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The Influence of Rice Water on Growth Performance of *Raphanus sativus* (Snow White Radish) Across Varying Soil Types

DR. CYBELLE A. GONZALES
MR. KEITH NICOLAS LOBITAÑA
MR. CHESTER A. CARBAJOSA
Cebu City Don Carlos A. Gothong Memorial National High School
C. Padilla St., Cebu City, Philippines
cybelle_2k@yahoo.com
keithlobitana08@gmail.com
carbajosachester@gmail.com

Abstract — This research aimed to know the influence of rice water on the growth performance of snow-white radish across varying soil types. The study utilized the Soil Texture Triangle by the U.S Department of Agriculture that served as the basis for measuring the soil composition of each soil type used in the study. The researchers utilized the Randomized Complete Block Design (RCBD) to eliminate the variation of all the possible factors upon conducting the study. There was a total of two groups observed in the study, with four blocks each. Each block is randomized by factorial combination of soil types and water treatments. A total of 16 snow white radish plants are manifested in the study. In each block, two plants are observed (n=2). The criteria in determining the growth performance of the radish plants are replicated by the study outlined by Umar (2019) namely: leaf count, leaf area, plant height, tuber length, tuber diameter, and tuber weight. Statistical treatment was applied using two-way ANOVA in Analysis Tool pack software to determine the significant differences of two water treatments under control (tap water) and experimental group (rice water). It was found that plants that are grown in clay loam soil applied with rice water produced the highest performance of snow-white radish crops with a mean of 22.53. The study also found out that rice water (Mean=19) is more influential to the growth performance of snow-white radish than tap water (Mean=16.27) across all soil types. The ANOVA revealed that there is a significant difference in between the tap water and rice water in affecting the growth performance of the plants ($p < a = 0.05$). Therefore, the results revealed that the choice of soil type and water treatment to apply can alter the growth performance of the crop. Based on the findings and conclusions of this study, utilize the other eight soil types in the soil texture triangle using the same concept as our study to have a wider comparison Use of other varieties of radish and compare the growth performance of the varieties with the same concept of using different soil types.

Keywords — Influence, Growth Performance, Rice Water, Across Soil Types, Information Dissemination Plan, True Experimental

I. Introduction

Agricultural crops play an important role in the economy. However, this sector also emits greenhouse gases into the atmosphere that contribute to climate change. Agricultural producers used chemical fertilizers to increase crop production. However, the use of these chemicals causes our environment to suffer. It is contributing to climate change because this type of fertilizer emits nitrogen, which eventually harms humans and plants. Producing crops has required excessive use of chemical fertilizers (Huarui Gong, 2020). According to Lenka, et al. (2015), the production of fertilizers demands much energy and generates considerable greenhouse gas emissions. Thus, the greater the fertilizer is used, the greater the emissions are. A study conducted by Dehkordi & Forootan (2020) showed that the N_2O and CO_2 emissions from chemical fertilizers made high contributions to Global Warming Potential.

Rice is a prominent food in every household. Rice is eaten by most of the world's population, particularly in Asian countries. The Philippine Statistics Authority (2021) reported that a single Filipino consumes 118.81 kilograms of rice annually, which is equivalent to 325.5 grams of rice daily. Rice is often washed before cooking, and the water after the rice is washed is merely thrown into the environment. The volume of rice washing water waste that is simply thrown into the environment is increasing along with population growth. So, wastewater from rinsing rice has the potential to cause environmental pollution. Rather than being merely discarded, unused, into the environment, the washed rice water ought to be reused as a nutrient source for plant growth.

