GALAXY INTERNATIONAL INTERDISCIPLINARY RESEARCH JOURNAL (GIIRJ)
ISSN (E): 2347-6915
Vol. 9, Issue 5, May (2021)

SEED GERMINATION AND SEEDLING GROWTH OF MANGO AS AFFECTED BY DIFFERENT CONCENTRATIONS OF WOOD VINEGAR

Ronel S. De Guzman
Faculty[1], President Ramon Magsaysay State University, Zambales, Philippines
*Corresponding author: neldaghostman06@prmsu.edu.ph

Michelle Irish Y. Dadural
Student Reseacher[2], President Ramon Magsaysay State University,
Zambales, Philippines

ABSTRACT

The study was conducted to assess the seed germination and seedling growth of Mango (Mangifera indica L.) as affected by different concentrations of wood vinegar.

The study was laid out in Randomized Complete Block Design (RCBD) with five (5) treatments, three (3) replications, and ten (10) samples per replication. The treatments are the following: Treatment 1 (no wood vinegar application), Treatment 2 (2% of wood vinegar), Treatment 3 (1% of wood vinegar), Treatment 4 (0.67% of wood vinegar), and Treatment 5 (0.5% of wood vinegar). The result showed that mango applied with Treatment 3 were the fastest to germinate, Treatment 2 produced the tallest seedlings. There was no significant difference in the stem diameter, number of true leaves, days of true leaves, number of seedlings per seed, length of longest roots, the diameter of longest roots, and the number of secondary roots as the analysis of variance the said parameters revealed.

Based on the study, the application of 1% of wood vinegar can be implemented to fasten plant germination, and also 2% of wood vinegar can be used to increase plant growth in a short period. Furthermore, studies on applying different concentrations of wood vinegar and lengthening the span of the study can be designed for future research.

Keywords: Mango, germination, seedling growth, and wood vinegar

INTRODUCTION

Rationale

Mango (Mangifera indica L.) belongs to the family Anacardiaceae and considered as National fruit of the Philippines is one of the most important crops of the country.

According to Philippine Statistics Authority (PSA, 2021), the October to December 2020 mango production of 27.53 thousand metric tons was a -0.9 percent decrease from 27.78 thousand metric tons' production in the same period of 2019. Still, the most produced variety is Carabao mango with 22.54 thousand metric tons, representing 81.9 percent of the total mango production. During the period, Caraga was the top producer of mango with 6.84 thousand metric tons output, a 24.8 percent share of the total production. The Zamboanga Peninsula and Northern Mindanao followed with 24.2 percent and 15.8 percent shares, respectively.

Mango can be propagated sexually using the seeds and asexually using vegetative parts. Propagation by seed is common, however, under orchard-type management, more growers

prefer to plant grafted mangoes instead of seedlings since more trees are planted to a hectare and fruit production is much early (Bureau of Plant Industry, 2015). One of the most used varieties as a rootstock in the Philippines is Katchamitha mangoes or also known as Indian mangoes because of their abundance and polyembryonic seeds.

Reddy and Vineeth Raj (2015) stated that although rootstocks have several applications such as improving fruit quality, imparting adaptability to climatic and edaphic conditions, and inducing dwarfing, the priorities of rootstocks selection in the tropics, and subtropics have been focused mainly on vigor management and securing regular high fruit yields.

According to Abbas et al. (2015), the highest germination percentage and germination velocity of mango seeds and average seedling growth could be achieved through husking seeds or sowing seed in a position vertical with the convex edge upwards after soaking in tap water (48h) or through soaking seeds in GA3 at 1000 ppm for 48h.

Apai and Thongdeethae (2001) stated that raw wood vinegar has more than 200 chemicals, such as acetic acid, formaldehyde, ethyl-valerate, methanol, tar, etc. Wood vinegar has been used in various processes, such as industrial, livestock, household, and agricultural products. Wood vinegar reportedly improves soil quality, eliminates pests, accelerates plant growth, and acts as a plant growth regulator or growth inhibitor.

Nakai et al. (2007) and Ho et al. (2013) added that wood vinegar is an acidic aqueous by-product obtained from the distillation of smoke generated during the carbonization process. It comprises water (80-90%) and a mixture of complex organic compounds (10-20%) such as phenolics, ketones, furan, pyran, and organic acids. Wood vinegar is known for its use in odor removal, smoke flavoring, promoting plant growth, acting as herbicides and pesticides, inhibiting bacterial growth, and antioxidant and anti-inflammatory activity.

