 (3:00 PM)	3 Jan. 2023 (2:50 PM)	5 Jan. 2023 (3:00 PM)	19 Jan. 2023 (4:30 PM)
Soil pH	7.57	7.5	7.5	7
Soil Temperature (5 cm)	32.67	31	31.67	32.66
Soil Temperature (10 cm)	32.67	31.67	31.67	32.66
Relative Humidity (%)	35.67	44.67	38.33	38.67
Air Temperature (°C)	32.9	30.33	31.3	29.23
Soil Color	Grayish brown	Grayish brown	Grayish brown	Grayish brown
Soil Structure	Granular	Granular	Granular	Granular
Soil Texture	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam
Soil Consistency	Loose	Loose	Loose	Loose
Soil Moisture	Dry	Dry	Dry	Dry

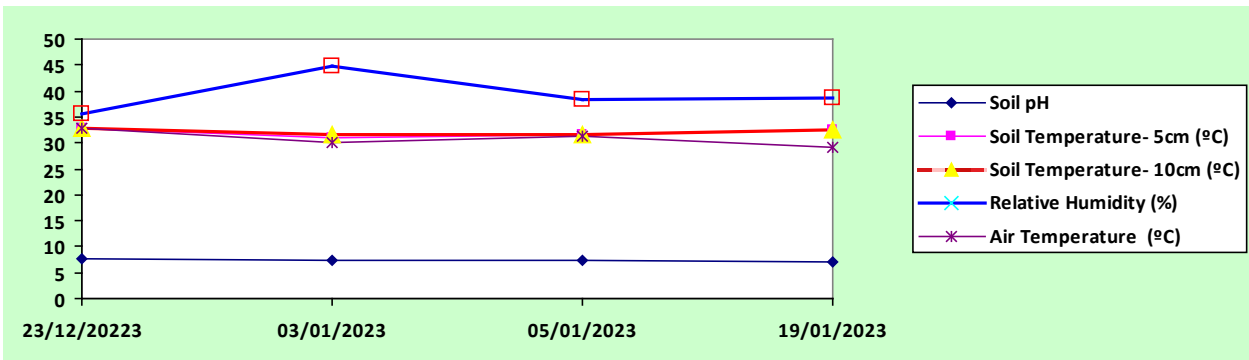


Figure 11. Average results of all soil parameters measured at Chonradsadornumrung School.

Table 1 and Figure 11 shows the average results of all soil parameters measured Chonradsadronumrung School, Chonburi, Thailand. These results were summarized after 4 series of experiments that started from 23 December 2022 to 19 January 2023. The average soil pH ranges from 7 - 7.5, soil temperature at 5cm depth ranges from 31 - 32.67°C, soil temperature at 10cm depth ranges from 31.67 - 32.67°C, relative humidity ranges from 35.67 – 44.67%, and air temperature ranges from 29.23 - 32.9°C. The soil tested from the experimental site also possess the following characteristics: grayish brown color, granular soil structure, sandy clay loam texture, loose consistency, and dry.

One-way ANOVA and Tukey HSD test were used to determine if there is significant difference in all soil parameters measured quantitatively at Chonradsadornumrung School. It was found out that the p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05 for soil pH, relative humidity, and air temperature suggesting that the one or more treatments is/are significantly different. For water soil temperature measured at 5 cm and 10 cm depth, the p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that the treatments are not significantly different for that level of significance. It means that there were no significant changes in the soil temperature measured for 4 consecutive times from the sampling site.