This study utilized rice water as a plant nutrient source to reduce the use of harmful chemicals that contribute to climate change. Instead of watering your plants with freshwater, rice water can also be used as a plant fertilizer to increase crop production and to have healthier plants. It contains enough NPK or Nitrogen (N) Phosphorus (P) and Potassium (K) fertilizers which are the essential nutrients needed for plants to grow. These minerals are not only good for plants, but the starchiness promotes the growth of helpful bacteria in the soil. Iskarlia (2017) stated that rice water can be used as liquid fertilizer. A research study by Nabayi et al. (2021) discovered that waste rice water contains a range of nutrients and minerals, including potassium, calcium, and magnesium, that can boost plant growth. As a matter of fact, there has been a lot of study that showed washed rice water increases vegetable growth, such as water spinach, pak choy, lettuce, mustard, tomato, and eggplant (Abba et al.,2022)

Several studies have shown that plant watering with washed rice water had increased the height, stem diameter, and yield of tomato, water spinach, eggplants, pak choy, lettuce, mushroom, adenium, chilli, and mustard green plants (Ariwibowo et al., 2012). Furthermore, a study conducted by Sarili et al. (2018) revealed that the washed rice water was found to contain plant growth-promoting bacteria (PGPB), such as Bacillus and Lactobacillus spp. The presence of these bacterias in rice water is particularly noteworthy because these bacteria can inhibit plant pathogens, produce phytohormones and siderophores, solubilize potassium and phosphate, and fix nitrogen Beneduzi et al (2012). Rice water is rich in amino acids, vitamins (A, B, C & E), antioxidants, flavonoids, and phenolic compounds (Burgess, 2018).

The researchers were intrigued that leftover rice water can be used as fertilizer for plants. This idea could reduce the use of chemical fertilizers and save money while increasing crop production at the same time. After all, rice water is not a waste at all. Syuhaibah (2017).

The term "soil" is mostly generalized. People are unaware that not all soils are the same. Gopal (2021) defined soil as a thin layer of the earth's crust which serves as a natural medium for plant growth. Soil is an important natural resource and key factor in global food production. The characteristics of soil are the possible factors affecting plant growth. However, most people have no idea what the different soil types and their differences are.

Raphanus sativus (snow white radish) is a common root vegetable crop that is grown for its enormous edible roots. It is a fast-growing, short-season vegetable crop that may be grown in both temperate and tropical climates (Satari, et al., 2020). Radishes are a good source of antioxidants like catching, pyrogallol, vanilla acid, and other phenolic compounds. These root vegetables also have a good amount of vitamin C, which acts as an antioxidant to protect your cells from damage (WebMD Editorial Contributor, n.d). Being a short-duration and quick growing crop, the root growth should be rapid and uninterrupted. Hence, to produce good quality radish optimum fertilization through organic, inorganic and biofertilizers are essential (Dhananjaya, 2007).

The purpose of this study was to determine the influence of rice water on growth performance of snow-white radish across varying soil types. Specifically, the study attempted to answer the following questions:

1. What is the composition of each soil type in terms of:

   1.1 clay;

   1.2 silt; and

   1.3 sand?

2. What is the water retention level and porosity level of each soil type?

3. How influential are rice water (experimental group) and tap water (controlled group) on the growth performance of Snow-white radish across different soil types in terms of:

   3.1 leaf count;

   3.2 leaf area;

   3.3 plant height (cm);

3.4 tuber length (cm);

3.5 tuber diameter (mm); and

3.6 tuber weight (g)?

4. Is there a significant difference between tap water and rice water on the growth performance of Snow-white radish in all growth parameters?

5.What is the rank by influence of rice water and tap water to the overall growth performance of snow-white radish in terms of:

5.1 soil types within the group; and

5.2 soil types across two groups?

6. Is there a significant difference between rice water and tap water on the overall growth performance of snow-white radish?

II. Methodology

Design

This true experimental study utilized the Randomized Complete Block Design (RCBD) with two (2) distinct treatments: Treatment 1 (tap water) and Treatment 2 (rice water) in first rinse, four (4) pots with distinct soil types of namely loam, clay loam, silt loam, and sandy loam, and each pot was planted two (2) seeds of Snow-white radish. A total of sixteen sample plants were used throughout the study. The treatments presented are equally applied to all the subsets throughout the study. Treatment 1 is applied to group A; all the four subgroups are poured the same amount of 200 ml of tap water. On the other hand, treatment 2 is applied to group B, all the four subgroups are poured the same amount of 20 ml of rice water throughout the study until harvest.

Subjects

The researchers used the Snow-White Radish as a subject in the study. The seeds are brought from the same brand to ensure that no external factors will be considered in the study. The germination rate of seeds is <85%, and the purity level of seeds is 99% as indicated in the packaging.