According to Garcia-Perez et al. (2007), wood vinegar affects plant growth and seed germination. Wang et al. (2017) studied the effects of wood vinegar on the germination and root growth of carrot, rape, and cabbage, and the results showed that wood vinegar could significantly promote the germination and root growth of carrot and cabbage seeds, while the effects on rapeseed germination were not noticeable. Wood vinegar had no significant effect on seedling growth. Mu et al. (2003) also found that the highly concentrated wood vinegar inhibited seed germination. The results revealed that the distilled wood vinegar could increase seed germination and promote the seedling growth of rape.

Thus, for a need of suitable methods for obtaining maximum germination and rapid growth to produce a large number of healthy, sizable mango seedlings and transplanting in a shorter possible time, this study was conducted to determine the effect of wood vinegar in seed germination and seedling growth of mango.

MATERIALS AND METHODOLOGY

Research Materials and Equipment

The materials used in this study were Indian mango seeds, wood vinegar, polyethylene plastic, pruning shear, beaker, test tube, caliper, measuring tape, and record book.

Experimental Design

The study was laid out in Randomized Complete Block Design (RCBD) with five (5) treatments, three (3) replications with ten (10) samples per replication.

Treatments

The different treatments will follow:
Treatment 1- Control (no application of wood vinegar)
Treatment 2- 2% wood vinegar (1-part wood vinegar: 50-part of water)
Treatment 3- 1% wood vinegar
Treatment 4- 0.67% wood vinegar
Treatment 5- 0.5% wood vinegar

Experimental Procedure

Gathering and Selection of Materials

Gathering and selecting materials by harvesting Indian mango seeds, a ripped fruit was taken. Wood vinegar was obtained in Zambali Beach Farm, Botolan, Zambales. Rice hull was used in making wood vinegar.

Soil Media Preparation

An equal proportion of topsoil, cattle manure, and carbonized rice hulls was used. Each pot was filled with a growing medium until 2 cm from the rim.

Seed Sowing

Before seed sowing, the mango seeds were dehusked and soaked in different treatments for 24 hours. The treated seeds were sown in polyethylene bags with the concave side down at 1-2 cm deep or the subsurface of the medium. Light irrigation was provided just after sowing.

Watering

When planting is done during the low rainfall season, the young plants were watered at least twice a week to avoid drying and wilting.

Treatment Application

Mangoes were watered once a week with wood vinegar based on the treatments to ensure that the plants would absorb all the nutrients present in the treatment used.

Data Gathered

The data were observed and recorded every week. Photos were also taken in every activity. The data gathered were as follows:

A. Average Number of Days to Germination

The days from planting until plants were germinated was counted.

B. Average Final Height of First Shoot (cm)

Initial height of seedlings was measured one week after germination. It was measured weekly to determine the weekly growth.

C. Average Final Stem Diameter of First Shoot (mm)

Stem diameter was measured weekly using caliper.

D.Average Number of True Leaves

The number of true leaves was counted when the leaves are green.

E. Average Days of True Leaves

The number of days of true leaves was counted from the day that the plant started to germinate until its leaves turn to green.

F. Average Number of Seedling per Seed

The number of seedling per seed was counted as the plant started to germinate.

G.Average Length of Longest Root (cm)

The length of longest root was measured using measuring tape and ruler.

H.Average Diameter of Longest Root (mm)

The diameters of the longest roots were measured using a caliper.

I. Average Number of Secondary Roots

The number of secondary roots was manually counted.

Statistical Analysis of Data

All the data gathered was tabulated and statistically analyzed using Analysis of Variance (ANOVA) in Simple Randomized Complete Block Design (RCBD). Significant differences were calculated using Least Significant Difference (LSD) at 5% and 1% of significant level.

RESULT AND DISCUSSION

In this study, the effect of different concentrations of wood vinegar in seed germination and seedling growth of mango was evaluated.

Table 1.a presents the average days to germination.

Table 1.a Average Days to Germination

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	12.70	13.22	13.22	39.14	13.05
Treatment 2- 2%	10.20	10.30	10.70	31.20	10.40**
Treatment 3- 1%	9.90	10.80	9.88	30.58	10.19**
Treatment 4- 0.67%	11.60	10.90	11.78	34.28	11.43**
Treatment 5- 0.5%	10.60	12.00	10.14	32.74	10.91**
Grand Total (G)				167.94	
Grand Mean					11.20

As shown in Table 1.a, the plants applied with Treatment 3 have the fastest plants that germinate with an average of 10.19 days, followed by Treatment 2, Treatment 5, Treatment 4, and Treatment 1 with averages of 10.40 days, 10.91 days, 11.43 days, and 13.05 days, respectively.