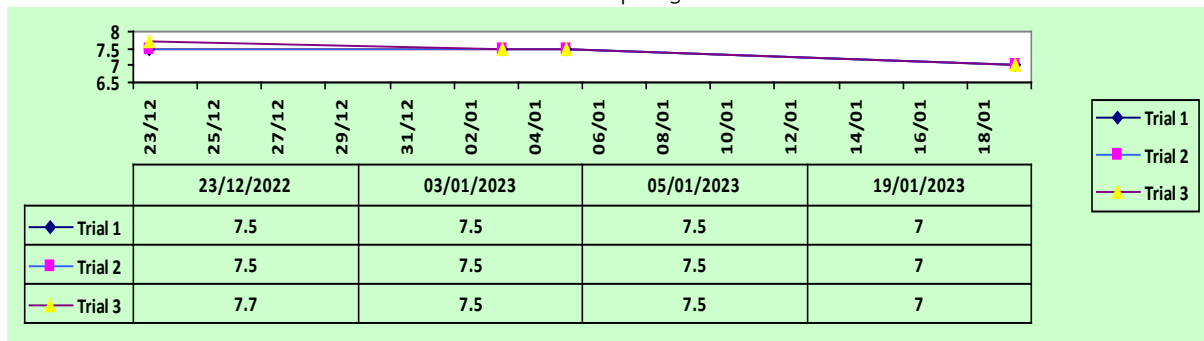


FIGURE 12. Soil pH

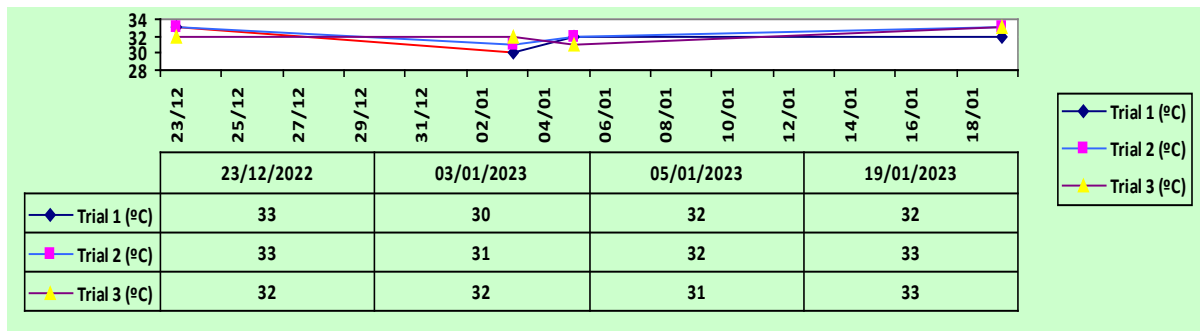


FIGURE 13. Soil temperature at 5 cm depth (°C).

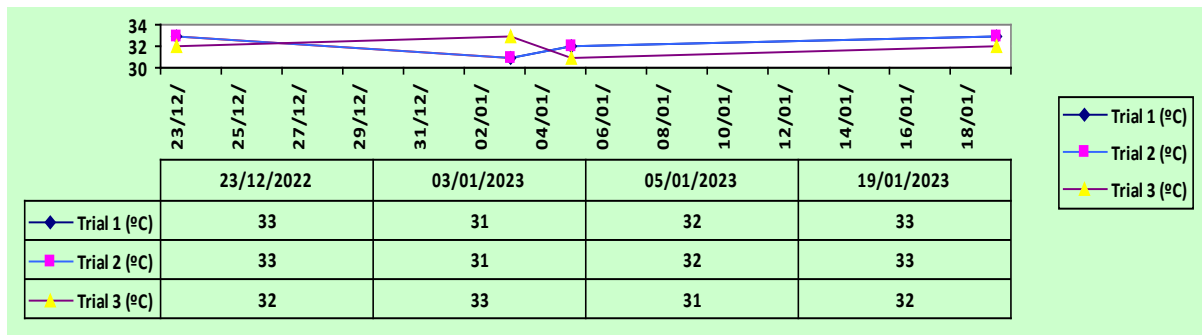


FIGURE 14. Soil temperature at 10 cm depth (°C).

