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The Study of Water Reconditioning using Magnetic Field for Plant Industry

Abstract. *This paper studies the growth of plants resulting from the use of magnetic-treated water. The emitter is designed by using a PVC pipe with inductance coils for inducting magnetic wave, divided into 5 types are one winding induction coil, two winding induction coils in the same direction, two winding induction coils in alternate directions, four winding induction coils in the same direction, and four winding induction coils in alternate directions. The simulation results are simulated by using CST Microwave Studio to analyze the magnetic field distribution that has an effect on the water. In addition, the five prototypes of inductance coils on pipe are constructed to be tested by watering real plants. When 40 liters of water flowed through the proposed pipe that surrounded by a magnetic field for 10, 30, and 60 minutes. It was found that the magnetic field generated by the four winding induction coils in alternate directions results in a transformation of water suitable for plant growth with 35.58 %, compared to the growth of plants grown by watering the elder does not pass through the magnetic field.*

Streszczenie. *W niniejszej pracy zbadano wzrost roślin w wyniku stosowania wody uzdatnionej magnetycznie. Emiter jest zaprojektowany przy użyciu rury PVC z cewkami indukcyjnymi do indukowania fali magnetycznej, podzielony na 5 typów to jedna cewka indukcyjna uzwojenia, dwie cewki indukcyjne uzwojenia w tym samym kierunku, dwie cewki indukcyjne uzwojenia w naprzemiennych kierunkach, cztery uzwojenia cewki indukcyjne w w tym samym kierunku i cztery uzwojenia cewek indukcyjnych w przeciwnych kierunkach. Wyniki symulacji są symulowane za pomocą CST Microwave Studio do analizy rozkładu pola magnetycznego, które ma wpływ na wodę. Ponadto skonstruowano pięć prototypów cewek indukcyjnych na rurze, które można przetestować poprzez podlewanie prawdziwych roślin. Kiedy 40 litrów wody przepłynęło przez proponowaną rurę, otoczono ją polem magnetycznym przez 10, 30 i 60 minut. Stwierdzono, że pole magnetyczne generowane przez cztery uzwojenia cewek indukcyjnych w naprzemiennych kierunkach powoduje przemianę wody odpowiedniej do wzrostu roślin o 35,58%, w porównaniu do wzrostu roślin uprawianych przez podlewanie bzu czarnego nie przechodzącego przez pole magnetyczne.* (***Badanie uzdatniania wody za pomocą pola magnetycznego dla przemysłu rolniczego***)

Keywords: Induction coil, Magnetic field, Plant growth, Magnetic-treated water
Słowa kluczowe: cewka, pole magnetyczne, przemysł rolniczy

Introduction

Nowadays, the agrichemical is used are widely used in cultivation. The chemical fertilizers herbicides and substances to accelerate growth these produce chemical residues in the produce and followed by health problems for both farmers and consumers. Moreover, the agrichemical has a high cost caused the non-toxic plants is grown. The non-toxic plants can be reduced agricultural chemicals and contaminants from chemical residues and it is also easy to grow and maintain. Non-toxic planting uses bio-compost, bio-fermented water themselves however, the cultivation of non-toxic plants also contributes to increasing the income of the produce. Besides, the planting without chemicals is also a method of growing plants without soil, known as hydroponics this method [1] – [2] of planting plants is planting without plant material, which is the cultivation of plants in the plant's nutrients. The roots are in direct contact with nutrients, which can be divided into 3 different planting methods. Firstly, the nutrient film technique (NFT) [3 – 6] is a method of providing nutrient solutions. This technique is a circulating flow where the plant roots are fully nutrient-rich. Secondary, the dynamic root floating technique (DRFT) [7 – 10] is a system of direct nutrient delivery to plant roots and have aeration to increase oxygen. Finally, deep flow technique (DFT) [11 – 15] planting system allow nutrients to flow through the roots continuously and rotate like a plant soaked in water and a water flows through the plant roots regularly.

At present, the magnetic fields are used to help grow plants and the effects of magnetic fields on plant growth have been studied such as magnetic water system to increase the growth rate of hydroponics vegetables [16 – 18]. An effect of static electric and magnetic field treatment on germination and growth rate of red rice [19], magnetic field (MF) applications in plants: an overview, and impact of magnetic water on plant growth [20-28]. From what was presented above, it was found that the magnetic field contributed to the growth rate of plants.

