Magna Scientia
Open access publication

Magna Scientia Advanced Biology and Pharmacy

eISSN: 2582-8363

Cross Ref DOI: 10.30574/msabp

Journal homepage: https://magnascientiapub.com/journals/msabp/

Magna Scientia Advanced Biology and Pharmacy (MSABP)

(Research Article)

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Study of geotropism versus hydrotropism in green bean radicles (*Vigna radiata* L.) by Oblique Olfactometer method

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Magna Scientia Advanced Biol ogy and Pharmacy, 2024, 11(02), 020–025

Publication history: Received on 01 February 2024; revised on 09 March 2024; accepted on 11 March 2024

Article DOI: https://doi.org/10.30574/msabp.2024.11.2.0018

Abstract

Plants respond to external stimuli which often involve constant movement of the plant. The movement of plant organs in response to external stimuli is responsible for the production of energy sources. Research on the nature of the radicle tropics aims to find out whether the roots actually grow downwards due to geotropism or hydrotropism. The mung bean species (*Vigna radiata* L.) is used because the germination process of this species does not require a long time and the seeds of this species are suitable for growing on olfactometer planting media and are suitable for growing in the climatic and geographical conditions in Indonesia. The method chosen in this research is the tilted olfactometer method, which is a planting method carried out using an aquarium hose and olfactometer connector which is tilted 30 degrees because this research aims to see the direction of growth of the radicles of mung beans (*Vigna radiata L.*) so this method was chosen; because the seeds can be positioned in the three-pronged olfactometer at an angle so that the final growth results can be distinguished between the tendency of the geotropism factor or the hydrotropism factor. It is proved that radicles tips would growth upward to wet cotton, against the geotropic effect.

Keywords: Tropism; Geotropism; Hydrotropism; Green beans (*Vigna radiata L.*)

1. Introduction

Plants respond to external stimuli which often involve constant movement of the plant. These stimuli such as light, gravity and water, as well as endogenous developmental signals are determined by the plant's biological clock. The movement of plant organs in response to external stimuli is responsible for the production of energy sources (Muther *et al.*, 2020).

Mung bean plants are one commodity that is widely consumed by people in Indonesia. Considering the importance of the availability of green beans as a food ingredient used by people in Indonesia, it is important to cultivate mung beans. Currently, the increasing need for mung bean plants is directly proportional to the increase in population and the development of the food industry in Indonesia (Prayitna, 2017).

The radicle or embryonic root is the main root candidate in a plant that will emerge from the seed during the germination process (Wibowo, 2020). The radicle is a characteristic of sprouts and the length of the radicle also indicates the optimality of the germination process (Khoirunnisa, 2022). In the germination process, physical changes occur in the seeds caused by active metabolic processes in the seeds.

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Mung bean plants have tap roots. The root system is divided into two, namely mesophytes and xerophytes. Mesophytes have many root branches on the soil surface and have a spreading growth type meanwhile, xerophytes have fewer branch roots and will extend towards the bottom (Purwono and Hartono, 2012).

The roots of green bean plants consist of tap roots, fibrous roots and lateral roots. The tap root is the primary root that grows earliest from the growing seed. The taproot grows to the center of the earth reaching a depth of more than 1 m. Lateral roots are secondary roots or root branches that grow from the primary root. These secondary roots grow spread sideways (horizontally) close to the soil surface with a width of more than 40 cm. l Fiber roots are hair roots that grow on the lateral roots (Pujiah, 2016).

The tilted olfactometer method is a planting method that is carried out using an aquarium hose and olfactometer connector that is tilted 30^{0} proven to be effective and successful and has its own advantages by using media other than soil as a growing medium, this method was chosen because the seeds can be positioned in the three-pronged olfactometer at an angle so that the final growth results can be distinguished between the tendency of the geotropism factor or the hydrotropism factor.

The movement of organs in biological organisms in response to external stimuli originating from the environment is part of the Tropical Phenomenon. The response that occurs in tropism depends on the direction of the stimulus source and the nature of the stimulus itself. Plants will grow towards the stimulus if the stimulus is considered to have a positive effect on the plant and plants will move away from the direction of the stimulus if the stimulus is considered to have a negative effect on plant growth.

