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Acetic Acid Percentages in Natural Herbicide for Weed Control

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Abstract: Inorganic herbicides mostly used toxic ingredients such as cyanide. It is different from organic herbicides where the material used is less toxic and safe to use such as vinegar with a low percentage of acetic acid. A mixture of vinegar and other ingredients such as dish soap is very effective in killing weeds in an instant. Acetic acid destroys plant tissue through contact action. The first objective of this study is to determine the acetic acid percentage to controlling the growth of weeds in residential area. The second objective of this study is to estimate the cost-effectiveness of organic herbicides. Titration method was carried out between vinegar and NaOH to determine the acetic acid percentage in vinegar. The average value of acetic acid found is 4.9%. Three herbicides with difference vinegar volume, 100 mL, 200 mL and 300 mL were prepared by adding 2 mL of dish soap. Then tap water was added so that the total volume of a mixture (vinegar, dish soap, and water) will become 500 mL. Then spraying were done on two types of weed selected for this study. The result shows, that organic herbicides with 2.0% of acetic acid gives a high percentage of weed killed (100%) using the lowest cost RM 1.70 per 500 mL mixture.

Keywords: Organic, Herbicide, Vinegar, Weed, Acetic Acid

1.0 Introduction

Inorganic herbicides mostly contained toxic ingredients such as cyanide and very expensive compare to organic herbicides where the materials use is less toxic and safe to use such as as vinegar with a low percentage of acetic acid and dish soap. The first objective of this study is to determine the acetic acid percentage to controlling the growth of weeds in residential area. The second objective of this study is to estimate the cost-effectiveness of organic herbicides. Acetic acid is the main materials in killing weeds compared to the dish soap. Dish soap act as a surfactant to decreases the surface tension of the herbicides. That's why this study is to focus more on the acetic acid percentage. The introduction of organic herbicides transformed weed control in the mid-twentieth century, making weed management less costly and decreasing energy costs due to weed growth [1]. Based on a study in America, there is still a lack of study on the effectiveness of natural herbicides to control weeds on highways and residential areas [2]. The majority of natural herbicide kill plant cells when they come into touch with them. Plants will begin to crumble or turn color within half an hour after the application

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of natural herbicide [3]. The rate of damage caused to the plant is mainly caused by the concentration of the herbicide determined besides the number and timing of applications [3]. The main chemical in natural herbicides is acetic acid. A study has shown a high percentage of weed (more than 50%) killed using low concentrations of acetic acid (less than 5%) [4]. In another study, 5% percent of acetic acid content in natural herbicides resulted in good destruction of wild weeds while in another study acetic acid concentrations below 10% destroyed the weeds within their first two weeks of growth [5]. The vinegar commonly contain 5% acetic acid (as per FDA regulation) and this will be futher diluted with water for herbicide. Vinegar is the most important ingredient compared to soap and even oil. That's why this study objective is to determine acetic acid percentage used to controlling the growth of weeds in residential area. The expected value for the acetic acid percentage is below 5% based on the another study. A study of herbicides containing glyphosate added with diluted vinegar containing below 1% acetic acid has shown good weed control in the palm plantation area. This result was the closest reference but not accurate enough since glyphosate was added [6]. Glyphosate is a strong pesticide that is widely used as a weedkiller. It is currently being banned because of its potential link to cancer in humans [7]. Some study has also suggested the addition of plant-based oil to the organic herbicides mixtures for weed control [8]. Pine oil has traditionally been used to kill insects in pest management in America [9]. In this study, dish soap was used to produce organic herbicide. Used of materials like dish soap supposedly produce cost effective herbicides with price below than RM 5.00. Natural herbicides also must be able to stop or slow down the weed regrowth for at least two weeks to compete with the current mowing practice which is carried out every two weeks [10].