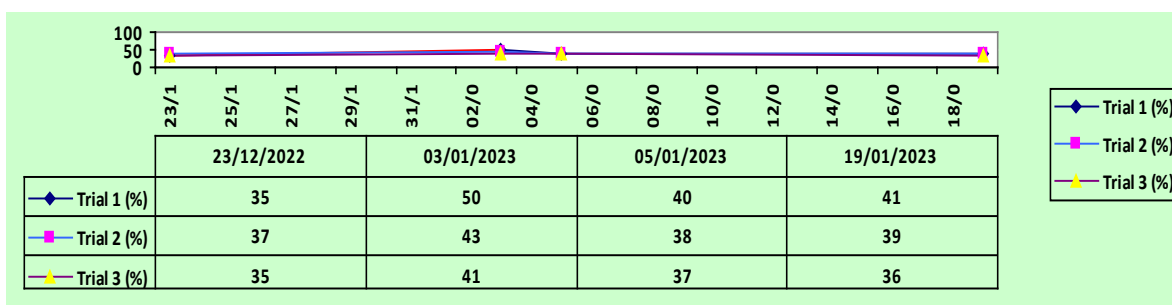


FIGURE 15. Relative humidity (%).

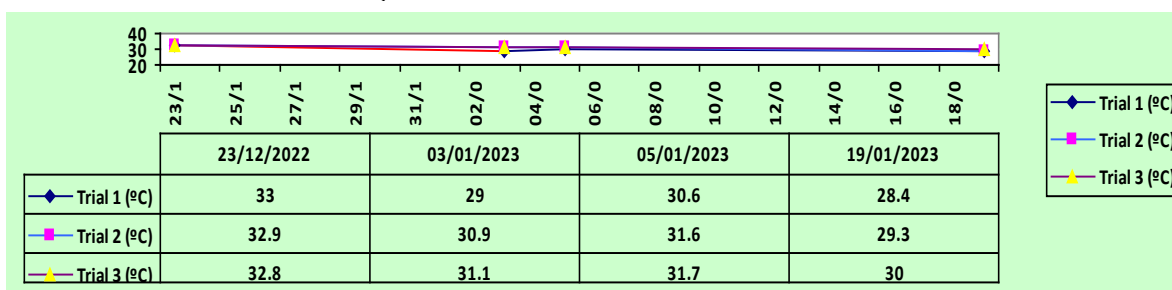


FIGURE 16. Air Temperature (°C).

FIGURE 12 to 16 shows all the soil parameters (soil pH, soil temperature, relative humidity, and air temperature) measured at Chonradsadornurung School, Chonburi, Thailand from December 23, 2022 to January 19, 2023. Each parameter was measured 3 times to get the valid result. All of the graphs above revealed that there are changes in all factors measured for 4 times. Analysis of variance and Tukey HSD test were the statistical method used to compare these results and to find out if there are significant differences among the collected data.

Table 2. *In vitro* Allelopathic Screening results on the growth of Mung Beans (*Vigna radiata*).

Treatments	Replications	Seedlings (Length of the Root and Shoot)						
		1 (cm)	2 (cm)	3 (cm)	4 (cm)	5 (cm)	Total (cm)	Mean (cm)
Control (Distilled Water)	1	5.21	6.89	4.81	3.5	4.30	24.71	4.94
	2	8.14	4.98	8.14	4.81	1.26	27.33	5.47
	3	5.6	2.7	4.2	4.6	4.6	21.7	4.34
100% Rose Apple Ethanollic Extract	1	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0
Boiled Rose Apple Extract	1	0.8	0	0	0	1.05	1.85	0.37
	2	1.4	1.9	1.05	1.5	1.1	6.95	1.39
	3	2.3	1.55	1.5	2.65	2.7	10.7	2.14

