A Case Study on the Effect of Temperature Monitoring Irrigation System for Pechay

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Abstract: - The vegetable Brassica rapa chinensis, well-known as Pechay, is one of the locally grown vegetables in the Philippines. Its expanded and tender leaves are the main ingredient for soups and stir-fried dishes. Pechay can be grown all year round, though it grows best in a cold, dry season. In hot weather, the pechay leaves wither easily as the temperature rises due to global warming. To ensure adequate moisture, a temperature-monitoring irrigation system was utilized to provide the needed water for the plant. The objective of the case study is to investigate the effect of a temperature-monitoring irrigation system on the growth of pechay. The system automates the irrigation process by regulating the amount of water supplied to the plants based on the soil temperature. The growth parameters, including leaf number, width, height, and length, were obtained and compared between the two groups: manual watering and an experimental group receiving water through the temperature monitoring irrigation system. In conclusion, the study indicates a positive effect of the temperature-monitoring irrigation system on the growth of pechay plants. Comparing the growth parameters of the pechay plants grown with the temperature-monitoring irrigation system revealed a higher average leaf number of 0.95, a wider leaf width of 0.93 cm, a greater leaf height of 1.55 cm, and a longer leaf length of 0.76 cm as compared to the plants grown with manual watering. These differences and the results of the t-test analysis were statistically significant, highlighting the advantage of automated irrigation for pechay growth. Therefore, the study supports the utilization of temperature-monitoring irrigation systems as a technological advancement for pechay cultivation that can help farmers enhance crop growth and improve irrigation efficiency. The system can contribute to sustainable food production and to changing climate conditions.

Key Words: - ***Pechay, Growth, Temperature, Monitoring, Irrigation.***

I. INTRODUCTION

Vegetable farming is essential to the food industry and to our daily lives. They provide farmers with a source of income while supplying us with essential nutrients. Growing vegetables efficiently and sustainably contributes to food security, economic stability, and environmental conservation. Emphasizing the importance of vegetables in our food cycle encourages healthy eating habits, supports local farmers, and promotes sustainable agricultural practices.

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Based on the latest reports of the Philippine Statistics Authority, the Philippines' Gross Domestic Product (GDP) in the first quarter of the year 2023 had increased by about 6.4 percent, with the agriculture, forestry, and fishing industry (AFF) having a positive growth of about 2.2 percent and contributing 9.1 percent towards the Gross Value Added towards the GDP of the Philippines despite having the least contribution of the three major sectors. [1,2]

The agricultural impact and contribution to the Philippine economy and food industry are significant proof that crop production of numerous fruits and vegetables, including locally grown crops such as palay or rice, onions, and garlic, has a high count in the country's food sector. Along with the several locally grown vegetables that play an important role in Filipino dishes, pechay is one of the most well-known vegetables in the Philippines.

Alongside these well-known crops are green, leafy vegetables, a core part of the Filipino diet, notably pechay. Aside from being a huge part of several Filipino dishes like Kare-Kare and Nilaga, pechay has its own benefits as part of the Filipino diet. According to Erlinda J. et al (2000)., pechay is a good source of nutrients due to its being dense in various minerals like calcium and lutein, a phytochemical that supports eye health while helping prevent the formation of cancer cells in the body, as stated by Dolkar, D. et al. (2016) [3,4].

Pechay is a versatile and flexible plant, and it can be planted in households as a form of small-scale cultivation. Similar to various crops, it requires sufficient soil moisture, which can be maintained through irrigation. However, Jimenez et al. (2000) have a guide on the production of pechay that shows the optimal conditions in order to grow pechay to its fullest. Starting with the type of soil it should be planted in, it is advised that Pechay plants be planted in sandy or clay loam soil that has a pH level of at least 5.5 to 6.5 [3]. For watering, pechay plants need around 300 milliliters of water per plant to ensure proper growth in each crop, while seedlings need 50–100 milliliters of water for optimal growth. All of the said factors are expected to be done manually, with water sprinklers through overhead sprinkler irrigation being the only form of technological support in the irrigation of the pechay plant.

Irrigation should be maintained to ensure that the pechay receives adequate moisture for optimal growth and tenderness. When rainfall is insufficient, various irrigation methods can be utilized to provide enough water supply to the crops. The most popular irrigation method is surface irrigation, where farmers apply water by gravity to the surface of the crops. Surface irrigation can be used for any type of crop, unlike sprinkler and drip irrigation, which are often utilized for high-value crops like vegetables and fruit trees due to their expensive capital investment per hectare. However, manual surface irrigation is inefficient, considering the amount of water wasted during irrigation. The estimation in manual irrigation may lead to over- or under-irrigation that can saturate the crops [5].