2.0 Materials and Methods

The main ingredient is acetic acid sourced from commercial vinegar. The percentage of acetic acid in the vinegar is determined using the titration process using burettes and pipettes. Three different volumes of vinegar tested in the herbicide mixture were 100 mL, 200 mL, and 300 mL. Then each of this mixture were added with 2 mL dish soap. Next the mixtures will be added with tap water until all the total mass of the mixture became 500 mL. For spraying, a 1-liter mini knapsack sprayer was used. The titration process was carried out in University Tun Hussein Onn Malaysia (UTHM) laboratory and the procedure is outlined in **Figure 1**.

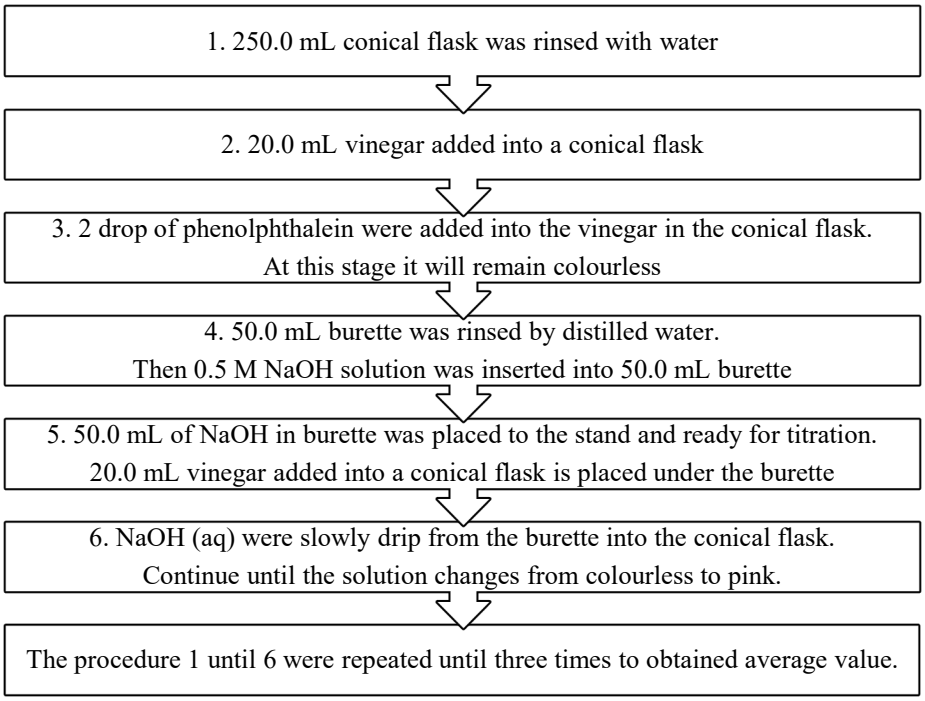

Figure 1:Procedure for titration method (vinegar and NaOH)

2.1 Calculation of acetic acid percentage in vinegar

Equation 1 indicate the process of titration between vinegar (acetic acid) and NaOH:

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O \quad (Eq.1)$$

After the experiment done, moles of NaOH used was find by using the Equation 2:

$$\text{Moles of NaOH used} = \left[volume\ of\ NaOH\ used\ (mL) \times \frac{1\ L}{1000mL}\right] \times 0.5M\ NaOH \quad (Eq.2)$$

Then, moles of acetic acid present was calculated by using molar ratio, 1 mol $HC_2H_3O_2$: 1 mol of NaOH. After that, mass of vinegar and mass of acetic acid were calculated. Mass of vinegar was calculated by multiply volume of vinegar used, 20.0 mL with density of vinegar, 1.000 g/mL (density of vinegar = density of water). Molecular weight for acetic acid is 60 g/mole $HC_2H_3O_2$. Mass of acetic acid was calculated based on Equation 3:

$$\text{Mass of Acetic Acid} = moles\ of\ acetic\ acid\ present \times \frac{60\ g}{mole\ CH_3COOH} \quad (Eq.3)$$

When mass of vinegar and mass of acetic acid were calculated, Equation 4 were used to find the acetic acid percentage:

$$\text{Acetic Acid Percentage \%} = \left(\frac{mass\ of\ acetic\ acid}{mass\ of\ vinegar}\right) \times 100 \quad (Eq.4)$$

Table 1 shows the results for initial and final volume of NaOH and the value of NaOH volume and moles used during the titration. The alkali used for this titration is 0.5M NaOH. The table was divided based on three trial made which were Trial 1, Trial 2 and Trial 3. Volume for vinegar was fixed for all three trial. Initial volume of NaOH were difference each trial. The moles of NaOH used for were calculated by following the Equation 2, which based on the volume of NaOH used were different for each trial. The results obtained were 5.06%, 4.92% and 4.75% as listed in **Table 2**. This gives the average value of 4.9% which round up to 5%.