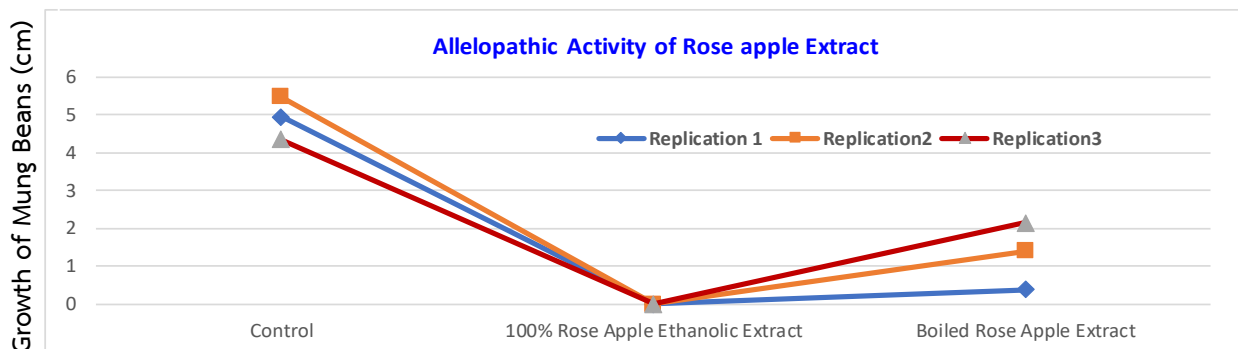


Figure 17. Results of the Allelopathic Screening on the growth Mung Beans (*Vigna radiata*).



Figure 18. Results of Allelopathic Test after 5 days observation.

TABLE 2 and FIGURE 17-18 shows the results of the *In vitro* allelopathic screening of the 100% ethanolic and boiled extracts of Rose apple against mung beans. It can be seen clearly that among the 3 treatments, the growth of mung beans can only be observed in the control set-up and boiled extract of Rose apple. Hence, the alternative hypothesis has to be accepted because the ethanolic and boiled extracts of the plant are effective allelopathic agent in inhibiting the growth of mung beans after 5 days observation.

One-way ANOVA was used to determine the differences among the treatments used in allelopathic screening using the ethanolic and boiled extracts of the experimental plant against Mung Beans (*Vigna radiata*). It was found out that the p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that the treatments were significantly different. With this, the alternative hypothesis has to be accepted since the extracts are effective allelopathic agent in inhibiting the growth of mung beans.

Table 3. Allelopathic Screening results on the growth of Mung Beans (*Vigna radiata*) planted in soil sample from Chonradsadornumrung School.

Treatments	Replications	Seedlings (Length of the Root and Shoot)				
		1 (cm)	2 (cm)	3 (cm)	Total (cm)	Mean (cm)
Control (Distilled Water)	1	10.5	9.80	10.45	30.75	10.25
	2	9.60	9.20	9.70	28.5	9.5
	3	13.20	12	10.40	35.60	11.87
100% Rose Apple Ethanollic Extract	1	0	0	0	0	0
	2	0	0	0	0	0
	3	0	0	0	0	0
Boiled Rose Apple Extract	1	0	0	0	0	0
	2	0	0	0	0	0
	3	0	0	0	0	0

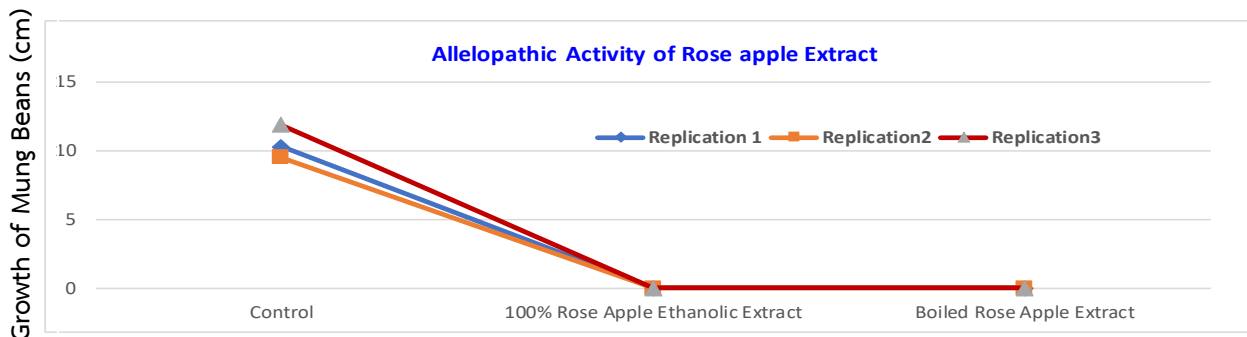


Figure 19. Results of the Allelopathic Screening on the growth Mung Beans (*Vigna radiata*).