Tropism originates from the differential growth of cells in some plant organs, for example at the root tip the growth of cells tends to be faster than cells in the opposite area. Growth that follows the direction of the source of stimulus is called positive tropism, while growth that is directed away from the source of stimulus is called negative tropism (Yamazaki *et al.,* 2019).

Geotropism or gravitropism is the movement of plant growth due to the influence of the earth's gravitational force. If the direction of movement is towards the stimulus, it is called positive geotropism, for example root movement towards the soil. If the direction of movement is away from the stimulus it is called negative geotropism, for example, the movement of stems growing away from the ground and for example the movement of roots that grow vertically towards the center of the earth. Meanwhile, hydrotropic movements in plants are caused by the influence of stimulation from water sources. If the plant's growth moves closer to water, it is called positive hydrotropism. For example, the growth movement of plant roots towards places that contain lots of water. If the movement of plants grows away from water, it is called negative hydrotropism (Astuti, 2022). In drought conditions, this tropical property is important because positive hydrotropism properties can function as plant protectors and when plants experience excess water, the hydrotropism properties are negative.

The phenomenon of negative geotropism in the roots of eucalyptus and gelam species was discovered by Marisa (2021). Where eucalyptus species are found to have roots growing hidden behind the bark, this indicates the existence of a negative geotropism phenomenon.The stem shows that this root was truly formed as an original root, not adventitious because the morphology shows branching in the root where this characteristic is included in the nature of the main root. This phenomenon prompted us to test whether plants, in this case green bean sprouts, if treated with the presence of water in cotton wool, would the roots choose to grow upwards or downwards.

2. Materials and Methods

2.1. Time and place

The research was carried out in July-August 2023. Located in a dark and dry room in a house located on Jl Nusantara Gang Buntu RT.04 LK01 No.25, Timbangan, Kec. Indralaya, Ogan Ilir District, Palembang City, South Sumatra.

2.2. Tools used

The tools used in this research included thread, clear insulation, cotton, ruler, acrylic board, dropper pipette, olfactometer hose connector, 24 aquarium hoses each 3 cm long, mung bean seeds.

2.3. Materials used

The materials used in this research were distilled water and mung bean seeds (*Vigna radiata* L.)

2.4. Research methods

The method used in this research is an experimental method with two groups of data, namely quantitative for radicle length and qualitative for radicle growth direction..

The observation parameters in this research are:

The length of the radicle of mung beans (*Vigna radiata* L.) which grows after 4 days, is measured using a thread and then measured thoroughly using a ruler.

The direction of growth of the radicle of mung bean sprouts (*Vigna radiata* L.) seen after 4 days has a predominantly geotropic growth direction (growth direction towards the direction of gravity) or a hydrotropic dominant growth direction (growth direction towards the water source).

Mung bean seeds (*Vigna radiata)* are soaked for 12 hours and then inserted into one of the arms of the olfactometer hose that has been prepared until it is located in the middle of the olfactometer hose. Next, carry out the previous procedure 24 times on each olfactometer tube. Separate 12 mung bean (vigna radiata) seeds each into the planting medium on the acrylic board so that there are 2 acrylic boards with 12 planting mediums using the olfactometer hose. On green bean seeds (*Vigna radiata*) 12 olfactometer tubes were dripped with water from the top end, and 12 more were not dripped with water. When the olfactometer media has been completed, it is placed at an angle of 30º using a wooden block so that the direction of movement of the radicle between wet cotton and dry cotton is known, then the sample is closed for 4 days. Observations were made on the length of the radicle and the direction of root growth.

2.5. Data analysis

Data were analyzed using the T Test. The treatments used were 2 treatments with 12 repetitions, 12 samples were treated with drops of water and 12 samples were not dripped with water as control samples. The data obtained from the research results will be analyzed using a two-way T test.