In this research, the solenoid coil is studied and designed by using a PVC pipe with inductance coils to generate the magnetic fields in to the water that have an effect on plant growing. Types of induction coil windings in order to study which kind of winding coil has the best effect on plant growth.

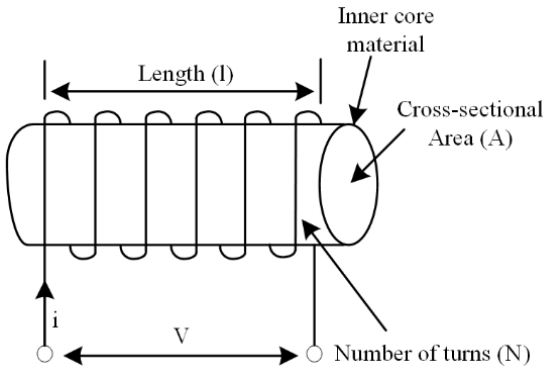


Fig.1. Solenoid coil.

Background theory

From the induction theory, the magnetic field is occurred when an electric current flow through a coil. The energy is temporarily stored in form a magnetic field. The inductance is the result of the magnetic field surrounding the conductor with current flowing through. The conductor wire generates the magnetic flux whereby inductance is determined by the amount of magnetic flux according to equation (1).

(1) $$L = \frac{d\Phi}{di}$$

when **L** is the inductance, Φ is magnetic flux, and **i** is the current. Inductance is the winding of a conductor several times, produced large amounts of flux and inductance. There are factors such as the number of windings, the cross-sectional area of the core used to wind the winding, the material of the core and the length of the core, according to the equation (2).

(2) $$L = \frac{N^2 \mu A}{l}$$

N is the number of windings, μ is the permeability of the material used to make the axis, **A** is the cross-sectional area of the axis and **l** is the length of the core as shown in Fig. 1. [29]

The magnetic fields can be changed the properties of water by making water increase its solvent properties, reduce surface tension, and increase its solubility. And there is an energy boost to the water because of the hydrogen bond arrangement. [30]

The systems of water conditioning by using magnetic wave for applying in planting industry are divided into two parts which are the induction coil design and the generator system.

Design system

Fig. 2 shows the generator system, it is divided into 5 parts it consists of power supply circuit, oscillator circuit, buffer circuit, signal drive circuit and resonant circuit. The power supply consists of a switching power supply circuit and a step-down circuit. The step- down circuit is divided into two circuits, the circuit in the first part will supply power to the oscillator circuit and the step-down circuit in the second part is used to feed the signal driving circuit. Arduino nano microcontroller board oscillator circuit is used as a signal generator. The oscillator circuit generates a PWM signal to control the signal driving circuit before entering to the drive circuit, the signal reverses the phase through the buffer circuit. For the driver circuit, L298n module is used for H-bridge circuit. When the signal passes through the buffer circuit, there are two signals which are phase reversal and non-phase reversal. Signals controls the module to drive the signal to induction coil and the resonant circuit part. In this section, parallel LC is used. The circuit in this section will reduce the power loss to the module. If there is no circuit in this section, the module will generate heat and maximize power to the induction coil. The magnetic field generator can be used no more than 10 watts of power.

Five types of the induction coil design are shown in Fig. 3. It uses a 1.5 mm wire as a conductor and uses a 1.5-inch pipe with a length of 1 m. A conductor wire wound with a pipe as a coil of inductance for all 5 types, each of which has the same length of wire and similar inductance by winding. Each of a pipe as a coil has an inductance of about 110 μH as illustrated in Fig. 3(a) will the first type by will winding coil the conductor in the same direction. The length of the induction coil winding is 80 cm. The second type, the induction coil is divided into two coils as shown in Fig. 3(b), both coils will be wound in the same direction, the length of each coil winding is 40 cm. Fig. 3(c) shows the third types of inductance coil, it is divided into two parts like the second type but the direction of winding on each side is opposites. The length of the winding on each side is 40 cm. The induction coil is divided into four parts with a winding length of 20 cm and each coil is wound in the same direction as shown in Fig. 3(d) is the fourth type. Fig. 3(e) is the fifth type. The induction coil divides into four parts just like the fourth type. But there will be different intertwined directions, each coil will be intertwined in alternating directions. and the length of each coil winding is 20 cm.