TABLE 3 and **FIGURE 19-20** shows the results of the allelopathic screening of the 100% ethanolic and boiled extracts of Rose apple against mung beans that were planted in the soil sample taken from Chonradsadronumrung School. It can be seen clearly that among the 3 treatments, the growth of mung beans can only be observed in the control set-up. The ethanolic and boiled extracts of rose apple inhibited the growth of mung beans. Hence, the alternative hypothesis has to be accepted because the ethanolic and boiled extracts of the plant are effective allelopathic agent in inhibiting the growth of mung beans after 5 days observation.

One-way ANOVA was used to determine the differences among the treatments used in allelopathic screening using the ethanolic and boiled extracts of the experimental plant

against Mung Beans (*Vigna radiata*). It was found out that the p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that the treatments were significantly different. With this, the alternative hypothesis has to be accepted since the extracts are effective allelopathic agent in inhibiting the growth of mung beans.



Figure 20. Results of Allelopathic Test after 5 days observation. **C-** Control group, **RA-** Rose Apple Ethanolic Extract, **RAW-** Boiled Ethanolic Extract of Rose Apple.

TABLE 4. Phytochemical constituents of Rose Apple (*Syzygium jambos*).

Phytochemicals	Rose Apple (<i>Syzygium jambos</i>)
Alkaloids	+
Saponins	-
Tannins	+
Phenolic Compounds	+
Flavonoids	+
Leucoanthocyanins	+

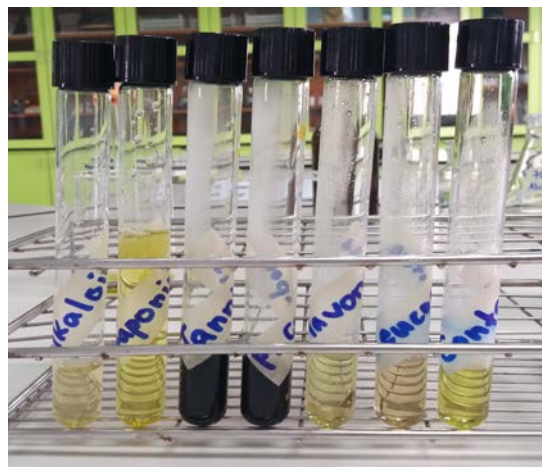


Table 4 shows the observations done by the researchers during the phytochemical screening of the ethanolic extract of Rose Apple (*Syzygium jambos*). After conducting various tests, it was found out that the leaves of the plant are positive for the presence of Alkaloids, Tannins, Flavonoids, Phenolic compounds, Flavonoids, and Leucoanthocyanins. These secondary compounds of the plant are responsible for its allelopathic potential against mung beans.

Discussion

The results of field measurement, ANOVA, and post-hoc Tukey HSD test showed that there was a significant difference in some soil parameters measured at Chonradsadornumrung School such as soil pH, relative humidity, and air temperature but there was no significant difference in the soil temperature measured at 5 cm and 10 cm depth. It shows that there were no significant changes in the soil quality inside the campus of Chonradsadornumrung school despite of the changes taking place and dry season. The acquired data is pertinent to the study of Milosevic et al., 2020 that claims that the physical characteristics of soil are largely fixed and won't change over time. These characteristics are crucial for the soils' long-term productivity. The main factors that can contribute to changes in soil health are soil organisms, including the abundance and diversity of bacteria, fungi, and nematodes, as they respond sensitively to anthropogenic disturbance (Lynch, 2015). In allelopathy test, it was found out that soil from Chonradsadornumrung School can still support the growth of plants. It shows that anthropogenic activities and drought season did not affect the quality of the soil inside the campus.