On the same note, it is important that pechay plants thrive in cool, sunny weather with temperatures around 20°C to 34°C [6], which only usually occurs in mid-to high-elevated places, unlike in other regions like Region 3. Unfortunately, according to Pag-Asa (DOST), Pampanga, specifically near the Clark area, ranked in the top 10 highest temperatures as of June 3, 2023, with a temperature that reached as high as 34.7°C [7]. The previously mentioned factors all affect the possibility of optimal growth of the pechay plant, rendering the crop susceptible to dehydration, which eventually leads to withering when left unattended.

Furthermore, with high temperatures or hot and dry weather, especially during the summer season, soil dries out easily. With the lack of rainfall and the heat during this season, the pechay plant being subjected to this type of weather requires a steady supply of moisture through proper irrigation to guarantee proper growth and a bountiful harvest. Manual irrigation, or surface irrigation, is one of the basic methods of providing water to crops. However, with technology like sprinklers or drip-type irrigation, more options have been opened to farmers [5]. The said types of irrigation can often lead to water waste or oversaturation of the soil, "drowning" the plants with too much water, making these systems not optimal in both costs and efficiency.

Also, the hot weather in the Philippines brought on by global warming intensifies drought and has an impact on plants and other crops with the temperature required for quality and optimal growth. As a result, the immature Pechay leaves are directly exposed to hot weather, causing them to wither.

To address these problems, the study aims to determine the effect of the temperature-monitoring irrigation system on the growth of Pechay. The system automates the irrigation of the plants, where the amount of water depends on the soil temperature. Specifically, its objective is to compare the growth of Pechay between manual watering and temperature monitoring irrigation and identifies any significant differences in leaf number, width, height, and length of the pechay grown with or without the system.

Based on the research objectives, the hypothesis states that the use of a temperature-monitoring irrigation system has a positive effect on the growth of Pechay plants compared to manual irrigation. By examining the effectiveness of the irrigation system, it has the potential to improve irrigation practices and crop performance, conserve water resources, increase productivity, and advance technological applications in agriculture. The findings can serve as a reference for farmers and policymakers in making decisions and implementing sustainable methods for Pechay cultivation and potentially other crops as well.

II. Methodology

The conceptual framework of the study input, as shown in Figure 1, involves the pechay plants, manual irrigation, and the temperature monitoring irrigation system. The process includes experimental design, data collection, and analysis. The output represents the effect of the temperature-monitoring irrigation system as compared to manual irrigation.

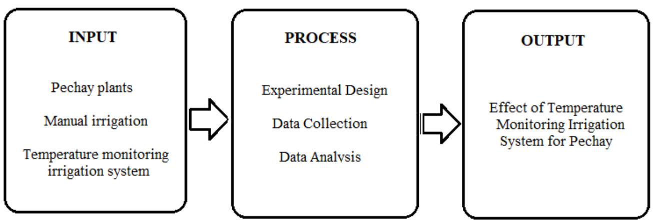

Fig.1. Conceptual Framework of Study

2.1 Research Design

The research design uses an experimental research method in assessing the dependent variables – the number of leaves, the average width, height, and length of leaves for every Pechay plant.

The pechay plants are the participants of the study with 10 seedlings for both groups. A total of 20 seedlings were put in a two-plot box for each group. The manual group is subject to manual watering commonly used for pechay plants. For the temperature monitoring irrigation system, irrigation of pechay plants is based on soil temperature.

2.2 Research Instrument and Data Collection

In gathering the data, a ruler or measuring tape was used to measure the growth parameters of the pechay plants in terms of the leaf's width, height, and length. All quantitative data were recorded and observed to compare and analyze these parameters. The pechay plants are the participants of the study, with 10 seedlings for both groups. For the statistical tool, Microsoft Excel was utilized for hypothesis testing and data analysis.

A total of 20 seedlings were germinated in a two-plot box for each group. The manual group is subject to manual watering commonly used for pechay plants. For the temperature-monitoring irrigation system, irrigation of pechay plants is based on soil temperature. The plants should be uniform in size and growing conditions to minimize bias and variations.

The data-gathering procedure was conducted after the transfer of the pechay plants to their respective plot boxes. On day 7, initial data was recorded by obtaining the number of leaves and measuring the width, height, and length of leaves for each plant with a seven-day interval. The treatment for both groups began with the manual irrigation group being watered twice every day with a constant amount of 300 mL of water, while the temperature-monitoring irrigation is dependent on the temperature of the soil. Generally, the experimental group automatically irrigates the plants under the condition that the temperature reads 30°C above the average temperature. The identified growth parameters were measured on a weekly basis within 28 days.