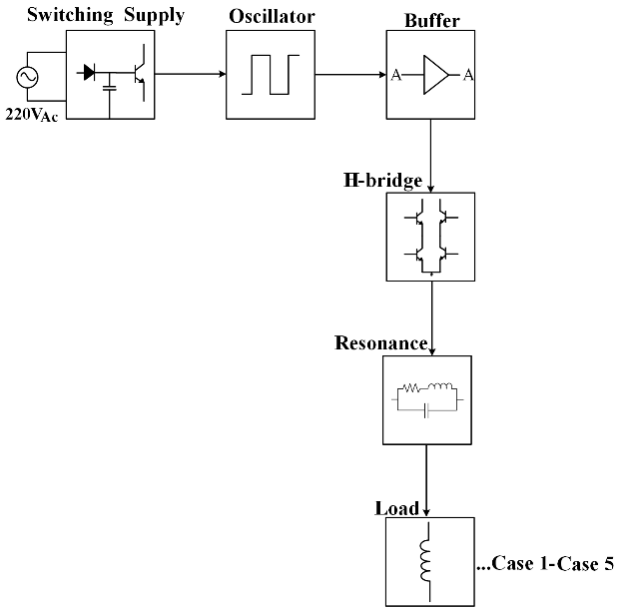


Fig.2. The generator system.

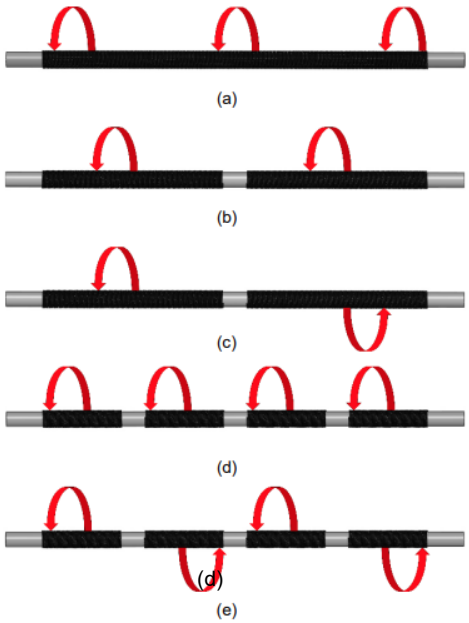
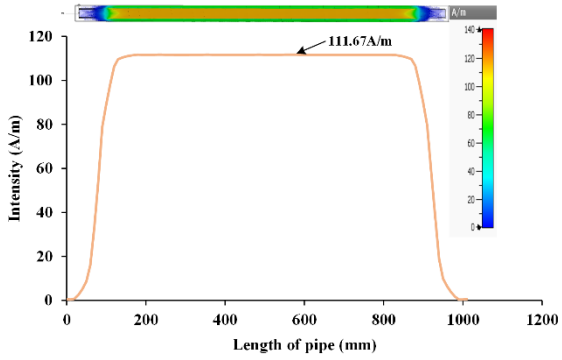


Fig.3. Various Winding of induction coil.

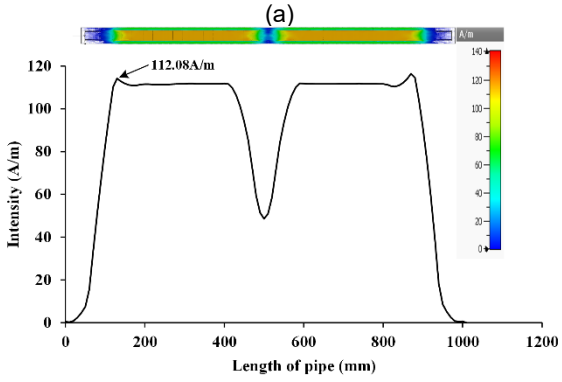
Simulation results

The simulation results of the magnetic field with the differenced coil winding patterns are performed by using the CST Microwave Studio program. Considering to the intensity of magnetic field on 5 types of inductance coil as shown in Fig. 4. To analyze and compare the results of the simulation, Fig. 4(a) shows the magnetic field intensity of first type. The most intensity of magnetic field radiates at the all area of the induction coil as 111.67 A/m. The intensity of the magnetic field gradually increases to the peak of the graph and the end of the intensity graph gradually decreases to zero. When the intensity increases to the peak, the intensity remains constant through until the