Table 1: Initial and final volume of NaOH, volume and moles used of NaOH

Trial	Volume of vinegar (mL)	Volume NaOH initial (mL)	Volume NaOH final (mL)	Volume NaOH used (mL)	moles of NaOH used
1	20.0	2.1	35.8	33.7	0.01685
2	20.0	1.5	34.3	32.8	0.0164
3	20.0	3.3	34.8	31.5	0.01575

Table 2: Numbers of trial , mass of acetic acid and percentage of acetic acid

Trial	Mass of acetic acid (g)	Percentage of acetic acid (%)
1	1.1011	5.060
2	0.984	4.920
3	0.945	4.725
Average percentage		4.9

2.2 Preparation of diluted acetic acid for herbicide

The vinegar were diluted with water prior to the herbicide trial as outlined in Table 3. Initially 2 mL of dish soap was added to desired volume of vinegar sample . Then tap water was added so that the total volume of mixture (vinegar, dish soap, and water) up to 500 mL. Since the average percentage of acetic acid in the vinegar was found to be 4.9%, the new acetic acid percentage will be calculated using the relationship of $MV_1 = MV_2$.

$$\text{Acetic Acid Percentage in Mixture } \% = \left(\frac{volume\ of\ vinegar}{total\ volume,500\ mL}\right) \times Average\ acetic\ acid, 5\% \quad (Eq.5)$$

Table 3: Acetic acid percentages in three trial mixtures

Trial mixture	Volume of vinegar (mL)	Volume of soap (mL)	Volume of water added (mL)	Acetid acid percentage (%)
1	100	2	398	1.0
2	200	2	298	2.0
3	300	2	198	3.0

2.3 Weeds selected, spraying method and monitoring

Only two weed types selected for this study which are Straggler Daisy and Bermuda Grass as shown in **Figure 2**. The study was conducted by two students and the test area was in their respective residential areas. However the size of the weeds tested had the same size which was between 1-5 cm, small weeds. Application of natural herbicide was carried out during the warm daytime hours. Spraying is done in the morning when the dew has disappeared (approximately 10 am). If rain occur 4 hours after spraying is performed the data is considered invalid and spraying will be carried out in the next day. The spraying area was measured with 1-meter x 1-meter. The weed is monitored after 3 days of spraying.

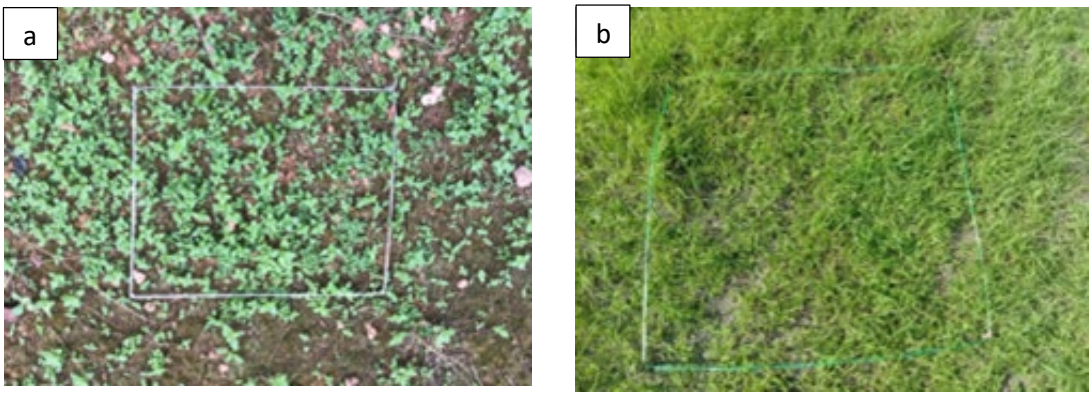

Figure 2: Straggler Daisy (a) and Bermuda Grass (b)