Instruments

The researcher performed a series of tests as an instrument in collecting and faceting data. The researchers utilized the Soil Texture Triangle model from U.S. Department of Agriculture

(2017) that served as the basis in measuring the respective compositions of clay, silt, and sand to come up with a specific soil type to be used in the study as medium for planting. The total number of soil types formulated was twelve, however, the researchers only used four types of soil namely loam, clay loam, silt loam, and sandy loam.

The researchers also conducted a water retention test in determining the water holding capacity of each soil type and as well as the porosity. The researchers utilized a standardized method, the percolation method as basis for the water holding capacity test, one of the four methods outlined by Pancarini (n.d.) as guide for conducting the porosity test. The statistical tool, the two-way ANOVA test, will be used in quantifying the significant differences between variables. In measuring the growth parameters outlined by Umar (2019), the researchers used appropriate tools with specified units.

Data Gathering Procedure

This section outlines the general experimental procedures, materials, and sequence of events involved in planting the snow-white radish on different loam soil types in depth. This section contains information on the materials utilized, planting processes and setups, rice water treatment, units of measurement used, and data analysis.

The researchers utilized the growth parameters outlined by the study of Umar (2019) as basis in determining the growth performance of snow-white radish. The growth parameters are leaf count, leaf area, plant height, tuber length, tuber diameter, and tuber weight. Each parameter is measured using the appropriate tool.

III. Results and Discussion

RESULT

Soil Compositions and Percentage Distribution of the Soil Types

1.1 **Clay**

As shown in Table 1, each soil type has different compositions of clay, silt, and sand. The Clay loam soil has the highest clay composition of 2kg, equivalent to 40% in total composition of 5kg across all soil types, followed by Loam soil that is composed of 25%. Sandy loam has the lowest clay content of 10% on the measured amount. The Soil Texture Triangle supports this measurement. According to the U.S Department of Agriculture (2017), clay loam soil contains 27 to 40% clay, and 20 to 45% sand.

1.2 **Silt**

The table showed that Silt loam has the highest composition in terms of silt with 3.75kg, equivalent to 75% in total composition across all soil types. It is followed by a clay loam with 38% silt composition. Sandy loam contains the lowest amount of silt in all soils. According to The Soil Texture Triangle by the U.S Department of Agriculture (2017), silty loam soils contain 50% or more silt and 12 to 27% clay or 50 to 80% silt and less than 125 clay.

Table 1 Presents the Soil Compositions and Percentage Distribution of the Soil Types

Compositions in kilograms				
Soil Type	Clay	Silt	Sand	Total
Loam	1.25 kg	1.75kg	2kg	5kg
Clay loam	2 kg	1.9kg	1.1kg	5kg
Silt loam	0.75kg	3.75kg	0.5kg	5kg
Sandy loam	0.5kg	1kg	3.5kg	5kg
Percentage Distribution				
Soil Type	Clay	Silt	Sand	Total
Loam	25%	35%	40%	100%
Clay loam	40%	38%	22%	100%
Silt loam	15%	75%	10%	100%
Sandy loam	10%	20%	70%	100%

1.3 **Sand**

As shown in the table, sandy loam has the highest sand composition in terms of sand with 3.5kg which is equivalent to 70% in total composition across all soil types, followed by Loam soil with 40% of sand composition. Silt loam, on the other hand, contains the lowest amount of sand.

The range of measurements are accurately in line with the proposed measurements by the U.S Department of Agriculture (2017) that sandy loam soils contain either 20% clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30, and 52% or more sand: or less than 7% clay, less than 50% silt, and between 43 and 52% sand.

Soil samples were measured accordingly to their respective compositions of clay, silt, and sand. The soil sample was then tested for water drainage and porosity to determine the difference in physical properties of the soil. The researchers used the outline from the percolation method for water holding capacity test and utilized one of the four methods outlined by Pancarani (n.d) as basis for porosity test. All the results in this test are only representative of physical characteristics from the soil sample.