end point. Fig. 4(b) simulates the effect of two induction coils that winds in the same direction. The radiated magnetic field strength is clearly divided into two parts with the maximum intensity of 112.08 A/m. When reaching the peak value, the magnetic field intensity is constant until the middle of the graph. In Fig. 4(c), two coils are wound with the differenced direction. The intensity of the radiated magnetic field is similar to the second type with maximum intensity of 116.43 A/m. From fourth type of induction coil as illustrated in Fig. 4(d), the intensity of magnetic field strength is divided into four series with the radiating characteristics similar to Fig. 4(b) by the of the magnetic field intensity is radiated into four sets according to the number of coils and when looking at the magnetic field region the induction coil, it is shorter than the radiated magnetic field strength of Fig. 4(b). The maximum intensity of magnetic field is 116.85 A/m. The intensity magnetic field strength of the fifth type of the induction coil close to Fig. 4(e). The intensity is radiated into four sets when observed in the middle region between the coils, the intensity in this region is less than Fig. 4(d).



(a)



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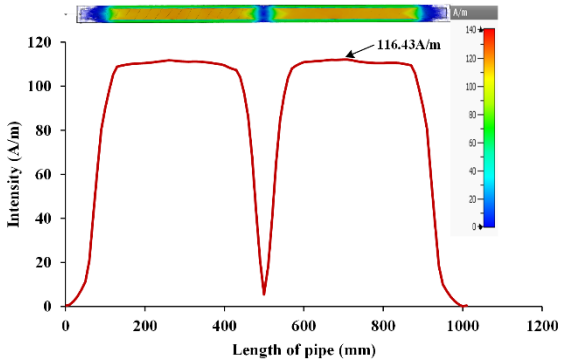
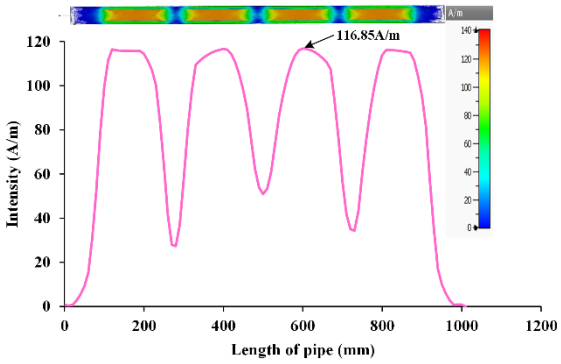
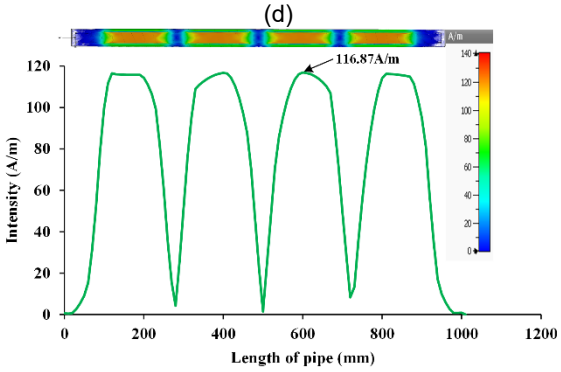


(c)



(d)



(e)

Fig.4. Simulation results of the magnetic field. (cont.)

The intensity of the five types of induction coils is occurred more in the pipe area where the induction is wound which are less intense with further when distance from the coil induction. The fourth and fifth types of magnetic field intensity graph from the figure are found to be similar to the second and third magnetic field intensity graphs, it can be observed that when the intensity reaches its peak and it stays constant for a while. It is found that the distance of the constant intensity value has a shorter distance of the constant intensity graph than that of the intensity graph type second and third, and the graph follows four cycles of ups and downs until the end for graph.