2.3 Statistical Treatment of Data

For the interpretation of the data sets collected, the study used a t-test between two independent samples, namely the manual irrigation group and the temperature-monitoring irrigation group. The t-test calculates a test statistic (t-value) based on the sample data, which measures the difference between the means of the control and experimental groups relative to the variability within each group.

Comparative analysis was employed to identify the significant difference in the growth of pechay leaves between manual irrigation and temperature-monitoring irrigation. With the use of this statistical method and comparative analysis of the samples, the researchers were able to determine whether the system improved pechay growth based on the parameters measured.

III. Results And Discussion

3.1 Average Number of Leaves

Table.1. Average Number of Leaves

Average Number of Leaves		
Day	Manual Irrigation	Temperature Monitoring Irrigation
7	4.1	4.1
14	5.5	6.6
21	8.2	9.4
28	11.7	13.2
Average	7.38	8.33

On day 7, the number of leaves had the same computed mean average of 4.1 leaves for both manual and temperature-monitoring irrigation. For days 14, 21, and 28, the average number of leaves improved, which means temperature monitoring irrigation has improved the number of leaves more than manual irrigation.

Since the computed average of temperature monitoring irrigation is greater than manual irrigation, the experimental study shows favorable results for temperature monitoring irrigation.

3.2 Average Width of Leaves

Table.2. Average Width of Leaves

Leaf Width (cm)								
Pechay No.	Manual Irrigation				Temperature Monitoring Irrigation			
	Day 7	Day 14	Day 21	Day 28	Day 7	Day 14	Day 21	Day 28
1	4.5	4.1	5.9	5.9	4.5	4.7	9	9
2	3.9	3.9	7.8	7.4	4	4.2	8.2	7.9
3	2.6	5.5	9.3	8.9	5.5	5.9	9.1	10.8
4	5.8	6.2	7.9	8.9	5.8	6	10.5	9.1
5	3.9	4.1	8.1	8.2	5.9	6.1	10.5	8.5
6	5.1	5.2	6.5	5.9	5.3	5.4	7.4	7.8
7	3.5	2.5	8	8.5	2.5	2.6	8.8	8.6
8	2.5	2.2	7.8	7.7	2.7	2.9	8.2	10.2
9	2.7	2.7	7.4	6.9	2.5	3	7.8	11.1
10	5.6	5.4	6.8	7.4	5.7	5.6	8	8.9
Average	5.83				6.76			

By comparing the means of the two samples in Table 2, it is evident that temperature monitoring irrigation improves the width of the Pechay leaf by 0.93 cm as compared to manual irrigation.

Day 7

	Manual Irrigtion	*Temperature Monitoring Irrigation*
Mean	4.01	4.44
Variance	1.492111111	2.020444444
Observations	10	10
Pearson Correlation	0.637115748	
Hypothesized Mean Difference	0	
df	9	
t Stat	-1.192554459	
P(T<=t) one-tail	0.131768045	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.26353609	
t Critical two-tail	2.262157163	

Fig.2. t-Test: Two-Independent samples

The computed t-score is -1.19, which is less than the alpha of 0.05. It means that leaf width shows improvement using temperature monitoring irrigation compared to manual irrigation on Day 7.

Day 14

	Manual Irrigtion	*Temperature Monitoring Irrigation*
Mean	4.18	4.64
Variance	1.930666667	1.904888889
Observations	10	10
Pearson Correlation	0.90720473	
Hypothesized Mean Difference	0	
df	9	
t Stat	-2.437995124	
P(T<=t) one-tail	0.018743857	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.037487715	
t Critical two-tail	2.262157163	

Fig.3. t-Test: Two-Independent samples

For day 14, the computed t-value is -2.43, which is less than the significant value of 0.05. It means that the leaf width improved from day 7 to day 14.

Day 21

	Manual Irrigtion	*Temperature Monitoring Irrigation*
Mean	7.55	8.75
Variance	0.913888889	1.133888889
Observations	10	10
Pearson Correlation	0.397853401	
Hypothesized Mean Difference	0	
df	9	
t Stat	-3.410828674	
P(T<=t) one-tail	0.003869728	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.007739456	
t Critical two-tail	2.262157163	

Fig.4. t-Test: Two-Independent samples

In Figure 4, the computer t-value is -3.41, which is less than the significant value of 0.05. It means that leaf width improved on Day 21.