Research done by many researchers revealed that plants produce natural products or secondary metabolites with a prominent function in the protection against predators and microbial pathogens on the basis of their toxic nature and repellence to herbivores and microbes and some of which also involved in defense against abiotic stress and also important for the communication of the plants with other organisms (Schafer et.al., 2009).

The existence of biologically active phytochemicals such as alkaloids, flavonoids, steroids, saponins, and terpenoids in the plants makes them medicinally important. Furthermore, plant bioactive compounds, also called allelochemicals (Farooq et al., 2011) act as pesticides and can be effectively used for weed management in field crops (Cheema et al., 2000). The experimental plant possessed different kinds of secondary compounds. Among these compounds; Alkaloids, Tannins, Phenolic compounds and Flavonoids have allelopathic properties. These allelochemicals are used by the plant as potent allelopathic agent for intraspecific and interspecific competition within their habitat (Guevara, 2005). These are the valuable reasons why rose apple extract can inhibit the growth of mung beans. Moreover, the secondary substances possessed by the experimental plant helps

them thrive despite of biotic and abiotic stressors from the environment. This is why there are Rose plants that can grow inside the campus.

CONCLUSION

Based on the experimentations, results and gathered data, the researchers concluded that there are significant differences in soil pH, relative humidity, and air temperature, except for soil temperature measured at 5 cm and 10 cm depth. Additionally, the ethanolic and boiled extracts of Rose Apple (*Syzygium jambo*) possess an allelopathic potential because it can inhibit the growth of Mung beans (*Vigna radiata*). Lastly, the extract of the plant contains secondary compounds such as alkaloids, tannins, phenolic compounds, flavonoids, and Leucoanthocyanins.

RECOMMENDATIONS

For the improvement of the study, more research should be done to test the other soil properties in the sampling site such as the soil fertility also the allelopathic activity of Rose Apple (*Syzygium jambo*) against other plants aside from Mung beans. Moreover, various types of soil sample from Chonradsadornumrung School will be used to determine the allelopathic activity of the experimental plant.

GLOBE Badges

I am a Collaborator

This environmental research was finished completely because of the collaborative efforts of various individuals. During the conduct of the study, the researchers were thoroughly guided and given knowledge by their teachers namely Ms. Rawadee Meesuk and Mr. Marvin Servallos. Furthermore, the soil quality testing was carried out properly because of some of the materials provided by the home economics department of the school such as shovel and hand forks. Thorough guidance and invaluable ideas from the above names were very significant to completely understand all the scopes of this research. Finally, the researchers of this science project have cooperated to finish the work entirely from the planning stage, experiments, analyzing of data, and packaging of the final research paper.

I Make an Impact

The observations of the researchers around Chonradsadronumrung School such as construction of infrastructures also the prolonged drought in Chonburi Province, Thailand led them to develop this type of research. The methods and results gathered in this study have great impact to the community of Chonradsadornumrung School especially, to the students because it serves as an eye opener for them that young learners like the researchers can have a valuable contribution in discovering the effects of human activities and natural phenomenon like drought to their environment. This research will significantly impact including the agriculture sector because the result of allelopathic test will propel them to use organic materials like plants in inhibiting the growth of unwanted plants instead of using commercial herbicides that are expensive and harmful to the body.

I am a Data Scientist

The researchers have studied systematically the current condition of soil sample from Chonradsadronumrung School campus. The results were collected, recorded, and analyzed properly. In addition, botany experiment was integrated to this environmental research. All of the data gathered from the field measurement were analyzed using some statistical models like ANOVA (Analysis of Variance) with post-hoc Tukey HSD (Honestly Significant Difference) Test. The results of the analysis were discussed and presented properly. Moreover, the results of the experiment were linked to the research done by other researchers.