Table 1.b presents the analysis of variance of average days to germination.

Table 1.b Analysis of Variance of Average Days to Germination

Source of Variation	DF	SS	MS	Computed F	Tabular F	
					5%	1%
Replication	2	0.51	0.17	**0.51**	4.46	8.65
Treatment	4	15.59	5.20	**15.58****	3.84	7.01
Error	8	2.67	0.33			
Total	14	18.77				

**= Highly Significant
CV = 5.16 %
LSD 5%=1.09%
LSD 1%=1.58%

Table 1.b revealed a highly significant difference in levels of wood vinegar because the computed F value was higher than 5% and 1% level of significance. The comparison means were further measured using LSD, where Treatment 2, Treatment 3, Treatment 4, and Treatment 5 have a highly significant difference to control.
The result of this study confirmed the statements of Mu (2003), Daws et al. (2007), Garcia-Perez et al. (2007), Daws et al. (2008), and Wang et al. (2017) that wood vinegar improves germination.

Table 2. a presents the average final height of plants (cm).

Table 2.a Average Final Height of Plants (cm)

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	23.92	22.40	20.04	66.36	22.12
Treatment 2- 2%	24.30	24.91	24.37	73.58	24.53
Treatment 3- 1%	26.41	22.11	21.48	70.00	23.33
Treatment 4- 0.67%	22.90	21.15	16.49	60.54	20.18
Treatment 5- 0.5%	25.03	22.51	23.69	71.23	23.74
Grand Total (G)				341.71	
Grand Mean					22.78

As shown in Table 2.b, the plants applied with Treatment 2 produced the tallest plants with an average of 24.53 cm, followed by Treatment 5, Treatment 3, Treatment 1, and Treatment 4 with averages of 23.74 cm, 23.33 cm, 22.12 cm, and 20.18 cm respectively.

Table 2.b presents the analysis of variance of average final height of plants.

Table 2.b Analysis of Variance of Average Final Height of Plants

Source of Variation	DF	SS	MS	Computed F	Tabular F	
					5%	1%
Replication	2	27.40	9.13	**3.65**	4.46	8.65
Treatment	4	34.44	11.48	**4.59***	3.84	7.01
Error	8	20.00	2.50			
Total	14	81.84				

*= Significant
CV = 6.94 %
LSD 5%=2.98
LSD 1%=4.33

Table 2.b revealed a significant difference in concentrations of wood vinegar because the computed F value was higher than the tabular F value at 5% but not higher than the tabular F value at a 1% level of significance. Also, LSD showed that there are no significant differences between the control and Treatments.

The result confirmed the statement of De Guzman and Adalla (2021) that the application of wood vinegar has a greater effect on plant growth that enables to accelerate the development of roots and leaves.

Yang et al. (2014) added that the plant growth might also have affected by the presence of organic acids, with acetic acid being one of the principal components and various forms of alcohol in wood vinegar. The presence of these alcohols, acids, and aldehydes in wood vinegar could also serve as carbon and energy substrates for soil microorganisms, thus promoting plant growth.

Table 3.1 presents the average final stem diameter of plants (mm).

Table 3.a Average Final Stem Diameter of Plants (mm)

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	5.55	5.07	4.88	15.50	5.17
Treatment 2- 2%	5.75	5.40	5.60	16.75	5.58
Treatment 3- 1%	5.20	5.80	5.06	16.06	5.35
Treatment 4- 0.67%	5.40	5.05	4.22	14.67	4.89
Treatment 5- 0.5%	5.05	5.13	5.21	15.39	5.13
Grand Total (G)				78.37	
Grand Mean					5.22

As shown in Table 3.a, Treatment 2 plants had the widest stem diameter with an average of 5.58 mm, followed by Treatment 3, Treatment 1, Treatment 5, and Treatment 4 with averages of 5.35 mm, 5.17 mm, 5.13 mm, and 4.89 mm, respectively.

Table 3.b presents the analysis of variance of average final stem diameter of plants.