Water Holding Capacity and Porosity of Soil Types Used in the Study

Water Holding Capacity

The table shows that Clay loam soil has the highest water holding capacity of 30ml, followed by Silt loam soil with 28.5ml. The soil with the lowest water holding capacity is the Sandy loam with 25ml per 200g. As presented in table 1, Clay loam soil has the highest composition of clay with 40% across all soil types, followed by Loam soil with 25%. Based on the results, Silt loam has a higher water retention level compared to Loam even though Loam soil has higher clay content than silt. It is since the relative composition of sand is higher in Loam than in Silt. Sandy Loam soil has the highest sand composition that greatly corresponds as to why it has the lowest water holding capacity. The results correspond to the compositions presented in table 1. As the clay composition of the soil increases, the water holding capacity also increases. But the relative compositions of silt and sand may also affect the overall physical property of the soil.

Table 2 Presents the Water Holding Capacity and Porosity of Soil Types Used in the Study

Soil Type	Water Holding Capacity (per 200g/100mL)	Porosity (%) (per 200g bulk density)
Loam	27.5	30.55%
Clay loam	30	25.93%
Silt loam	28.5	27.01%
Sandy loam	25	32.66%

When it comes to soil texture, silt and clay have a bigger surface area than soil made up of larger particle sizes. The soil may hold more water because it is easier to hold onto water when it is on a higher surface area. Sand, on the other hand, has big particle sizes, which reduces its surface area. Sand has a low water-holding capacity (Eurasian J Soil Sci, 2016).

Porosity

The table shows that Sandy loam has the highest porosity level with 32.66% per 200g bulk density, followed by Loam with 30.55%. The soil type with the lowest porosity is the clay loam with 25.93%. As presented in table 1, Sandy loam has the highest sand composition of 70%, followed by Loam soil with 40%. Clay Loam soil has the lowest porosity because of higher clay content than Silt Loam. The results greatly correspond to the soil compositions presented in table 1. As the sand composition of the soil increases, the porosity of the soil also increases. The relative compositions of clay and silt may also affect the overall porosity of the soil.

The Growth Performance of Snow-White Radish in Tap Water (Control Group) And Rice Water (Experimental Group) In Terms of the Parameters

According to the SF Gate Contributor (2022), sand and other coarse soils are porous, which usually allows water to drain directly off the surface. On the other hand, water travels slowly and diffuses from its application site in clay soils with limited pore spaces due to capillary action. Which implies that porous soil needs more watering as its water drains fast and nutrients from soil with high sand content be lost quickly, reducing the efficiency of fertilizers on porous soil.

Leaf Count

Table 3 shows that plants in Clay loam B have the highest number of leaves with an average of 12.5, followed by Silt loam B, Loam A and Sandy loam B with averages of 12 and 11 respectively. Plants grown in Loam A and Sandy loam B have the same average of 11. Silt loam A produced the least number of leaves with a mean of 5. Based on the gathered data, Treatment B is more influential than Treatment A with an average of 11.25 across all soil types within the group compared to Treatment A with only an average of 9.13.

Table 3 Presents the Growth Performance of Snow-White Radish in Tap Water (Control Group) And Rice Water (Experimental Group) In Terms of the Parameters

Growth Parameters		Tap Water (A) Control Group	Rice Water (B) Experimental Group
Leaf count	Loam	11	9.5
	Clay loam	10.5	12.5
	Silt loam	5	12
	Sandy loam	10	11
	Mean	9.13	11.25
Leaf Area	Loam	35.39	29.85
	Clay loam	34.56	37.52
	Silt loam	13	25.22
	Sandy loam	30.73	36
	Mean	28.42	32.15
Plant height	Loam	17.45	17.6
	Clay loam	17.7	19.2
	Silt loam	8	17.7
	Sandy loam	18.45	18.95
	Mean	15.4	18.36
Tuber length (cm	Loam	6.9	6.3
	Clay loam	7	7.4
	Silt loam	2.55	6.2
	Sandy loam	5.85	6.2
	Mean	5.58	6.53
Tuber diameter	Loam	38.5	34
	Clay loam	47	49.5
	Silt loam	11	36.5
	Sandy loam	39	38
	Mean	33.88	39.5
	Loam	5.43	4.13
	Clay loam	8.23	9.03

Tuber weight	Silt loam	1.51	7.83
	Sandy loam	5.71	3.53
	Mean	5.22	6.13

Leaf Area

Results showed that Clay loam treated with rice water have the highest leaf area of 36.45 $cm2$, followed by Sandy loam B and Loam A with a mean of 36 $cm2$ and 35.39 $cm2$ respectively. The difference between Clay loam B and Silt loam A, the lowest in leaf area of 13 $cm2$, is 23.45 $cm2$. Across all soil types with regards to their water treatments, rice water is more influential with a mean of 31.88 $cm2$ compared to tap water with 28.42 $cm2$.