Acknowledgment

The researchers of the study would like to acknowledge the following for making this science project possible. First, they would like to convey their genuine thanks to the Head of CRU English Program Ms. Rawadee Meesuk for her utmost support, suggestions, and encouragement as well as for providing all the Laboratory equipment and chemicals that they need in their study. Second, the researchers would like to thank their Science teacher-Mr. Marvin Servallos, for his guidance towards the completion of the study. Finally, the researchers would like to give their special thanks to the committee of IPST and Globe Student Research Competition for conducting this prestigious event that enabled young scientists to share their scientific discoveries.

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Appendix 1

ANOVA (Analysis of Variance) for soil pH measured from Chonradsadornumrung School for 4 consecutive times.

Treatment →	A	B	C	D	source	sum of squares SS	degrees of freedom	mean square MS	F statistic	p-value
Input Data →	7.5	7.5	7.5	7.0	treatment	0.6225	3	0.2075	62.2500	6.8912e-06
	7.5	7.5	7.5	7.0	error	0.0267	8	0.0033		
	7.7	7.5	7.5	7.0	total	0.6492	11			

Conclusion from ANOVA:

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that one or more treatments are significantly different for that level of significance. The Tukey HSD test multiple comparison tests follow. This post-hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

Tukey HSD results for soil pH.

Treatments pair	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inference
A vs B	2.0000	0.5242643	insignificant
A vs C	2.0000	0.5242643	insignificant
A vs D	17.0000	0.0010053	** p<0.01
B vs C	0.0000	0.8999947	insignificant
B vs D	15.0000	0.0010053	** p<0.01
C vs D	15.0000	0.0010053	** p<0.01

Appendix 2

ANOVA (Analysis of Variance) for soil temperature at 5 cm depth measured from Chonradsadornumrung School for 4 consecutive times.

Treatment →	A	B	C	D	Source	sum of squares SS	degrees of freedom	mean square MS	F statistic	p-value
Input Data →	33.0	30.0	32.0	32.0	treatment	6.0000	3	2.0000	4.0000	0.0519
	33.0	31.0	32.0	33.0	error	4.0000	8	0.5000		
	32.0	32.0	31.0	33.0	total	10.0000	11			

Conclusion from ANOVA:

The p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that are not significantly different for that level of significance. The Tukey HSD test multiple comparison tests follow. This post-hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

Tukey HSD results for soil temperature at 5 cm depth.

Treatments pair	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inference
A vs B	4.0825	0.0781101	insignificant
A vs C	2.4495	0.3694296	insignificant
A vs D	0.0000	0.8999947	insignificant
B vs C	1.6330	0.6570228	insignificant
B vs D	4.0825	0.0781101	insignificant
C vs D	2.4495	0.3694296	insignificant

Appendix 3

ANOVA (Analysis of Variance) for soil temperature at 10 cm depth measured from Chonradsadornumrung School for 4 consecutive times.

Treatment →	A	B	C	D	Source	sum of squares SS	degrees of freedom	mean square MS	F statistic	p-value
Input Data →	33.0	31.0	32.0	33.0	treatment	3.0000	3	1.0000	1.7143	0.2409
	33.0	31.0	32.0	33.0	error	4.6667	8	0.5833		
	32.0	33.0	31.0	32.0	total	7.6667	11			

Conclusion from ANOVA:

The p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that are not significantly different for that level of significance. The Tukey HSD test multiple comparison tests follow. This post-hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

Tukey HSD results for soil temperature at 10 cm depth.

Treatments pair	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inference
A vs B	2.2678	0.4294844	insignificant
A vs C	2.2678	0.4294844	insignificant
A vs D	0.0000	0.8999947	insignificant
B vs C	0.0000	0.8999947	insignificant
B vs D	2.2678	0.4294844	insignificant
C vs D	2.2678	0.4294844	insignificant

Appendix 4

ANOVA (Analysis of Variance) for relative humidity measured from Chonradsadornumrung School for 4 consecutive times.