Table 3.b Analysis of Variance of Average Final Stem Diameter of Plants

Source of Variation	DF	SS	MS	Computed F	Tabular F	
					5%	1%
Replication	2	0.42	0.14	**1.21**	4.46	8.65
Treatment	4	0.81	0.27	**2.31^{ns}**	3.84	7.01
Error	8	0.93	0.12			
Total	14	2.17				

^{ns}= Not Significant

CV = 6.53 %

Table 3.b revealed no significant difference in concentrations of wood vinegar because the computed F value was lower than the tabular F value at 5% and 1% level of significance.

Table 4.a presents the average number of true leaves.

Table 4.a Average Number of True Leaves

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	5.00	4.44	4.25	13.69	4.56
Treatment 2- 2%	4.70	4.40	4.80	13.90	4.63
Treatment 3- 1%	4.30	5.40	5.63	15.33	5.11
Treatment 4- 0.67%	3.90	4.00	2.89	10.79	3.60
Treatment 5- 0.5%	3.90	4.00	5.14	13.04	4.35
Grand Total (G)				66.75	
Grand Mean					4.45

As shown in Table 4.a, the evaluation of an average number of true leaves showed that Treatment 3 has the highest number of true leaves with an average of 5.11 leaves, followed by Treatment 2, Treatment 1, Treatment 5, and Treatment 4 with averages 4.63 leaves, 4.56 leaves, 4.35 leaves and 3.60 number of leaves, respectively.

Table 4.b presents the analysis of variance of average number of true leaves.

Table 4.b Analysis of Variance of Average Number of True Leaves

Source of Variation	DF	SS	MS	Computed F	Tabular F	
					5%	1%
Replication	2	0.08	0.03	**0.07**	4.46	8.65
Treatment	4	3.66	1.22	**3.23^{ns}**	3.84	7.01
Error	8	3.02	0.38			
Total	14	6.77				

^{ns}= Not Significant

CV = 13.81 %

Table 4.b revealed no significant difference in concentrations of wood vinegar because the computed F value was lower than the tabular F value at 5% and 1% level of significance.

Table 5.a presents the average days of true leaves.

Table 5.a Average Days of True Leaves

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	11.90	11.78	14.63	38.31	12.77
Treatment 2- 2%	12.00	12.10	11.90	36.00	12.00
Treatment 3- 1%	12.70	12.30	12.50	37.50	12.50
Treatment 4- 0.67%	11.70	12.40	12.89	36.99	12.33
Treatment 5- 0.5%	13.20	12.13	12.86	38.19	12.73
Grand Total (G)				186.99	
Grand Mean					12.47

As shown in Table 5.a, the evaluation of the fastest days of true leaves was Treatment 2 with an average of 12.00 days, followed by Treatment 4, Treatment 3, Treatment 5, and Treatment 1 with averages of 12.33 days, 12.50 days, 12.73 days and 12.77 days, respectively.

Table 5.b presents the analysis of variance of average days of true leaves.

Table 5.b Analysis of Variance of Average Days of True Leaves

Source of Variation	DF	SS	MS	Computed F	Tabular F	
					5%	1%
Replication	2	1.86	0.62	**1.05**	4.46	8.65
Treatment	4	1.20	0.40	**0.67^{ns}**	3.84	7.01
Error	8	4.75	0.59			
Total	14	7.81				

^{ns}= Not Significant

CV = 6.18 %

Table 5.b revealed no significant difference in concentrations of wood vinegar because the computed F value was lower than the tabular F value at 5% and 1% level of significance.

Table 6.a presents the average number of seedling per seed.

Table 6.a Average Number of Seedling per Seed

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	3.20	3.11	3.25	9.56	3.19
Treatment 2- 2%	3.00	3.50	3.30	9.80	3.27
Treatment 3- 1%	3.50	3.30	3.63	10.43	3.48
Treatment 4- 0.67%	3.50	2.90	2.11	8.51	2.84
Treatment 5- 0.5%	3.10	3.25	2.86	9.21	3.07
Grand Total (G)				47.51	
Grand Mean					3.17

As shown in Table 6.a, the highest number of seedlings per seed mean is Treatment 3 with an average of 3.48 seedlings, followed by Treatment 2, Treatment 1, Treatment 5, and Treatment

4 with averages of 3.27 seedlings, 3.19 seedlings, 3.07 seedlings, and 2.84 seedlings, respectively.

Table 6.b presents the analysis of variance of average number seedling per seed.