Day 28

	Manual Irrigtion	*Temperature Monitoring Irrigation*
Mean	7.57	9.19
Variance	1.211222222	1.312111111
Observations	10	10
Pearson Correlation	0.246520327	
Hypothesized Mean Difference	0	
df	9	
t Stat	-3.714797378	
P(T<=t) one-tail	0.002404579	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.004809159	
t Critical two-tail	2.262157163	

Fig.5. t-Test: Two-Independent samples

In Figure 5, the computer t-value is -3.71, which is less than the significant value of 0.05. It means that the leaf width also improved on Day 28. Therefore, temperature-monitoring irrigation for pechay shows improvement in the leaf width of pechay.

3.3 Average Height of Leaves

Table.3. Average Height of Leaves

Leaf Height (cm)								
Pechay No.	Manual Irrigation				Temperature Monitoring Irrigation			
	Day 7	Day 14	Day 21	Day 28	Day 7	Day 14	Day 21	Day 28
1	9.5	9.5	9.4	9.5	9.2	10	13	12.3
2	9.1	8.9	11.8	11.9	9.5	9.5	13.5	11.9
3	7.2	9.9	12.4	12.3	9.8	10	18.5	18.6
4	9.5	10.8	12.9	12.9	10	11.2	15	12.7
5	6.5	7.8	12.4	12.5	7.1	7.2	15.1	12.4
6	9	9.5	9.5	9.6	9.2	9.2	14.1	11.6
7	7.4	6.5	12.4	12.5	7	7.2	12.2	14.8
8	5.1	6.1	12.3	11.8	5.9	6.3	13.6	15.9
9	7.1	7.5	10.5	11.2	7.5	7.8	14.6	16.3
10	9.2	10.4	10.1	11.5	10.2	10.5	14	13.5
Average	9.90				11.45			

In Table 3, comparing the means, the computed average for temperature monitoring irrigation is 11.45. This indicates that Pechay leaves exhibit significantly better and faster growth in terms of height compared to manual irrigation.

Day 7

	Manual Irrigtion	Temperature Monitoring Irrigation
Mean	7.96	8.54
Variance	2.289333333	2.307111111
Observations	10	10
Pearson Correlation	0.848778346	
Hypothesized Mean Difference	0	
df	9	
t Stat	-2.199889558	
P(T<=t) one-tail	0.02767527	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.055350541	
t Critical two-tail	2.262157163	

Fig.6. t-Test: Two-Independent samples

The computed t-value in Figure 6 is -2.19, which is less than the alpha of 0.05. It means that leaf height shows improvement using temperature monitoring irrigation on Day 7.

Day 14

	Manual Irrigtion	Temperature Monitoring Irrigation
Mean	8.69	8.89
Variance	2.656555556	2.718777778
Observations	10	10
Pearson Correlation	0.969885974	
Hypothesized Mean Difference	0	
df	9	
t Stat	-1.570271768	
P(T<=t) one-tail	0.075399595	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.15079919	
t Critical two-tail	2.262157163	

Fig.7. t-Test: Two-Independent samples

On day 14, the computed t-value is -1.57, which is less than the significant value of 0.05. It means that leaf height shows consistent improvement from day 7 to day 14.

Day 21

	Manual Irrigation	Temperature Monitoring Irrigation
Mean	11.37	14.36
Variance	1.813444444	2.909333333
Observations	10	10
Pearson Correlation	0.29594983	
Hypothesized Mean Difference	0	
df	9	
t Stat	-5.155768471	
P(T<=t) one-tail	0.000299241	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.000598481	
t Critical two-tail	2.262157163	

Fig.8. t-Test: Two-Independent samples

Figure 8 shows that the t-value is -5.57, which is less than the alpha of 0.05. It means that on day 21, leaf height is consistently growing.

Day 28

	Manual Irrigation	Temperature Monitoring Irrigation
Mean	11.57	14
Variance	1.389	5.362222222
Observations	10	10
Pearson Correlation	0.328147429	
Hypothesized Mean Difference	0	
df	9	
t Stat	-3.450329497	
P(T<=t) one-tail	0.003635465	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.00727093	
t Critical two-tail	2.262157163	

Fig.9. t-Test: Two-Independent samples

For day 28, the computed t-value is -3.45, which is less than the significant value of 0.05. It means that the leaf height improved consistently from day 7 to day 28. Thus, temperature-monitoring irrigation shows a positive effect on the leaf height of pechay.