Treatment →	A	B	C	D	Source	sum of squares SS	degrees of freedom	mean square MS	F statistic	p-value
Input Data →	35.0	50.0	40.0	41.0	treatment	130.0000	3	43.3333	5.3608	0.0257
	37.0	43.0	38.0	39.0	error	64.6667	8	8.0833		
	35.0	41.0	37.0	36.0	total	194.6667	11			

Conclusion from ANOVA:

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that one or more treatments are significantly different for that level of significance. The Tukey HSD test multiple comparison tests follow. This post-hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

Tukey HSD results for relative humidity.

Treatments pair	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inference
A vs B	5.4829	0.0196628	* p<0.05
A vs C	1.6246	0.6600767	insignificant
A vs D	1.8276	0.5866194	insignificant
B vs C	3.8583	0.0976610	insignificant

B vs D	3.6552	0.1195542	insignificant
C vs D	0.2031	0.8999947	insignificant

Appendix 5

ANOVA (Analysis of Variance) for air temperature measured from Chonradsadornumrung School for 4 consecutive times.

Treatment →	A	B	C	D	source	sum of squares SS	degrees of freedom	mean square MS	F statistic	p-value
Input Data →	33.0	29.0	30.6	28.4	treatment	21.7558	3	7.2519	12.2568	0.0023
	32.9	30.9	31.6	29.3	error	4.7333	8	0.5917		
	32.8	31.1	31.7	30.0	total	26.4892	11			

Conclusion from ANOVA:

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that one or more treatments are significantly different for that level of significance. The Tukey HSD test multiple comparison tests follow. This post-hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

Tukey HSD results for relative humidity.

Treatments pair	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inference
A vs B	5.7795	0.0148343	* p<0.05
A vs C	3.6028	0.1257605	insignificant
A vs D	8.2565	0.0017401	** p<0.01
B vs C	2.1767	0.4611536	insignificant
B vs D	2.4769	0.3608283	insignificant
C vs D	4.6536	0.0441865	* p<0.05

Appendix 6

ANOVA (Analysis of Variance) for the *In vitro* Allopathic activity of Rose Apple.

Treatment →	A	B	C	Source	sum of squares SS	degrees of freedom	mean square MS	F statistic	p-value
Input Data →	4.94	0.0	0.37	treatment	38.9439	2	19.4719	52.6775	0.0002
	5.47	0.0	1.39	error	2.2179	6	0.3696		
	4.34	0.0	2.14	total	41.1618	8			

Conclusion from ANOVA:

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that one or more treatments are significantly different for that level of significance. The Tukey HSD test multiple comparison tests follow. This post-hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

Tukey HSD results for *In vitro* Allelopathic activity of Rose Apple.

Treatments pair	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inference
A vs B	14.0068	0.0010053	** p<0.01
A vs C	10.3033	0.0010053	** p<0.01
B vs C	3.7035	0.0874300	insignificant

Appendix 7

ANOVA (Analysis of Variance) for the Allopathic activity of Rose Apple on the growth of Mung Beans planted in soil sample from Chonradsadornumrung School.

Treatment →	A	B	C
Input Data →	10.25	0.0	0.0
	9.5	0.0	0.0
	11.87	0.0	0.0

source	sum of squares SS	degrees of freedom	mean square MS	F statistic	p-value
treatment	222.1832	2	111.0916	227.1347	2.2152e-06
error	2.9346	6	0.4891		
total	225.1178	8			

Conclusion from ANOVA:

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that one or more treatments are significantly different for that level of significance. The Tukey HSD test multiple comparison tests follow. This post-hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

Tukey HSD results for Allelopathic activity of Rose Apple.

Treatments pair	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inference
A vs B	26.1037	0.0010053	** p<0.01
A vs C	26.1037	0.0010053	** p<0.01
B vs C	0.0000	0.8999947	insignificant