When the conductors are winded in opposite directions, the intensity in the middle between the inductance coils is greatly reduced to near zero, but when the conductors are wound in the same direction, the intensity in the middle between the inductance coils. The inductance is also reduced, but less than with opposite direction windings. From the five types of magnetic field intensity curves, at the highest magnetic field intensity, it can be seen that the graphs of type 4 and 5 are higher than those of type 1, 2 and 4.

Experimental results

The 40 liters of water is prepared in order to bring it into the pipe that is wrapped with various induction coils. In addition, morning glory seeds, nursery trays, and potting soil are made ready for trial. The experiment is wet the morning glory seeds in normal water for 12 hours and preparing the soil in the nursery tray for planting morning glory seeds. The morning glory has been compared in the growth with all six types of watering: normal water and induced water with the five types of the induction coils. Induction coil of the 5 types as shown in Fig. 6(a). Fig. 6(b) depicts the induction system that a water circulation system flows through a PVC pipe, bended by varies induction coils. The flowing time of water is considered for three periods time as 10 min, 40 min and 60 min

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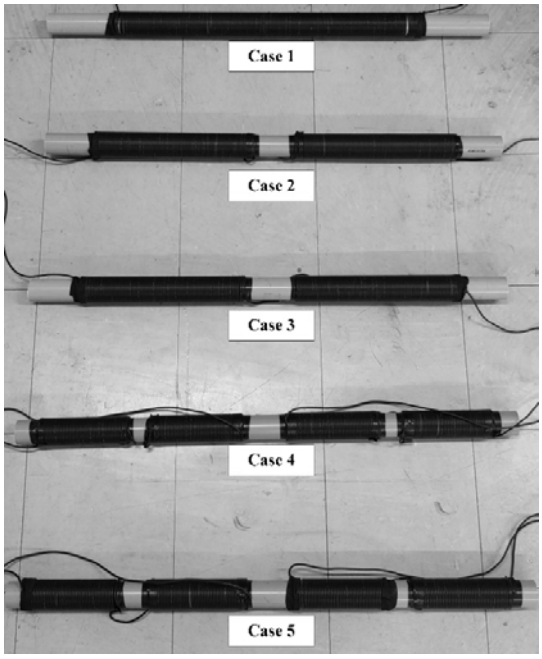
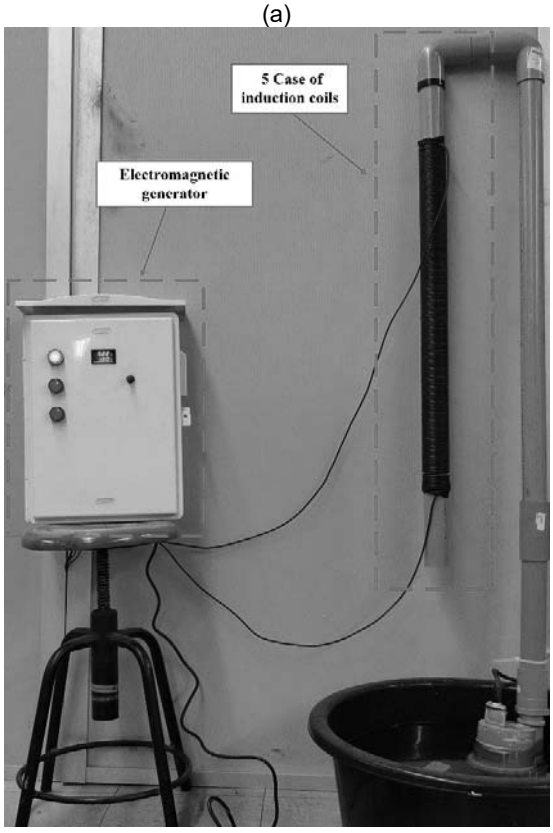


(a)



(b)

Fig.6.Test of magnetic field application to water pretreatment (a) 5 types of induction coils (b) Water circulation system through induction coil.

The five types of water under test by using induction coil technique are used to water the morning glory in twice time per day at 9:00 a.m. and 4:00 p.m. When the plants began to grow, it is measured the height of morning glory. And then, the measuring height results are collected in every 4 days. The results are collected for a total of 7 days and the experimental data are compared between normal water and water treated with an induction coil to see how it effects the growth of morning glory.