Plant Height

The results in Table 3 revealed that plants in Clay loam treated with rice water (Treatment B) produced the tallest plant height with 19.2cm among all combinations of water treatments and soil types, it is followed by Sandy loam A and Sandy loam B with a mean of 18.75cm and 18.45 cm respectively. The shortest was garnered by those plants in Silt loam B (8 cm) being treated with tap water. In between water treatments, rice water is more influential in terms of plant height with a mean of 18.3cm compared to tap water with 15.4cm across all soil types.

Tuber length

Table 3 revealed that plants in Clay loam soil treated with rice water produced the longest tuber with an average of 7.4cm, followed by plants in Clay loam A with a mean of 7cm and 6.9cm respectively. Though there is not much of a significant difference, plants in each treatment still differ in a few centimeters. Silt loam A produced the shortest length of tuber with an average of 2.55cm, which is significantly 4.85cm shorter than Clay loam B. Rice water is more effective than tap water in terms of tuber length.

Tuber diameter

As shown in Table 3, plants grown in Clay loam soil as treated with rice water produced the biggest tuber diameter of 47.5mm, followed by Clay loam A and Sandy loam A with averages of 47mm and 41.55mm respectively. Silt loam A produced the least diameter of 11mm followed by Loam B with 32.5mm. In between water treatments, rice water is more influential to the tuber diameter with an average of 37.86mm compared to tap water with only an average of 34.5mm.

Tuber weight

Table 3 shows that plants grown on Clay loam soil treated with rice water produced the heaviest fruits with an average of 9.03g, followed by Clay loam A and Silt loam B with averages of 8.23g and 7.83g respectively. Clay loam B performed 8.37g higher than Silt loam A. In between water treatments, rice water produced an average weight of 6.14g, which is significantly higher than produced by tap water with 5.01g. Thus, rice water is more effective than tap water in terms of tuber weight.

Significant Differences Between Tap Water and Rice Water on All Growth Parameters

Leaf count

The ANOVA revealed that there is no significant difference in the water treatments, between rice water and tap water affecting the growth of the plant. The computed F value of 1.457 was lower than the F critical of 3.86255. The p-value can also attest to the result. Thus, the null Hypothesis is accepted.

Leaf area

The ANOVA revealed that there is no significant difference in the water treatments in response to the growth performance of radish because the computed F value of 1.676 was lower than the F critical of 3.86255. The p-value was higher than the 5% level of significance.

Plant height

The statistical analysis revealed that there is no significant difference in the water treatments between tap water and rice water because the F value was lower than the F critical. The p-value was also higher than the level of significance. Which leads to accepting the null hypothesis on both assumptions.

Table 4 Presents the Significant Differences Between Tap Water and Rice Water on All Growth Parameters

Growth Parameters	SS	MS	F value	F critical	Decision	Interpretation
Leaf count	45.687	15.229	1.457	3.8625	Fail to Reject Ho	Not Significant
Leaf Area (cm^2)	394.68	131.56	1.676	3.8625	Fail to Reject Ho	Not Significant
Plant height (cm)	129.76	43.25	2.562	3.8625	Fail to Reject Ho	Not Significant
Tuber length(g)	17.82	5.94	2.135	3.8625	Fail to Reject Ho	Not Significant
Tuber diameter(mm)	4342.18	1447.396	6.542	3.8625	Reject Ho	Significant
Tuber weight(g)	233.23	77.743	4.185	3.8625	Reject Ho	Significant

Tuber length

The statistical analysis also revealed that there is no significant difference between the water treatments as the computed F value was lesser than the F critical. The p-value was also significantly higher than the 5% significance. Thus, null hypothesis can't be rejected on both assumptions.