3. Results and Discussion

Based on research that has been completed on mung bean radicles (*Vigna radiata* L), data was obtained from 24 samples based on the results after four days of observation which stated that the direction of growth of the radicles on the W-D (Wet-Dry) media was visible, namely that there were 11 radicles in the sample that showed an upward growth direction or positive hydrotropism and 1 sample radicle growth direction that was pointing towards downwards or positive geotropism, which can prove that the hydrotropism properties of mung bean radicles (*Vigna radiata* L.) can defeat the geotropism properties of mung bean roots (*Vigna radiata* L.).

The sample of mung bean seeds (*Vigna radiata* L.) used in the olfactometer media was placed in such a way that the olfactometer media was tilted 30^0 so that it would trigger bending of the root organ. . D-D media (dry-dry) as a control showed that there were 12 radicles in the sample which showed a downward growth direction or positive geotropism.

Positive hydrotropism properties are successful in fighting geotropism that occurs in mung bean radicles (*Vigna radiata* L.), one of which can be influenced by abscisic acid (ABA). Asam absisat (ABA) hast important role plants tolerance to drought condition . ABA maintains a higher growth rate on the side with lower water potential in the roots so that it is hydrotropic responsive (Eapen *et al.,* 2005).

Physiological and biochemical processes in plants are processes involved in geotropism. So the water stimulus provided can be more dominant than the stimulus from gravity. The first hydrotrophic phase will be mediated by APA, which will encourage root growth to search for water in conditions of low water stress, then the plasma membrane HC-ATPase is activated which inhibits the columella pH changes required during the initial gravitropic process. Early gravitropic signal transduction in columella cells that influences changes in pH and auxin distribution and is a target of ABA during the hydrotropic response (Ober and Sharp, 2003).

Figure 1 Results of Hydrotropic radicle growth direction on WD (Wet-Dry) media.

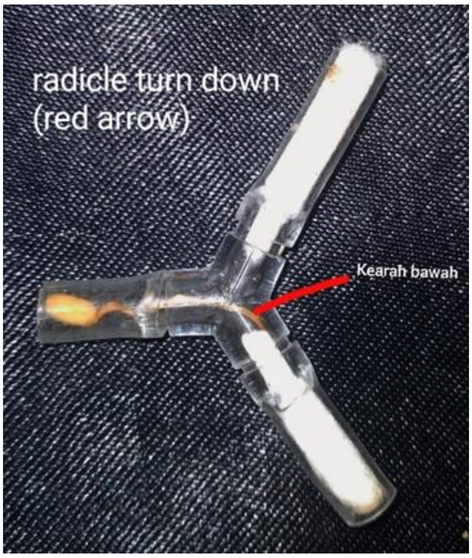

Figure 2 Results of geotropic Radicle Growth Direction on DD (Dry-Dry) media**.**

The oblique olfactometer method used in this research is one of the factors why the hydrotopism properties can defeat the geotropism properties that occur in the radicles of mung bean plants (*Vigna radiata* L.). Plant roots require sophisticated mechanisms to interpret continuously incoming signals so they can modify their growth appropriately. The process of hydrotropism in roots begins in the roots by sensing the humidity gradient, then providing environmental signals regarding water humidity which involves a number of loci in the mechanism and the transmission of signals between cells that trigger root growth leading to a stimulus.

The results are visible in the direction of growth of the mung bean (*Vigna radiata* L) samples in this research, by having a close distance from the hydrostimulant so that the positive hydrotropism root properties can counter the positive geotropism root properties of the mun bean radicle (*Vigna radiata* L.). This is in line with the results of research conducted by (Takahashi and Scott, 1991), where the distance of the water stimulus (hydrostimulant) given affects the hydrotropism response in the radicle. The hydrotropism response was seen in samples that had a distance of 2 mm from the stimulant so that the positive hydrotropism root properties could oppose the positive geotropism root properties of the radicle, while samples at a distance of 5 and 10 mm from the hydrostimulant had a reduced hydrostimulant response.