From the test it was found that when taking the height data of the morning glory to plot the graph, divided by the time that the water passes through the induction coil is 10 minutes, 40 minutes and 60 minutes. Fig. 8 shows a graph of water that passes through the five types of induction coil for 10 minutes compared to normal water. In the first day experiment, it was found that the height of the morning glory using normal water tended to be higher than the water that passed through all 5 types of induction coils. The results of day 2, the height of morning glory using normal water also tended to be higher than that through induction coils of types 1, 2, 3 and 4, except type 5 which have a tendency to be higher than a normal water. On day 4 collect results, water through induction coils types 4 and 5 had a higher height of morning glory than normal water, but water through induction coils types 1 and 2 also had a lower height of morning glory normal water. On the 5th day of the collect results, the water that passed through the type 2 of the induction coil had a higher height than the normal water, but the water that passed through the type 1 of the induction coil still tended to be lower than the normal water. On the 5th, 6th and 7th day of the collect results, the height of the induction coil type 2, 3, 4 and 5, the height of the morning glory still tended to be higher than normal water and the water passing through the induction coil type 1 remained has a lower height than normal water**.**

Fig. 9 is a graph showing the relationship between water under test at 40 minutes and normal water. When starting to collect the results on day 1, it was found that the water that passed through the induction coil type 2, 3, 4 and 5 have a tendency to have a higher height of the morning glory than the normal water, while the water that passed through the induction coil type 1 have a tendency to be lower than normal water. For result collected on day 2 and 4, the water treated with type 1 coil still have a tendency to have a lower height of morning glory than normal water, and water that has passed through other coil types still tends to be higher than that of normal. Collection result of date 4 to 7, a water that passes through the 5 types of induction coils tends to have a higher height of morning glory than normal water. From the graph, it can be seen that the water that passes through the induction coil all of five types has a higher tendency of than the control water

Fig. 10 plots a height of plant that is growing by watered under test for 40 minutes compared to normal water. When collecting results between day 1-2, it was found that morning glory height of watered from induction coil type 1 is more than normal water, while water passing through other types of coil tendency to be higher normal water. At the start of collect results on the 4 days, the water through the induction coil type 1 have a tendency to a higher height of morning glory than normal water and on the 4-7 day o collect results, the water through the **5** types of induction coils tends to be noticeably higher than normal water. When observing from the graph, it was found that the water passing through coils 4 and 5 had similar heights of morning glory, but the water passing through coils 5 still have a little tendency to be higher than the water passing through coils type 4

Table 1. Morning glory growing percentage compared with a normal water

Time	Type of coil				
(min)	1	2	3	4	5
10	17.74	21.25	29.11	42.68	44.27
40	19.44	22.77	41.04	44.22	45.58
60	20.04	22.88	40.60	44.24	44.67

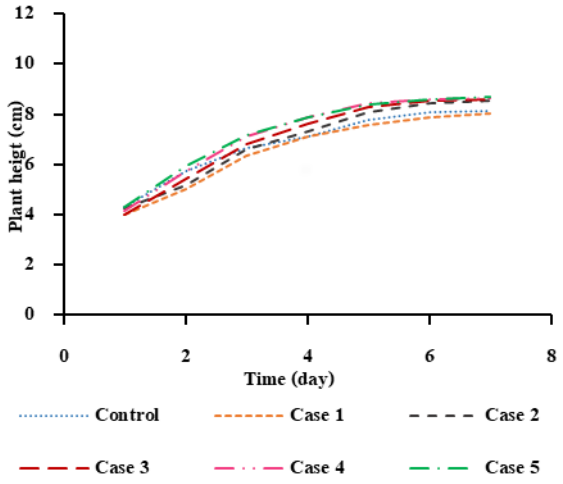


Fig.8. Plant height growing by normal watered and watered through the induction coil in 10 minutes.

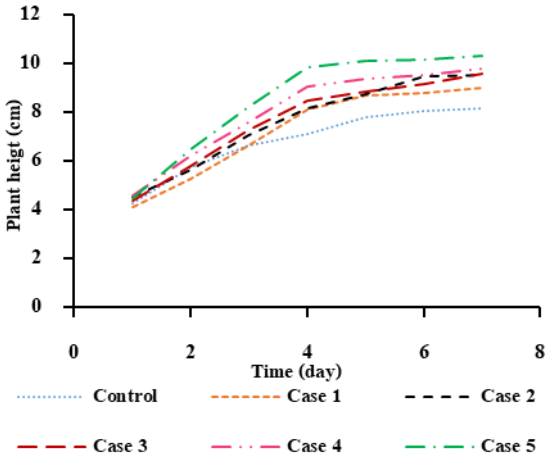


Fig.9. Plant height growing by normal watered and watered through the induction coil in 40 minutes.