Table 6.b Analysis of Variance of Average Number Seedling per Seed

Source of Variation	DF	SS	MS	Computed F	Tabular F 5%	Tabular F 1%
Replication	2	0.15	0.05	**0.36**	4.46	8.65
Treatment	4	0.67	0.22	**1.64^{ns}**	3.84	7.01
Error	8	1.09	0.14			
Total	14	1.92				

^{ns}= Not Significant

CV = 11.68 %

The Analysis of Variance revealed no significant difference in concentrations of wood vinegar because the computed F value was lower than the tabular F value at 5% and 1% level of significance.

Table 7.a presents the average length of longest roots (cm).

Table 7.a Average Length of Longest Roots (cm)

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	23.49	15.62	17.53	56.64	18.88
Treatment 2- 2%	23.14	18.84	16.06	58.04	19.35
Treatment 3- 1%	18.05	15.54	23.28	56.87	18.96
Treatment 4- 0.67%	18.05	20.10	18.69	56.84	18.95
Treatment 5- 0.5%	19.97	22.86	19.47	62.30	20.77
Grand Total (G)				290.69	
Grand Mean					19.38

As shown in Table 7.a, that plants applied with Treatment 5 have the longest roots with an average of 20.77 cm, followed by Treatment 2, Treatment 3, Treatment 4, and Treatment 1 with averages of 19.35 cm, 18.96 cm, 18.95 cm, and 18.88 cm, respectively.

Table 7.b presents the analysis of variance of average length of longest roots (cm).

Table 7.b Analysis of Variance of Average Length of Longest Roots (cm)

Source of Variation	DF	SS	MS	Computed F	Tabular F 5%	Tabular F 1%
Replication	2	10.53	3.51	**0.32**	4.46	8.65
Treatment	4	7.64	2.25	**0.23^{ns}**	3.84	7.01
Error	8	88.67	11.08			
Total	14	106.84				

^{ns}= Not Significant

CV = 17.18 %

The Analysis of Variance revealed no significant difference in concentrations of wood vinegar because the computed F value is lower than the tabular F value at 5% and 1% level of significance.

Table 8.a presents the average diameter of longest roots (mm).

Table 8.a Average Diameter of Longest Roots (mm)

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	5.50	4.83	5.81	16.14	5.38
Treatment 2- 2%	6.65	6.00	6.10	18.75	6.25
Treatment 3- 1%	5.80	6.15	5.56	17.51	5.84
Treatment 4- 0.67%	5.70	5.90	4.94	16.54	5.51
Treatment 5- 0.5%	5.60	6.13	5.71	17.44	5.81
Grand Total (G)				86.38	
Grand Mean					5.76

As shown in Table 8.a, the plants that have the widest diameter of roots are Treatment 2 with an average of 6.25 mm, followed by Treatment 3, Treatment 5, Treatment 4, and Treatment 1 with averages of 5.84 mm, 5.81 mm, 5.51 mm and 5.38 mm, respectively.

Table 8.b presents the analysis of variance of average diameter of longest roots (mm).

Table 8.b Analysis of Variance of Average Diameter of Longest Roots (mm)

Source of Variation	DF	SS	MS	Computed F	Tabular F 5%	Tabular F 1%
Replication	2	0.14	0.05	**0.26**	4.46	9.65
Treatment	4	1.36	0.45	**2.50^{ns}**	3.84	7.01
Error	8	1.45	0.18			
Total	14	2.95				

^{ns}= Not Significant

CV = 5.58 %

The Analysis of Variance revealed no significant difference in concentrations of wood vinegar because the computed F value was lower than tabular F at 5% and 1% level of significance.

Table 9.a presents the average number of secondary roots.

Table 9.a Average Number of Secondary Roots

Treatment	R1	R2	R3	Total	Mean
Treatment 1- (Control)	12.70	9.67	9.50	31.87	10.62
Treatment 2- 2%	28.60	26.40	21.40	76.40	25.47
Treatment 3- 1%	11.10	18.00	24.63	53.73	17.91
Treatment 4- 0.67%	19.00	30.70	12.89	62.59	20.86
Treatment 5- 0.5%	16.00	23.50	14.29	53.79	17.93
Grand Total (G)				278.37	
Grand Mean					18.56

As shown in Table 9.a, the highest number of secondary roots per plant is Treatment 2 with an average of 25.47, followed by Treatment 4, Treatment 5, Treatment 3, and Treatment 1 with averages of 20.86, 17.93, 17.91, and 10.62, respectively.

Table 9.b presents the analysis of variance of average number of secondary roots.