Observations were made after 4 days where the direction of growth of the mung bean radicle (*Vigna radiata* L.) was so that the observation time was also taken to maintain the humidity gradient in the mung bean radicle (*Vigna radiata* L.). minimizing evaporation in the planting medium so that it can successfully encourage a positive hydrotropic and response in the radicle by (Takahashi and Scott, 1991), The results of this research show that the level of humidity provided and the water content of the seeds have an influence on the direction of radicle growth.

The water content in the WD (wet-dry) medium is one of the factors that causes the hydrotropism properties to defeat the geotropism properties in green bean (*Vigna radiata* L) radicles. Water treatment had a positive effect on the length of green bean radicles (*Vigna radiata* L.). The results of observing the length of the radicle of mung beans (*Vigna radiata* L.) can be seen in table 1 below.

The difference that can be seen from the samples of mung bean seeds (*Vigna radiata* L) in this study is that the media that was treated by dripping with distilled water had a radicle length that was on average longer than the samples on media that were not treated by dripping with distilled water. This can prove that the treatment given can affect the length of the mung bean radicle.

Green beans are one of the plants that require water as an energy source for the growth and development of mung bean plants (V*igna radiata* L.). The availability of water in green bean plants influences physiological and metabolic processes in plants. Water deficit conditions or water shortage stress can inhibit the growth and development of mung beans (*Vigna radiata* L.) (Felania, 2017).

The water content in the wet-dry medium is a factor that causes the hydrotropism properties to defeat the geotropism properties in mung bean radicles (*Vigna radiata* L.). When the roots find a zone that is rich in nutrients, the roots will reposition the organs so that they get nutrients as a source of plant energy.

Statistical analysis has been carried out on the data obtained from the experiment. Because the treatments in the two experiments are not related, the data will be analyzed using Independent T Test analysis. Before the data can be tested using the T Test, the first thing to do for parametric statistical analysis is Dry – Dry carry out the analysis requirements, namely the assumption test. The normality assumption test is then continued with the homogeneity test.

Table 1 Results of measuring radicle length on two mediums dry-dry (top bottom) and wet-dry (top bottom) in centimeters

Treatment	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R 10**	**R 11**	**R12**
Dry cotton upward– Dry cotton below	1.1	1.2	1.3	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.9	2.0
Wet cotton upward– Dry cotton below	1.9	1.9	1.9	2.1	2.1	2.1	2.1	2.2	2.3	2.4	2.6	2.8

Note: R = replication

Homogeneity test

This aims to find out whether the data that will later be analyzed meets the requirements of the computational formulation. The first assumption test was carried out, namely the normality test.

The normality test needs to be used as an initial regression analysis in order to find out whether the sample requirements for the treatment of each population are normally distributed or not so that the research results can represent the population (Sari, 2017). The Lilliefors test is the normality test assumption used in analyzing the data in this research. If the amount of data used is less than 50 data or the amount of data is small, then the Lilliefors test data analysis is used. After carrying out the normality test, it will be continued with the homogeneity test to find out whether the population of the data is homogeneous (the same). The homogeneity test is carried out after carrying out a normality test which results in the form of normally distributed data so that it can be continued with a homogeneity test as a requirement before carrying out the t test. The Herley test was used as a homogeneity test in this study. The Herley test is used if the two data in the research sample have the same amount. The hypothesis test used is combined S2 because the data held is homogeneous (same).

Data analysis in this study used the Independent T Test because the populations tested have no attraction to each other and do not influence each other or are independent.

Based on the statistical data analysis that has been carried out and explained above, The value of T = 5.801 > T0.025;22 = 2.179 then H0 is accepted, This means that with a 95% confidence level it can be stated that there is a difference in the length of the radicle of mung beans (*Vigna radiata L.*). on dry-dry media with wet-dry media.

4. Conclusion

The conclusion that can be drawn from the research is the hydrotropic response at the radicle tip of mung bean sprouts (*Vigna radiata* L.) more dominant so that it can overcome its geotropic properties and a positive influence on the length of the radicle of mung beans (*Vigna radiata L.*) in the wet-dry medium olfactometer is tilted, compared to the dry-dry medium. Hydrotropism is wins against geotropism.

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