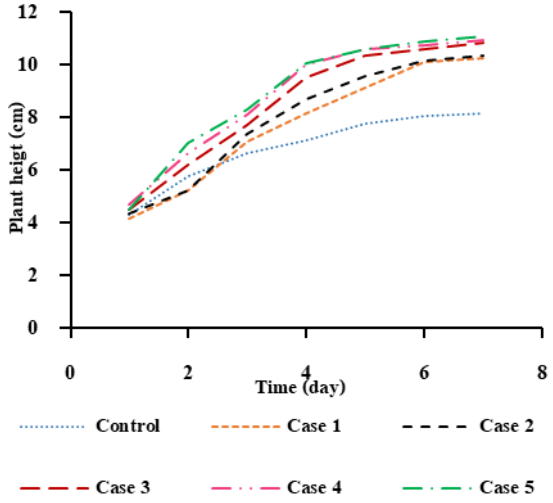


Fig.10. Plant height growing by normal watered and watered through the induction coil in 60 minutes.

When the water through the induction coil type 5 for each period the water passed through the inductor coil was compared with normal water it was found that the duration of water through the induction coil had an effect on the height of the morning glory as shown in the graph in Fig. 11. It can be seen that the water that passed through the coil with 60 min had the highest rate of increasing the height of the morning glory compared to the normal water and water passing through the induction coil at 10 minutes and 40 minutes and water for 40 minutes to pass through the induction coil will increase the height of morning glory second after water passing through the induction coil 60 minutes and the duration of 10 minutes is the lowest height rate so it can be concluded that when the water takes longer to pass through the induction coil, it will increase the height of the morning glory. The height of the water that passed through the magnetic field for each time period was averaged from the 7-day results collection and calculated as a percentage of the water that passed through the 5 types of induction coils as a result, how many percent increase in the height of morning glory compared to normal water as shown in Table 1. From Table 1, the average height of morning glory at each time of water through the induction coil from the 7-day results collection it was found that the water that passed through the induction coil when using the time that the water circulated through the coil will increase the percentage of the height of the morning glory and the 4 and five winding types have a similar and have larger percentage compared to the others type.

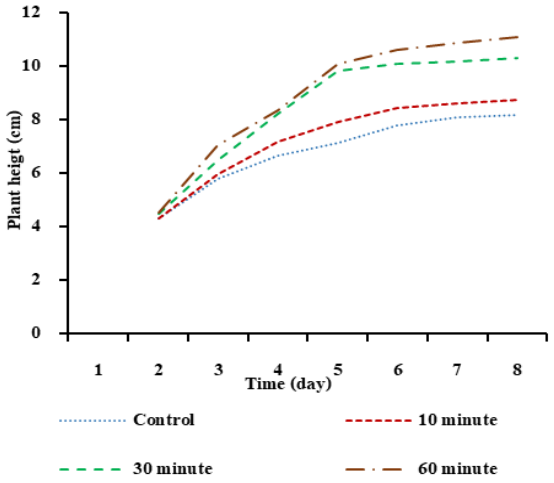


Fig.11. The water passing through the induction coil type 5 at different times compared to the control water.

Conclusion

The magnetic fields generated by induction coil on water conditioning has an effect for growing of plant industry**.** It was found that magnetic fields resulted in better plant growth compared to using conventional methods. When the water passing through the four induction coils in alternating directions have a tendency to increase the height of morning glory the most compared to water that passes through other coils and the amount of time the water passes through the induction coil will result in the tendency for the height of the morning glory to be higher than that of the water that takes the time to pass through the less induction coil. Therefore, it was concluded that when the magnetic field was very intensity and the period of time the water passed through the magnetic field; the height of the morning glory would be higher than that of normal water ostensibly. Therefore, type 5 inductor winding have a higher rate of morning glory than other types of induction windings.

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