Tuber diameter

The ANOVA revealed that there is a significant difference between water treatments, the F value was 6.542 which is greater than the F critical of 3.86255. The p-value is lower than the 5% significance. Thus, the Null hypothesis is rejected on the water treatments. Water Treatments applied significantly altered the results of the study in terms of the plants' tuber diameter.

Tuber weight

The ANOVA revealed that there is a significant difference between water treatments in affecting tuber weight of the plants. The computed F value of 4.185 was significantly greater than the F critical value. The p-value is lower than the 5% level of significance.

Therefore, water treatments have significant effects in altering the growth performance of the plants in terms of tuber weight.

Comparison Between Tap Water and Rice Water on the Overall Growth Performance of Snow-White Radish in All Growth Parameters as Ranked

The results from Table 5 shows that in between water treatments, Rice water is more influential to the overall growth performance of snow-white radish plants across all soil types within the group with a mean of 19. The Tap water produced lesser quality of crops with a mean of 16.27.

The results from table 5 also show that in each respective group regardless of the water treatment, plants grown in clay loam soil have the highest growth performance in each group with a mean of 20.83 and 22.53 for Tap water and Rice water respectively.

Table 5 Presents the Comparison Between Tap Water and Rice Water on the Overall Growth Performance of Snow-White Radish in All Growth Parameters as Ranked

Soil Types	Mean	Rank within Group	Rank Overall
Control Group			
Tap Water (A)			
Loam	19.11	2	3
Clay Loam	20.83	1	2
Silt Loam	6.84	4	8
Sandy Loam	18.29	3	5
=16.27			
Experimental group			
Rice Water (B)			
Loam	16.89	4	7
Clay Loam	22.53	1	1
Silt Loam	17.58	3	6
Sandy Loam	18.95	2	4
=19			

Across all soil types and water treatments combined, plants in Clay loam soil treated with rice water have the highest growth performance among all blocks observed with a mean of 22.53, ranked 1st. It is followed by clay loam soil and loam soil in Treatment A with a mean of 20.83 and 19.11 respectively. Thus, plants grown in clay loam soil will have higher growth performance when applied with rice water.

Significant Difference Between Tap Water and Rice Water on the Overall Growth Performance of Snow-White Radish Plants

The ANOVA revealed that there is a significant difference in between water treatments. The F value is 72.38, which is statistically greater than the F critical of 2.485. The p-value is lower than the 5% level of significance that supports the findings. Thus, the use of different soil types and water treatments can alter the growth performance of snow-white radish.

Table 6 Presents the Significant Difference Between Tap Water and Rice Water on the Overall Growth Performance of Snow-White Radish Plants

Water Treatment	Overall Growth Performance	F value	F critical	Decision	Interpretation
Tap Water (control group)	16.34	7.031	2.285	Reject H_o	Significant
Rice Water (experimental group)	18.60				

a=0.05 p=0.00003he

IV. Conclusion

The study concluded that rice water is more influential to the growth performance of snow-white radish than tap water. Plants grown in clay loam soil (Clay loam B) applied with rice water produce the best crop of snow-white radish. Clay loam B consistently produced the highest growth performance of all parameters. Based on the study, the use of different soil types and application of different water treatments can alter the growth of a plant. Thus, statistical analysis using ANOVA revealed that there is a significant difference between soil types and water treatments. Plants grown in clay loam soil in both groups obtained the highest growth performance. Therefore, soils that have high water holding capacity greatly influence the growth of a plant as clay loam soil has the highest clay percentage of 40% among all soil types. The physical properties, particle composition, and nutrient availability of the water treatment correlate with each other that will help to determine the absolute growth performance of a plant.

Based on the findings and conclusions of this study, the following recommendations are presented.

1. Utilize the other eight soil types in the soil texture triangle using the same concept as our study to have a wider comparison.

2. Use other varieties of radish and compare the growth performance of the varieties with the same concept of using different soil types.

3. Determine the bacterial and nutrient content of each soil after application of rice water.

4. Test the pH level of the soil, rice water, and tap water.

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