Table 9.b Analysis of Variance of Average Number of Secondary Roots

Source of Variation	DF	SS	MS	Computed F	Tabular F 5%	Tabular F 1%
Replication	2	74.08	24.69	**0.75**	4.46	8.65
Treatment	4	350.51	116.84	**3.55^{ns}**	3.84	7.01
Error	8	262.97	32.87			
Total	14	687.56				

^{ns}= Not Significant

CV = 30.89 %

The Analysis of Variance revealed no significant difference in concentrations of wood vinegar because the computed F value was lower than the tabular F value at 5% and 1% level of significance.

CONCLUSION AND RECOMMENDATION

The result showed that mango applied with Treatment 3 (1% of wood vinegar) was the fastest to germinate. Treatment 2 (2% of wood vinegar) produced the tallest seedlings. Based on the study, the application of 1% wood vinegar can be recommended to fasten plant germination, and 2% of wood vinegar can increase plant growth in a short period.

Furthermore, studies on the application of different concentrations of wood vinegar and lengthening the span of the study can be used for future research.

REFERENCES

1) Abbas, M. T., Seif, M. I., Gomaa A. M., and Nada, E. E. M. (2015). Effect of Seed Husk, GA3, KNO3 and Seed Orientation in Seedbed on Germination Characters of White Succary Mango Seeds. Hortscience Journal of Suez Canal University. Volume (3): 55-60.
2) Apai, W. and Thongdeethae, S. (2002). Wood vinegar: new organic for Thai Agriculture. The 4th Toxicity Division Conference, Department of Agriculture, pp. 166-169.
3) Bureau of Plant Industry. (2015). Mango Production Manual. Department of Agriculture. http://bpi.da.gov.ph › bpi › images › pdf › Mango.
4) Daws, M. I., Davies, J., Pritchard, H. W., Brown, N. A. C., and Van Staden, J. (2007). "Butenolide from plant-derived smoke enhances germination and seedling growth of arable weed species," Plant Growth Regulation (51)1, 73-82. DOI: 10.1007/s10725-006-9149-8.
5) Daws, M. I., H. W. Pritchard and J. Van Staden. (2008). "Butenolide from plant derived smoke functions as a strigolactone analogue: Evidence from parasitic weed seed germination," South African Journal of Botany 74(1), 116-120. DOI: 10.1016/j.sajb.2007.09.005

6) De Guzman, R. S., and Adalla, J. A. (2021). Growth of First Three Seedlings from Polyembryonic Mango Seed Applied with Wood Vinegar. European Journal of Agricultural and Rural Education, 2(4), 14-32. Retrieved from https://scholarzest.com/index.php/ejare/article/view/542
7) Garcia-Perez M., Chaala, A., and Pakdel, H. (2007). Production and Fuel Properties of Pine Chip Bio-oil/Biodiesel Blends. Journal Analytical and Applied Pyrolysis, 78(1): 104-116.
8) Ho, C.L., Lin, C. Y., Ka, S. M., Chen, A., Tasi, Y. L., Liu, M. L., Chiu, Y. C., and Hua, K. F. (2013). Bamboo vinegar decreases inflammatory mediator expression and NLRP3 inflammasome activation by inhibiting reactive oxygen species generation and protein kinase C-α/δ activation. PloS One 8(10): 1-11.
9) Mu, J., Uehara, T., and Furuno, T. (2003). Effect of bamboo vinegar on regulation of germination and radicle growth of seed plants. J. Wood Sci. 49:262-270.
10) Nakai, T., Kartel, S. N., Hata, T., and Imamura, Y. (2007). Chemical characterization of pyrolysis liquids of wood-based composites and evaluation of their bio efficiency. Building and Environment. 42, 1236-1241.
11) Philippine Statistics Authority. (2021). Major Fruit Crops Bulletin, October-December 2020. https://psa.gov.ph/fruits-crops-bulletin/mango.
12) Reddy, Y. T. N., and Vineeth Raj, A. V. (2015). Standardization of Rootstock in Mango. Acta Hortic. 1066, 99-108. https://doi.org/10.17660/ActaHortic.2015.1066.10.
13) Wang, Y. Y., Jing, X. R., Li, L., Liu, W. J., Tong Z. H., and Jiang, H. (2017). ACS Sustainable Chem. Eng. 5. 481−488.
14) Yang, X.J., Lin, Z. K., Chen, L., Wu, J. H., Si, H. P., and Lin, K. Y. (2014). Research progress of biochar, pyroligneous acid and organic fertilizer mixture and its components in agricultural production. Applied Mechanics and Materials 448: 680-687.