2.4 Calculation for percentage of weeds killed

In another study that were referred to, it does not specify how to calculate the percentage of weed killed. It only shows the results in percentage. For this study, the percentage of weed killed was calculated based on Equation 5.

$$\text{Percentage } of\ Weeds\ Killed\ \% = \left(\frac{dead\ weeds\ area}{plot\ area}\right) \times 100 \quad (Eq.5)$$

3.0 Results and Discussion

Table 4 shows the results from the herbicides that were mixed with 2 mL dish soap. The trial results in the Table 4 explained the weed's reactions after being sprayed by the organic herbicides. As shown in Table 4, the acetic acid percentage used for mixture were 1.0%, 2.0% and 3.0%. From Table 4, it also determine the percentage of weeds killed after 3 days of spraying.

Table 4: Herbicides mixed with vinegar and 2 mL dish soap

Trial mixture	Acetid acid percentage (%)	Trial results
1	1.0	95% weed killed after 3 days
2	2.0	100% weed killed after 3 days
3	3.0	100% weed killed after 3 days

3.1 Percentage of weeds killed based on acetic acid percentage

Based on the **Table 4**, percentage of weed killed shows that Trial mixture1, Trial mixture 2 and Trial mixture 3 can kill weeds by a percentage of over 95% . Results of mixtures of vinegar and dish soap were taken to estimate the cost effectiveness of organic herbicides with a good quality. Based on Table 4, it show that at 2.0% and 3.0%, the percentage of weeds killed is effective with 100% dead weeds after 3 days. Compare to the 2.0% and 3.0%, the effectiveness of weed killed at 1.0 % is lower.

3.2 The costs of herbicides with a mixtures of vinegar and dish soap

Table 5 shows the costs of material use in produce organic herbicides. List of costs shown in Table 5 was based on the volume of vinegar and dish soap use in Trial mixture 1, Trial mixture 2 and Trial mixture 3. Meanwhile, in **Table 6** shows the cost of herbicides for Trial mixture 1, 2 and 3.

Table 5: The costs of materials used in Trial mixture1, 2 and 3

Materials	Volume (mL)	Acetid acid percentage (%)	Cost
Dish soap	2	-	RM 0.70
Vinegar	100	1.0	RM 0.50
	200	2.0	RM 1.00
	300	3.0	RM 1.50

Table 6: Total costs of Trial mixture 1, 2 and 3

Trial mixture	Acetid acid percentage (%)	Cost
1	1.0	RM 1.20
2	2.0	RM 1.70
3	3.0	RM 2.20

4.0 Conclusion

In conclusion, the main key of the study is to determine the acetic acid percentage to controlling the growth of weeds in residential area. Based on the findings obtained and shows in this study, it can be concluded that the best acetic acid percentage to be used to produce organic herbicides is 2% due to it's cost-effectiveness of RM 1.70 per 500 mL mixture combined with its high percentage of weed killed. A low percentage of acetic acid in herbicide is sufficient to kill the unwanted plants and can also help in producing cost effective organic herbicides. Due to the cleaning and weed killing activities done every 2 weeks it is also difficult to test herbicides on other weeds to time constraints as well as limited movement, this study was unable to determine the rate of weed regrowth (after a few weeks). Due to data of herbicides based on weed regrowth will further strengthen the current results. With the findings in this study, it looks ahead to introduce and raise awareness towards communities to practice themselves in using organic herbicides where it is safer and cheaper. Suggestion for the next paper is to study the use of a lesser percentage of acetic acid in vinegar to achieve a more cost effective herbicide. Future research should study natural herbicide formulation that can last up to two weeks to complete with a mechanical grass cutter.

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