3.4 Average Length of Leaves

Table.4. Average Length of Leaves

Leaf Length (cm)								
Pechay No.	Manual Irrigation				Temperature Monitoring Irrigation			
	Day 7	Day 14	Day 21	Day 28	Day 7	Day 14	Day 21	Day 28
1	6.3	7.5	7.1	7.4	5	6.9	9.4	10.4
2	6.5	6.4	9.8	9.6	6.2	6.5	9.9	9.5
3	4.8	7.1	9.9	10.2	7.5	7.7	10.7	13.1
4	7.5	8.3	9.5	10.3	7.5	8.2	11.9	10.2
5	5.2	5.6	9.5	10.1	6.4	6.8	12.9	10.1
6	6.4	6.9	7.8	7.9	6.4	6.7	9.5	9.6
7	5.6	4.9	9.3	10.4	5	5.1	10	10.5
8	3.9	3.9	9.6	9.6	4.2	2.7	10	12.6
9	4.2	4.4	8.5	9.3	3.9	4.2	8.2	13.8
10	7.1	7.2	7.9	9.5	7	7.2	9.3	10.4
Average	7.57				8.33			

Based on Table 4, comparing the means of the two samples, the average length for manual irrigation is 8.33 cm, while for temperature monitoring irrigation it is 7.57 cm, resulting in a mean difference of 0.76 cm. Therefore, this study demonstrates that the leaf length of pechay grows more when using temperature-monitoring irrigation.

Day 7

	Manual Irrigation	Temperature Monitoring Irrigation
Mean	5.75	5.91
Variance	1.469444444	1.714333333
Observations	10	10
Pearson Correlation	0.624800682	
Hypothesized Mean Difference	0	
df	9	
t Stat	-0.461794706	
P(T<=t) one-tail	0.327593793	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.655187587	
t Critical two-tail	2.262157163	

Fig.10. t-Test: Two-Independent samples

The day 7 computed t-value is -0.46, which is less than the significance value of 0.05. It means that the pechay leaf was growing after 7 days in terms of length.

Day 14

	Manual Irrigation	Temperature Monitoring Irrigation
Mean	6.22	6.2
Variance	2.112888889	2.877777778
Observations	10	10
Pearson Correlation	0.927784003	
Hypothesized Mean Difference	0	
df	9	
t Stat	0.098162999	
P(T<=t) one-tail	0.46197717	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.923954339	
t Critical two-tail	2.262157163	

Fig.11. t-Test: Two-Independent samples

Figure 11 shows a t-value of 0.09, which is greater than the significant value of 0.05. It means that the leaf length of the pechay grew insignificantly on Day 14.

Day 21

	Manual Irrigation	Temperature Monitoring Irrigation
Mean	8.89	10.18
Variance	0.976555556	1.837333333
Observations	10	10
Pearson Correlation	0.543984404	
Hypothesized Mean Difference	0	
df	9	
t Stat	-3.502441726	
P(T<=t) one-tail	0.003348872	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.006697744	
t Critical two-tail	2.262157163	

Fig.12. t-Test: Two-Independent samples

On day 21, the t-value is -3.50, which is less than the significant value of 0.05. It means that the pechay leaf significantly grows and shows improvement from day 14 to day 21.

Day 28

	Manual Irrigation	Temperature Monitoring Irrigation
Mean	9.43	11.02
Variance	1.031222222	2.381777778
Observations	10	10
Pearson Correlation	0.198796507	
Hypothesized Mean Difference	0	
df	9	
t Stat	-3.010257664	
P(T<=t) one-tail	0.007354854	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.014709708	
t Critical two-tail	2.262157163	

Fig.13. t-Test: Two-Independent samples

Therefore, the temperature monitoring irrigation system for pechay indicates a significant and positive effect on the growth of pechay.

IV. Conclusions

In conclusion, the study indicates a positive effect of the temperature-monitoring irrigation system on the growth of pechay plants. Comparing the growth parameters of the pechay's leaves between the two irrigation methods revealed significant differences in the increase of leaf number, width, height, and length. Specifically, the Pechay plants grown with the temperature-monitoring irrigation system displayed a higher average leaf number of 0.95, a wider leaf width of 0.93 cm, a greater leaf height of 1.55 cm, and a longer leaf length of 0.76 cm as compared to the plants grown with manual watering.

These differences were statistically significant, highlighting the advantage of automated irrigation for Pechay growth. Therefore, the study supports the utilization of temperature-monitoring irrigation systems as a technological advancement for pechay cultivation to enhance crop growth and improve watering efficiency.

RECOMMENDATIONS:

For future research, the study can explore other growth parameters such as weight and water efficiency, which are significant in the cultivation of pechay plants. Additionally, include the study of the long-term effect of the temperature monitoring irrigation on pechay in different environmental conditions.

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